2015 IEEE/RSJ International Conference
on Intelligent Robots and Systems

IROS 2015

Conference Digest

Hamburg, Germany

September 28 – October 02, 2015

IROS 2015 PROCEEDINGS

IEEE Catalog Number:	CFP15IRO-ART
ISBN:	978-1-4799-9994-1
IEEE Catalog Number (USB):	CFP15IRO-USB
ISBN (USB):	978-1-4799-9993-4

The Institute of Electrical and Electronics Engineers, Inc.

Conference Schedule

Mo. Sep 28	Tue. Sep 29		Wed. Sep 30		Thu. Oct 01		Fr. Oct 02
Workshops, Tutorials, Technical Tours	Conference		Conference		Conference		Workshops, Tutorials, Technical Tours
	8:30 - 10:00 Opening			8:30 - 10:00 **Sessions WeAT1–15**	8:30 - 10:00 **Poster Session**	8:30 - 10:00 **Sessions ThAT1–15**	Citizen Forum
	Coffee Break		Coffee Break		Coffee Break		
	10:30 - 11:15 **Plenary**		10:30 - 11:15 **Plenary**		10:30 - 11:15 **Plenary**		
	11:30 - 15:30 **Government Forum**	11:20 - 12:50 **Sessions TuCT1–15**	11:30 - 15:30 **Futurist Forum**	11:20 - 12:50 **Sessions WeCT1–15**	11:30 - 15:30 **Entrepreneur Forum**	11:20 - 12:50 **Sessions ThCT1–15**	
	Lunch Break		Lunch Break		Lunch Break		
	11:30 - 15:30 **Government Forum**	14:00 - 15:30 **Sessions TuDT1–15**	11:30 - 15:30 **Futurist Forum**	14:00 - 15:30 **Sessions WeDT1–15**	11:30 - 15:30 **Entrepreneur Forum**	14:00 - 15:30 **Sessions ThDT1–15**	
	Coffee Break		Coffee Break		Coffee Break		
	16:00 - 16:45 **Plenary**		16:00 - 16:45 **Plenary**		16:00 - 16:45 **Plenary**		
	16:50 - 18:20 **Keynotes 1–3**	16:50 - 18:20 **Sessions TuFT1–15**	16:50 - 18:20 **Keynotes 4–6**	16:50 - 18:20 **Sessions WeFT1–15**	16:50 - 18:20 **Keynotes 7–9**	16:50 - 18:20 **Sessions ThFT1–15**	
Welcome Reception (Town Hall)	**OC & CPRB Dinner** (Miniatur Wunderland)		**Conference Banquet** (Fischauktionshalle)		**Farewell Reception** (Congress Center)		

Robotics Exhibition and Competition (Tue. Sep 29 – Thu. Oct 01)

ROSCON
Hamburg, October 03–04

MICCAI
Munich, October 05–09

IROS Hamburg 2015

Conference Venue

CCH
Messeplatz 1
20357 Hamburg
Germany

☎ +49 40 3569 - 0

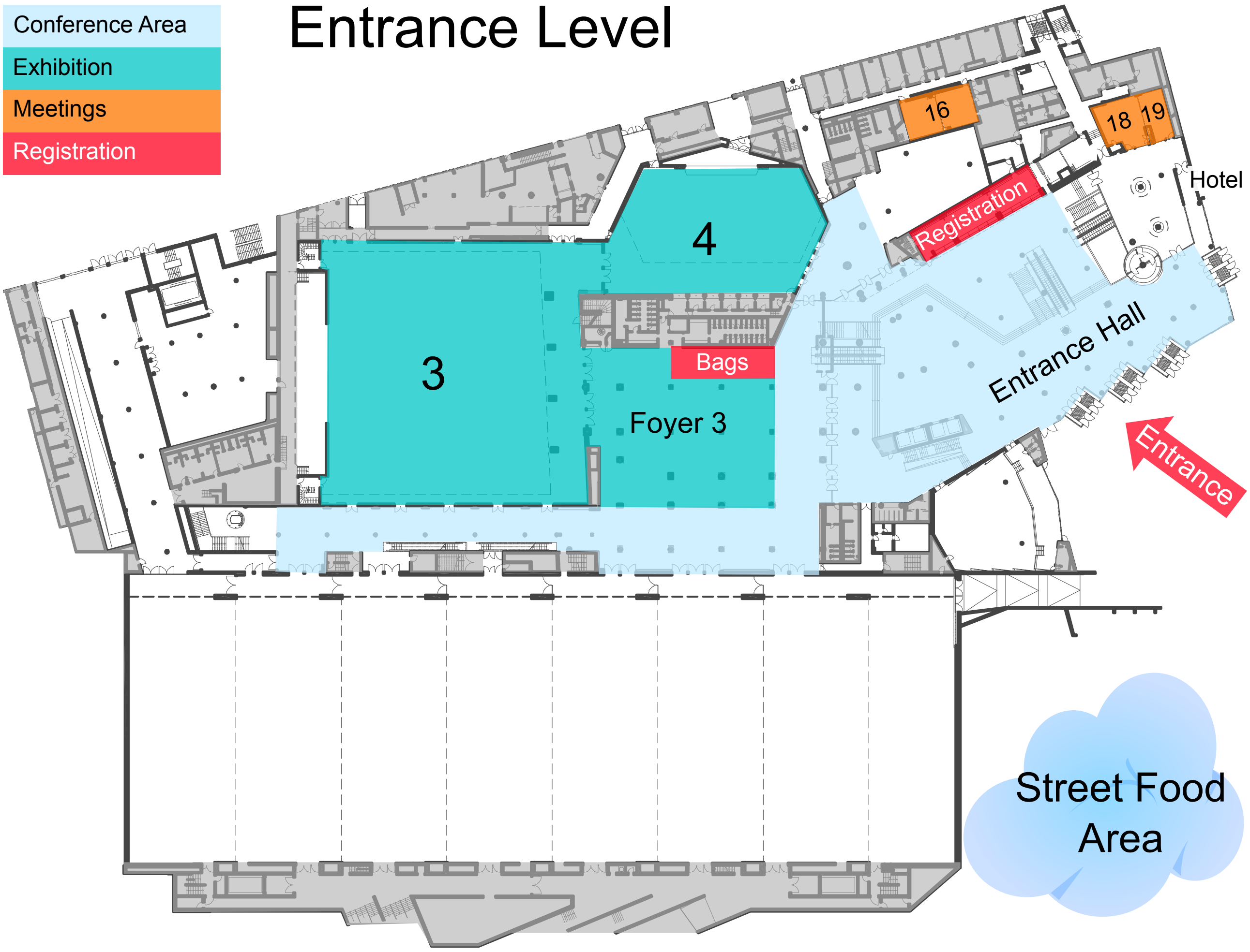
FAX +49 40 3569 - 2203

53.56201, 9.98560
N 53° 33’ 43.247”
E 9° 59’ 8.159”

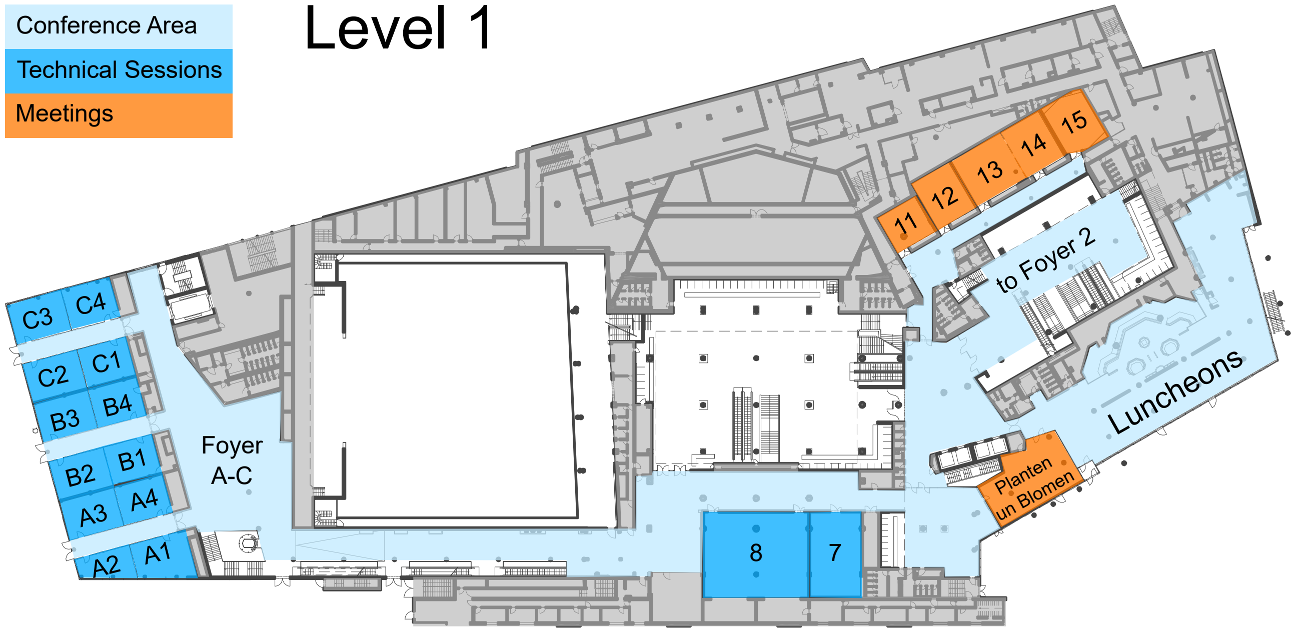
Conference Desk

☎ +49 40 3569 - 5300

How to reach: Dammtor: S11, S21, S31 — Stephansplatz: U1 — Taxi to CCH



Level 1



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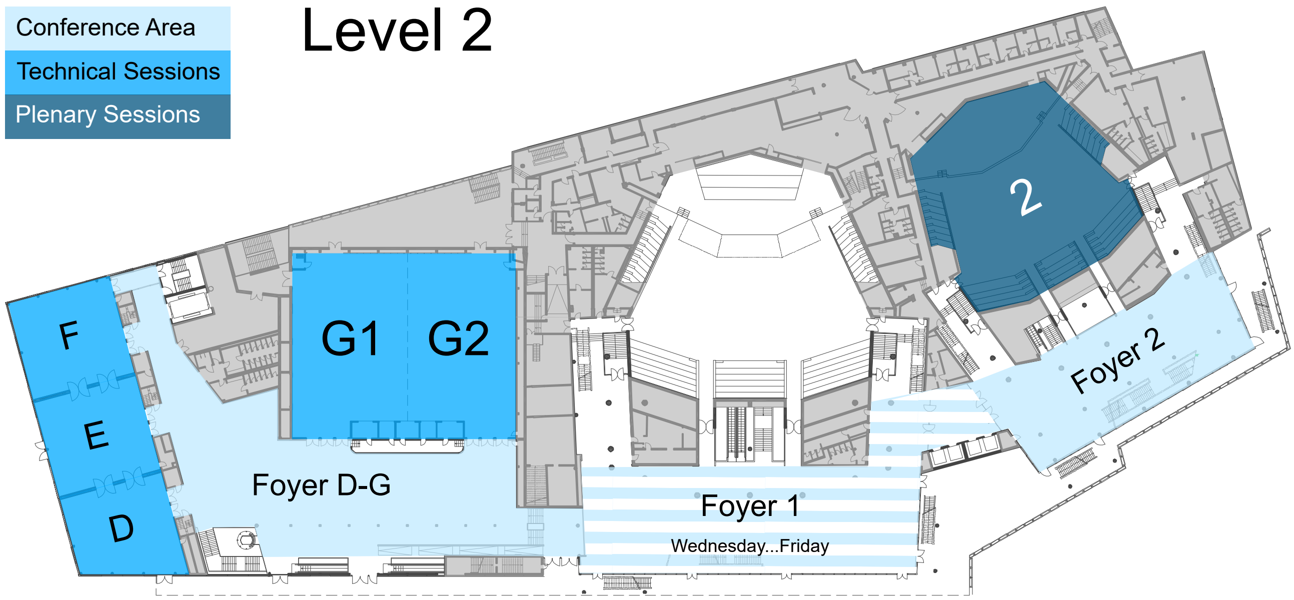
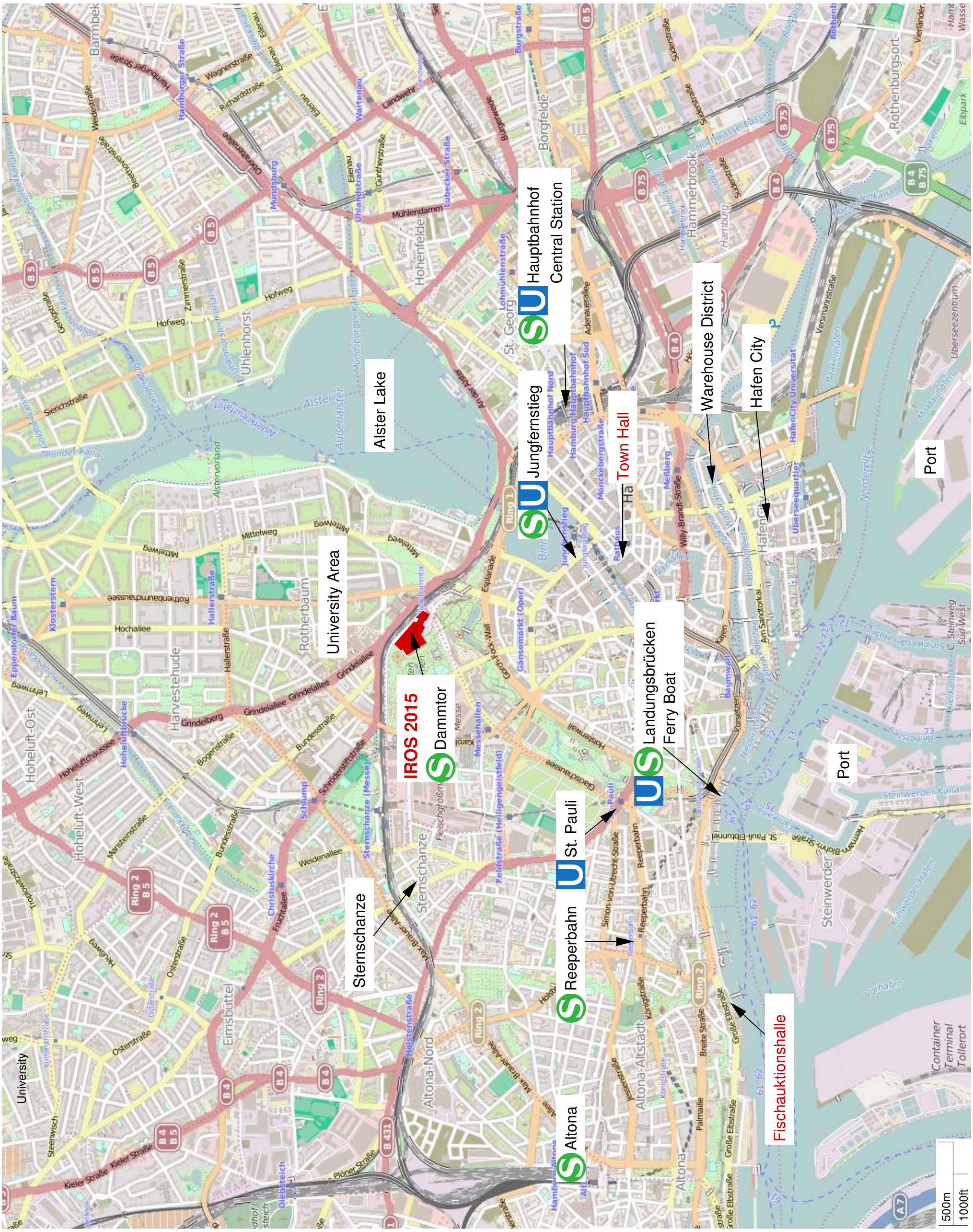
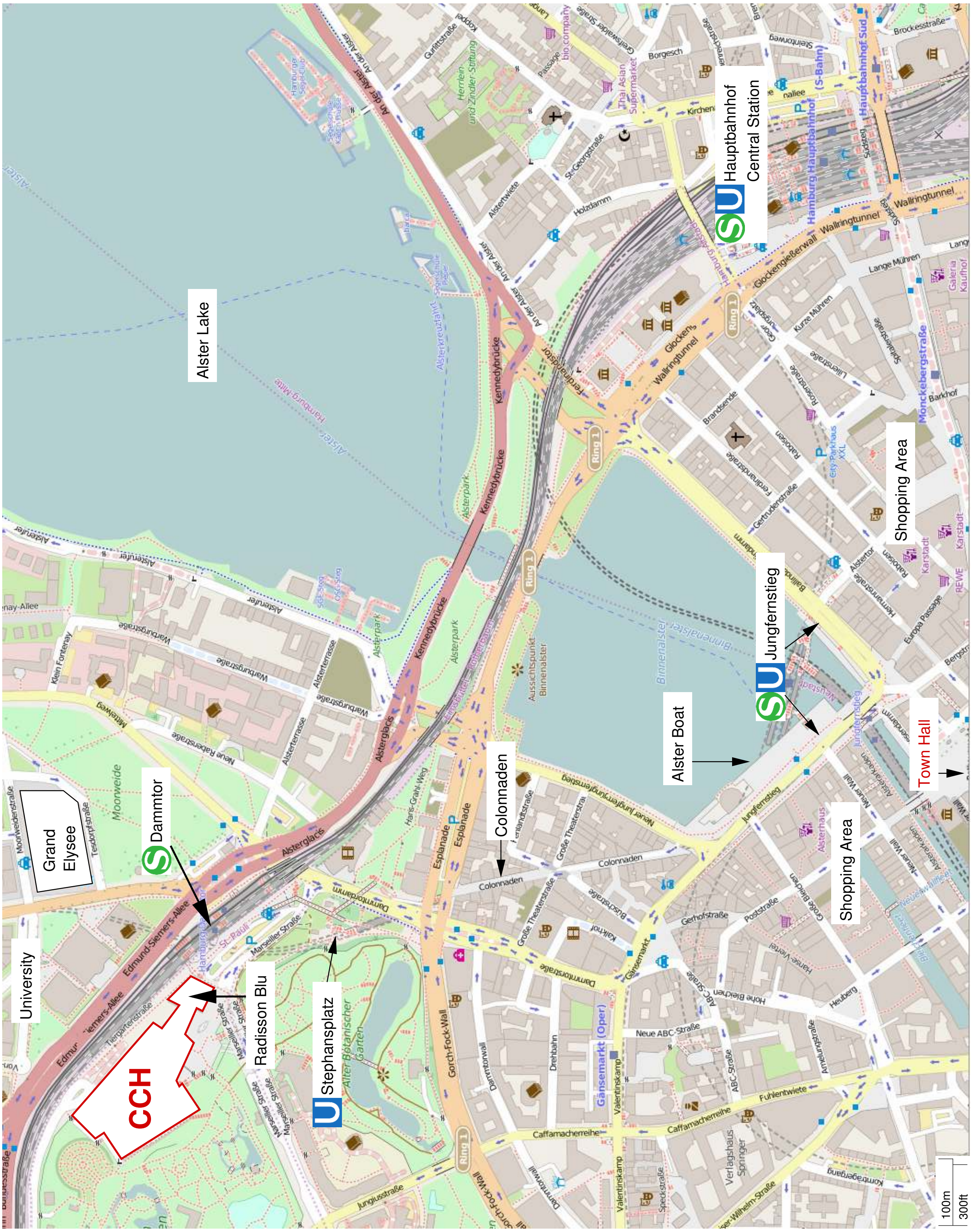


CCH · Congress Center Hamburg

Hamburg Map with Points of Interest




Alster Lake
Hauptbahnhof
Central Station
Grand
Elysee
Dammtor
University
Radisson Blu
CCH
Stephansplatz
Colonnaden
Alster Boat
Jungfernstieg
Shopping Area
Shopping Area
Town Hall
100m
300ft

General Information

On-Site Registration and Helpdesk

The counter for general information and on-site registration will be open during:

Day	Time
Sunday Sep. 27	**17:00–19:00**
All days Sep. 28 – Oct. 02	**08:00–18:30**

Internet Access

Free wifi is available during the conference at the entire congress center. The login details are:

SSID	*see printed digest or*
Password	*contact registration*

Additionally, wired network is available at every speaker desk for use during the presentations and at some public desks.

IROS 2015 Mobile App

Please download the conference4me app to your device from your favorite app-store {Android, iOS, Windows, Amazon}. The IROS-2015 conference data can be downloaded from inside the installed application. For details and documentation, please visit `http://conference4me.psnc.pl/en/`.

Official Language

The official language of the conference is English.

Presentations

Projectors and computers for presentations are placed in every room. It is possible to connect the presenter's own computer by VGA. Sound systems are available in most rooms.

Conference Attire

The dresscode for the entire event is casual and casual business for the welcome reception.

Currency

The currency in Germany is the Euro (€) and Eurocent. The exchange rates vary but can be expected to be about €0.91 per US Dollar ($) based on the exchange rates from the beginning of August 2015.

Emergency Numbers

Police	**110**
General emergency (fire brigade)	**112**
Credit/debit card deactivation	**116 116**

On-site Registration

Conference

Category	Price
IEEE/RSJ Member	€850
IEEE/RSJ Member – one day	€300
Nonmember	€1050
Nonmember – one day	€375
IEEE Student Member*	€450
Student Nonmember*	€550
IEEE Life Member	free

*Students are required to provide a valid student ID or other verification at the registration desk.
**Banquet participation cannot be guaranteed for on-site registration.

Registrations include the conference bag with conference proceedings and of course admission to technical sessions, coffee breaks, receptions and the banquet. Payments are possible by credit card (Visa, MasterCard, and American Express) or cash.

Workshops and Tutorials

Category	Price
IEEE/RSJ Member	€175
Nonmember	€325
IEEE Student Member*	€105
Student Nonmember*	€175
IEEE Life Member	free

*Students are required to provide a valid student ID or other verification at the registration desk.

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Foreword

After 21 years, IROS returns to Germany — to Hamburg, “Germany’s Gateway to the World”, one of the largest and most beautiful cities in the country. While the Hanseatic city of Hamburg has been a very international trading, business and seafaring city for centuries, with the harbour’s roots dating back to the ninth century, it has also been very open to new technologies: the port of Hamburg is not only the second-biggest container-terminal in Europe, but in terms of adoption of Internet-technology and automation, it is also one of the most advanced — ranking it one of the world’s most flexible, high-performance universal ports. Moreover, Hamburg is strong in medical industries, microelectronics and civil aerospace, as well as heavy industries, including the making of steel, aluminium and copper and shipyards. It is also Germany’s number one city in the media industry, and it is home of the TV station producing the most reputable daily news show from a fully robotized studio. The University of Hamburg is one of the largest universities in Germany.

Referring to Hamburg’s role as a gateway for seafarers, we have chosen the conference theme to be “Gateway to the Era of Robots”. In view of the positive development that the field of robotics has seen, both in terms of technology and in terms of business, over the last ten years, we think that as roboticists we are not only witnessing the emergence of a new age, but through our work, we are ushering in a new era of intelligent machines — and with that comes quite some responsibility. For those of us who had the pleasure to attend the first IROSes, the growth of the conference over the last three decades, which reflects the growing breadth of the field, is phenomenal. But also the younger participants will find the numbers impressive: this year we received 2134 paper submissions and 62 proposals for workshops and tutorials. A total of 5444 high-quality review reports were received from 3465 reviewers and then checked and ranked by the Conference Editors. Finally, 969 papers were accepted for publication, which is 45% of the overall papers received. Thanks to the work of the program committee and in particular to the participants of the Senior Program Committee Meeting held in Munich in June 2015, the conference could be successfully structured to fit perfectly into this conference week.

Looking at the numbers, it is also interesting to see how the set of accepted papers reflects the continents: roughly 28% of the papers come from Asia, 29% from the Americas and 41% from Europe. This is certainly a result of the high priority that individual European countries give to robotics. But it is also a consequence of the European Commission’s strong commitment to and significant investment in robotics. In the past two EU framework programs for research and development (FP6, running from 2002 to 2006, and FP7, running from 2007 to 2013), the EU spent a total of about €680 million on robotics and cognitive systems, funding about 180 collaborative projects. In the current research and innovation program, Horizon 2020, EU funding has been about €170 million so far, including funding for almost 40 large robotics projects.

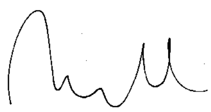
This conference offers six plenary talks with outstanding speakers, three sessions with keynotes from leading experts in their fields, fifteen parallel tracks with full oral presentations, a Late-Breaking Poster session, five technical tours, a Government Forum, a Future of Robotics forum, an Entrepreneurship Forum & Start-Up Competition, and a Citizens’ Forum. Two full days are dedicated to 51 workshops and tutorials.

Our general goal is to create a variety of opportunities and formats for a lively exchange among participants, especially young researchers, to present their work to larger audiences – often for the first time in their scientific career. Furthermore, IROS 2015 will be an ideal platform to connect robotics academia and industry, and to facilitate entrepreneurship. Over 50 companies have already signed-up for the IROS exhibition, with established global players next to small start-ups demonstrating exciting new products.

In addition to being an international hub, Hamburg, as an old harbour town, also has a vibrant and world-famous night life. We will offer a large number and wide variety of unique social events in Hamburg and its surroundings. There will also be a conference dinner in a very traditional setting.

We are greatly appreciative of the strong support from our sponsors and exhibitors, both industrial and institutional, without whom the program would not have been possible. Likewise, we would also like to thank the entire Organizing Committee, the Conference Editorial Board, the 300 Program Committee members, the over 3000 reviewers, the Senior Program Committee members, the local arrangement team, and the student volunteers. Their valuable contributions and assistance have greatly improved both the quality of this event and its international success. Last but not least, our thanks go to the authors, the conference participants and all those whose help and support make this conference possible. Finally, we wish you an interesting, pleasant and memorable stay in Hamburg!

General Chair
Jianwei Zhang



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IROS 2015 Local Organization and Digest Team

Welcome to Hamburg

The Free and Hanseatic City of Hamburg, one of the 16 states of the Federal Republic of Germany, is the second largest city in Germany with its 1.7 million inhabitants. In this sense, it is a city as well as a state. Economically and culturally, Hamburg is also the centre of Northern Germany. 3.5 million people live in the 755 square kilometres large metropolitan region of Hamburg - for them, Hamburg is a shopping and cultural metropolis. With 30 square metres of living space per person, Hamburg has the biggest average living space of all major cities in the world. As much as 14% of the city area is made up of green spaces and recreational areas. As a surprise to many, Hamburg has 2,302 bridges - more than Venice and Amsterdam combined! With over 90 consulates, Hamburg is second only to New York City. As a historical trade centre, Hamburg has always been outward-looking, a fact that has shaped the mentality of Hamburg's inhabitants.

Places to see — Things to Do

Hamburg offers many highlights to explore on foot. The *Landungsbrücken* Area is one of the oldest parts of Hamburg, where the big migrations to Hamburg, and from Hamburg to overseas, took place at the end of the 19th and in the early 20th century. You can easily get there by the U3 or S1 metro lines. A special attraction is the *Alter Elbtunnel*, which means "old Elbe tunnel". The 426 m long tunnel was opened in 1911 and was a technical sensation at the time. We highly recommend visiting this marvel of civil engineering. It is open 24 hours for pedestrians and bicycles. The *Reeperbahn* is Hamburg's oldest and most famous red light and entertainment district. Revelers of all ages and backgrounds will find entertainment from ritzy nightclubs to quirky little bars, from strip clubs to restaurants and theaters.

The *Hamburg Fishmarket* attracts over 70,000 visitors to the Elbe every Sunday. Here you can find fresh fish, fruit baskets and tropical flowers. It is best to make a very early morning visit, and you will get to experience the bustling trade at a place that is as much an institution as a real marketplace. As an added bonus, you can get fresh regional fruits and other produce at immense discounts near the closing time, if not for free ! If you're on time, you'll catch the live band with some dancing and breakfast in the beautiful *Altona Fischauktionshalle* (Altona Fish Auction Hall), where the IROS2015 banquet will also take place.

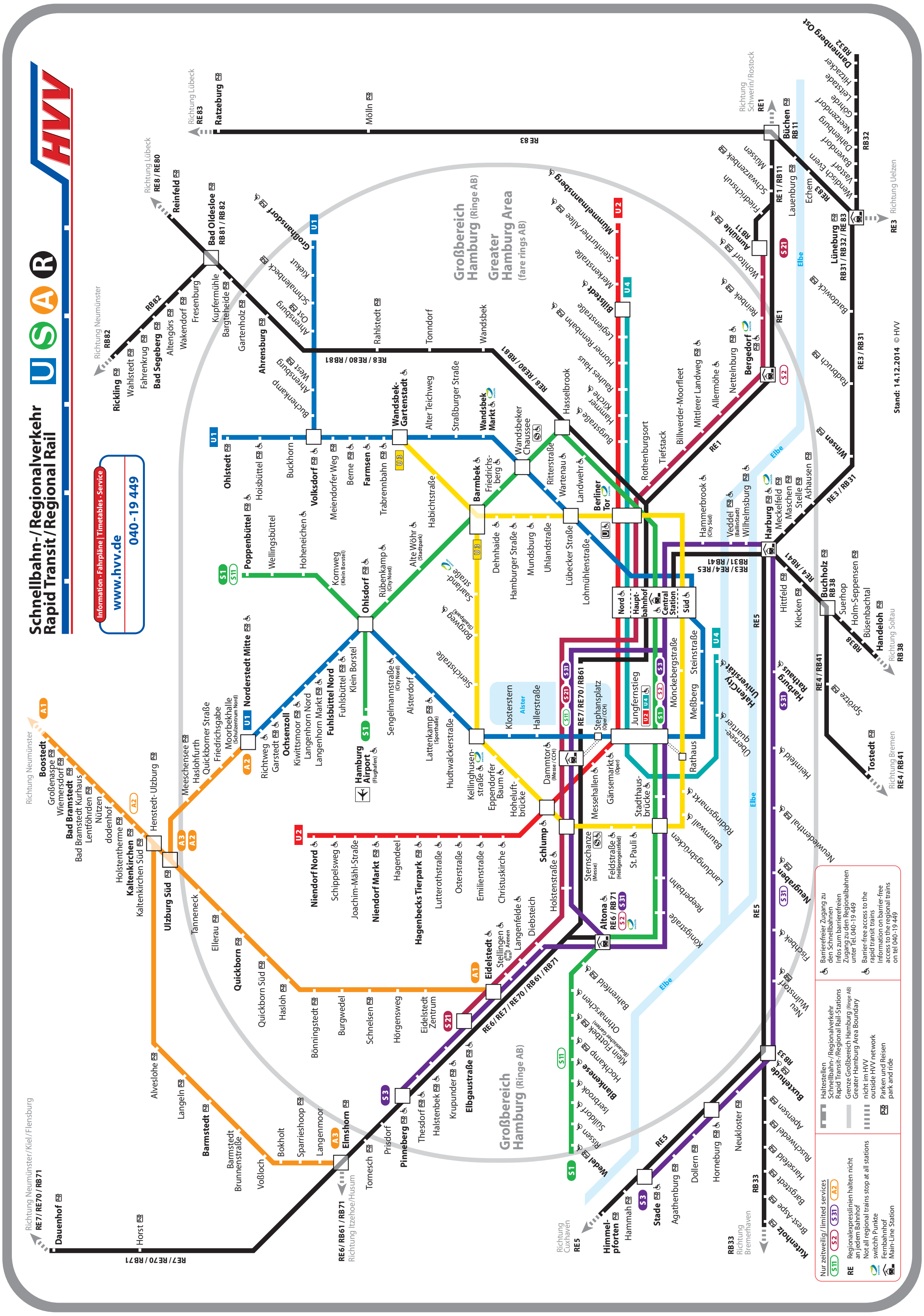
Address: Große Elbstraße 9, 27767 Hamburg
Opening times: Every Sunday, 05:00 – 9:30
April to October
Public transport:

- S1, S3 — Exit at "Reeperbahn"
- U3 — Exit at "Landungsbrücken"
- Bus 112 — Exit at "Fischmarkt".

The *Speicherstadt* (Warehouse City) with its neo-gothic brick warehouses and the adjacent *Kontorhaus district*, newly appointed UNESCO World Heritage sites together with the modernist *Chilehaus*, is one of the largest coherent historic ensembles of port warehouses in the world (300,000 m^2). Today it houses restaurans, cafes, museums, shops, hotels and the mind-boggling *Miniaturwunderland*, the world's lagest model railway. This historic district to the east of the *Landunsgbrücken* area has recently received a posh new neighbour in the *Hafencity*, Hamburg's youngest quarter with great views of the river Elbe and its cruise terminal where cruise liners like the Queen Mary II regularly set off on new journeys. Discover these quarters on foot, or take a port cruise through the red canals of the Speicherstadt.

A city with a lake at its heart — this is Hamburg. Take a stroll on the urban banks of the inner Alster along picturesque Jungfernstieg shopping street in the city centre, turn right into Neuer Jungfernstieg, passing the grand Hotel Vier Jahreszeiten (Four Seasons), amble along the benches at the northern edge of the inner Alster, cross under Lombardsbridge and Kennedy bridge and see the outer Alster open up before you: a wide lake dotted with sailing boats, lined with lawns and trees, walkways and bicycleways, with here and there a restaurant or cafe and plenty of benches to sit and soak in the holiday atmosphere. Again, welcome to Hamburg!

Public Transport



The public transport in Hamburg is run by the *HVV* (Hamburger Verkehrsverbund or Hamburg Transport Association) which integrates the city bus services, the underground network (U-Bahn), light rail (S-Bahn, A-Bahn) and regional rail services (R-Bahn), as well as the harbour ferries. For details and timetables visit `http://www.hvv.de/en/`

We recommend the app *DB Navigator* for online route planning. It is available for all major mobile OS. For Android, the app *Öffi* is also available. Furthermore a foldable map of the metro network can be obtained at any ticket counter at the major metro stations. There is also a map in your Tour Guide.

Tickets are available at the vending machines in the train stations or from the bus drivers. Please enter buses at the front door and prepare to show your ticket. The network pricing system offers a wide variety from short trip to multiple-day tickets. At each station, a *Fare Zone Plan* is available. The Public transportation is divided into rings (A to E) and zones (000 to 999). The recommended Tickets for your stay in Hamburg are listed below.

Kurzstrecke €1,50 – *Short Trip* – Valid in ring A and B for traveling within one zone

Nahbereich €2,10 – *Close Range* – Valid in ring A and B for traveling within two zones

Großbereich €3,10 – *Large Range* – Valid for any route within ring A and B

Gesamtbereich €8,40 – *Full Range* – Valid for any route within all rings

Ganztageskarte €7,50 – *All-Day* – All day in ring A and B, until 06:00 of the next day

9-Uhr-Tageskarte €6,00 – *Semi-Day* – Same as Full-Day but not between 06:00 and 09:00

9-Uhr-Gruppenkarte €11,20 – *Group Ticket* – Semi-Day ticket for groups up to 5 people

Wochenkarte €26,90 – *7-day Ticket* – Valid for 7 days in ring A and B

StadtRad (CityBike) rates

The public bicycles called *StadtRad* are available in the inner city area. Registration requires a Credit- or EC-card and €5, which will be credited to your account. Online registration is available at `stadtrad.hamburg.de`. The first 30 minutes of each ride are free of charge, afterwards each minute will be charged with €0,08, with a max. charge of €12 for a full day. The *StadtRad* mobile app is available for major OS.

Taxi rates

Taxis must use the calibrated taximeter. The basic charge is €3,20 and €2,35 per kilometer (€2,10 after 5 km, €1.45 after 10 km). When waiting for more than 60 seconds, the taximeter will add €0,10 per 12 seconds. The *myTaxi* app will automatically send a taxi to your location.

Social Events of the Conference

Welcome Reception

Monday Sep 28, 19:30–21:30 *Historic Festival Hall at the Hamburg City Hall*

The IROS 2015 will welcome you at Hamburg's lovely City Hall on Monday September 28 from 19:30 to 21:30. Walk for around 15 minutes in groups with our helpers setting off in 15-minute intervals, starting from 18:30 from the CCH venue, or take buses 5 or 109 to Rathausmarkt station. In the Historischer Festsaal (Historic Festival Hall), drinks will be served and the Hamburg Senator for Science will address our robotics community.

Coffee Breaks

Most coffee breaks will take place in the Exhibition Hall, i.e. Hall 3.

Conference Banquet

Wednesday Sep 30, 20:00–23:59 *Fischauktionshalle*

It's Oktoberfest-time at the IROS2015, so get out your *Lederhosen* and *Dirndl* and let's raise those beermugs to the success of our conference. Powered by our main Sponsor KUKA, our Bavarian-Style banquet will take place on Wednesday September 30 in Hamburg's beautiful historic Altona *Fischauktionshalle* (Altona Fish Auction Hall) in the port.

Shuttle Buses can take you there from the CCH IROS venue from 18:30 to 19:30. Or you could get there yourself, by bus 112 from *Stephansplatz* to *Hafentreppe* and then walk west for 5 min on *St.Pauli Fischmarkt* Street. This takes around 30 min altogether. Or take subway S1 from *Dammtor* Train Station to *Reeperbahn*, get into Bus 111 and get off directly in front of *Fischauktionshalle* (on a ground of cobblestones — beautiful, but not suitable for high heels).

You'll be welcomed with cold drinks and our Bavarian Brass band from 18:45, then your host, IROS2015 general chair Jianwei Zhang will open the banquet at 20:00 and, most importantly, the buffet with Northern German as well as typical Oktoberfest flavors. And we've got some seriously German folklore show acts from Bavaria waiting in the wings to entertain you as well as fun and games down in the hall.

Then from 23:30 to 00:30, shuttle buses can take you back to the CCH. Or take buses 111 or 112, or walk 15 min along the river *Elbe* to Subway station *Landungsbrücken* and take subway U3 or S1, S2 or S3 to your hotel.

You could also consider a stroll through neighboring St Pauli and the *Reeperbahn*, the famous nightlife district of Hamburg.

Farewell Reception

Thursday October 01, 18:30 — *CCH, Foyer 2*

The farewell reception will close the conference part on Thursday October 01 from 18:30 to 21:00 pm in the lobby of the plenary hall (Hall 2), and the adjacent lobby of Hall 3. Weather permitting, we'll venture out onto the terrace next to the lobby facing Planten & Blomen Park. Cold drinks and fingerfood will see the Hamburg IROS 2015 out.

OC & CPRB Dinner (Editor's Dinner)

Tuesday Sep 29, 19:00–23:59 — *Speicherstadt*

In Hamburg's neo-gothic warehouse district in the port, the Editors and Associate Editors will be welcomed to a unique dinner experience: in a former red-brick historic coffee warehouse, enjoy great food from 19:00 and then an unforgettable tour from 21:15 to 23:59 through the world's biggest miniature railway landscape, the Miniatur Wunderland, in the same building. Buses will bring you there from the CCH from 18:30 and back again between 23:30 an 00:30. You could also walk 9 minutes to subway station *Baumwall* and take the U3 from there, but only until 23:53.

IEEE RAS Lunch with Leaders (LwL) - Student Lunch

Wednesday Sep 30 — *CCH, Kranzler Restaurant*

Lunch with Leaders (LwL) offers IEEE student members an opportunity to network with RAS leaders and get advice and mentoring on their career and research.

IEEE RAS Young Professionals Lunch

Wednesday Sep 30 — *CCH, Hall Planten & Blomen*

This luncheon is open to recent IEEE graduates, so that they can network with peers and find out more about the benefits of RAS.

IEEE RAS Women in Engineering Leadership (WiEL) Lunch

Tuesday Sep 29 — *CCH, Kranzler Restaurant*

The WiEL luncheon provides an opportunity for all the female and male professionals who are interested in women engineering education to discuss the subjects of career path, career/family choices, and other topics.

Awards Lunch

Thursday Oct 01 — *CCH, Plenary Hall Foyer*

On your way to the Awards Ceremony, grab your lunch box in the foyer of the Plenary Hall from 12:15. The Awards Ceremony will start at 13:00 in the Plenary Hall.

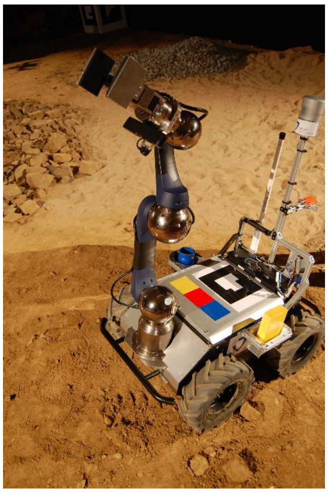
Technical Tours

Tour 1

Bremen: Lab tour through the Jacobs University, DFKI and University of Bremen

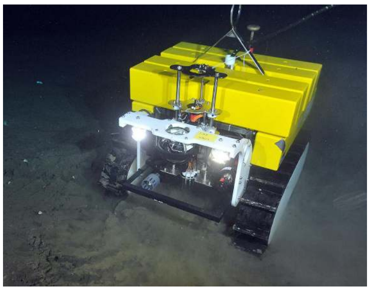
Monday September 28	
09:00	Departure from CCH
11:00–13:00	Jacobs University
13:00–14:00	Lunch
14:30–15:30	DFKI
16:00–17:00	University of Bremen
19:00	Arrival at CCH

Jacobs University



Robotics research at Jacobs University is demonstrated in the morning part of the tour. Jacobs University is a private research university founded in 1999. It has a highly selected, international study body and a residential college system. Robotics research at Jacobs started with the very beginning of research and teaching activities of the university in September 2001. Jacobs University offers among others a flagship BSc program on "Intelligent Mobile Systems".

The tour at Jacobs University features several demonstrations from different research groups that engage in multiple international and national robotics research projects. For example, research on 3D perception and world-modeling is demonstrated in challenging unstructured environments. The demonstrations include object recognition and manipulation in cluttered scenes, especially for logistics applications, and very robust 3D mapping featuring novel registration methods and new ways to cope with outlier rejection in SLAM, demonstrated among others in underwater applications.



Marine robotics is also the topic for the demonstration of "Wally" — a Deep Sea Crawler that serves as a universal device carrier for ocean sensors that can be operated via the internet from all over the world and that will be operated live during the tour. Research on Affective Computing and Social Robotics is also shown on the tour. This includes the presentation of a laboratory setup for the assessment of physiological and expressive emotional reactions in the context of human robot interaction and the demonstration of a standardized set of sounds (The Bremen Emotional Sound Toolkit BEST) for use as nonverbal acoustical emblems for Robot-Human Interaction.

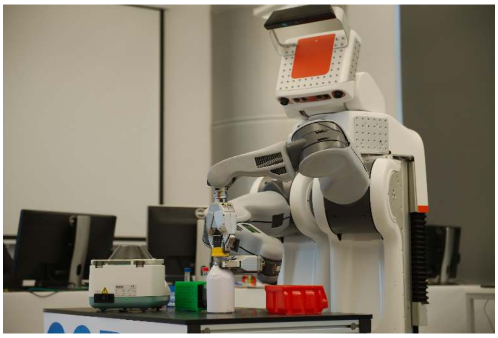
Robotics Innovation Center of the DFKI in Bremen

The Robotics Innovation Center (RIC) of the German Research Center for Artificial Intelligence (DFKI) and the Robotics Group at the University of Bremen welcome the participants of the IROS 2015 for guided tours through their laboratories and testing facilities.

The DFKI, based in Kaiserslautern, Saarbrucken, Bremen and leading a project office in Berlin is the world's largest research center in the field of Artificial Intelligence.The Robotics Innovation Center, headed by Prof. Dr. Frank Kirchner, develops robot systems to be used for complex tasks on land, under water, in the air, and in space. The RIC closely cooperates with the Robotics Group at the University of Bremen.

The guided tours start at 14:30 in the DFKI-building at Robert-Hooke-Straße 1 in Bremen. During the visit the participants will pass different labs — for example the 1,300 m^2 Maritime Exploration Hall, which is unique in Europe, and the Space Exploration Hall, where robots are tested under realistic conditions — and see multiple robot systems, which were developed at the DFKI and will be demonstrated by the scientists.

University of Bremen



The Institute for Artificial Intelligence (IAI) directed by Prof. Michael Beetz is part of the Faculty of Computer Science at the University of Bremen. The research group investigates methods for cognition-enabled robot control. The research is at the intersection of robotics and Artificial Intelligence and includes methods for intelligent perception, dexterous object manipulation, plan-based robot control, and knowledge representation for robots.

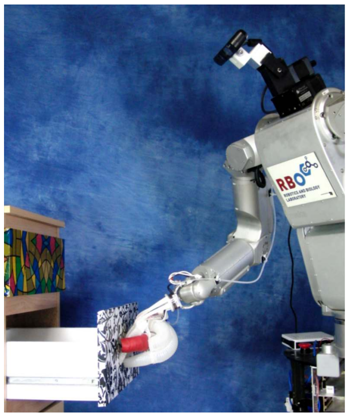
The team will demonstrate results from the EU projects RoboEarth, RoboHow, SHERPA, SAPHARI, and ACAT as well as from the RoboSherlock project funded by the German research foundation (DFG). Live demonstrations will be presented which cover a variety of complex manipulation tasks, including popcorn making and a chemical experiment. The focus will be on AI-based technologies for perception, knowledge representation, reasoning, and plan-based control. The presentation at the University of Bremen will also feature the new web-based cloud-robotics platform openEASE, which is intended to facilitate the exchange, retrieval, semantic annotation, and re-use of big data both in the AI and the robotics community.

Tour 2

Berlin: Technische Universität Berlin and Humboldt-Universität zu Berlin

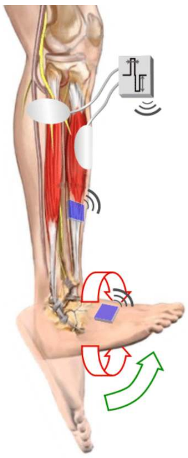
Friday October 2	
08:00	Departure from CCH
11:30–12:45	TU Berlin Part I
12:45–13:45	Lunch
13:45–15:00	TU Berlin Part II
15:00–16:00	Sightseeing Berlin
19:00	Arrival at CCH

The internationally renowned Technische Universität Berlin is located in Germany's capital city at the heart of Europe. It will host a technical tour featuring demonstrations by four laboratories from Technical University Berlin and from Humboldt-Universität zu Berlin as well as a demonstration by ReWalk^{TM} Robotics:



The *Robotics & Biology Laboratory*, headed by Oliver Brock, focusses on research in mobile manipulation. The group develops solutions for mobile manipulation that tightly couple various aspects that traditionally were considered separately (e.g. hardware, planning, control, perception, etc.). The concept of interactive perception, for example, considers perception and manipulation as inseparable components of a single problem, leading to novel solutions both in perception and in manipulation. The lab's grasping research combines the development of novel hands with associated planning and perception algorithms. The lab will present the resulting mobile manipulation capabilities in various demonstrations, amongst them a demonstration from the *Physical Exploration Challenge DFG project* in collaboration with the *Machine Learning and Robotics Laboratory* from Universität Stuttgart, headed by Marc Toussaint.

The *Compliant Robotics Lab*, headed by Ivo Boblan, investigates how compliant and resilient control can be implemented in both actuators and supporting structure. Inherent compliance of systems is the key for safe interaction between humans and robots. The way how the total compliance should be divided between the construction and the actuators, is a main subject and mission of the lab. Since 2015 the group has a mandate, received from the Federal Ministry of Education and Research (BMBF), to work out the principles/basics related to a human-centered human-robot interaction (HRI) within the scope of demographic change. An interdisciplinary team of researchers from the fields of robotic engineering, biophysics, science and technology studies, neurobiology and interaction design has come together to investigate criteria and possibilities of a successful HRI with a holistic approach. For this purpose an HRI FabLab is built to experience and develop HRI with participants of all areas of society. Furthermore an associated HRI network of representatives of organizations and industry will evaluate the results. The group will present a robotic manipulator according to the role model of an elephant's trunk, which was developed in a former project BROMMI:TAK.



The research focus *Rehabilitation Engineering and Assistive Technology*, led by Thomas Schauer, is part of the TU Berlin Control Theory Group. It focuses on feedback control and electromechanical design problems in biomedical engineering and the development of technical aids for the neurological rehabilitation of motor function disorders caused by stroke and spinal cord injury. We will demonstrate how feedback-controlled neuroprostheses can be used to restore motor function in paretic limbs. To this end, we derive realtime motion parameters using adaptive inertial sensor networks. By means of functional electrical stimulation, we trigger muscle contraction and generate or support functional motions like grasping, cycling, and walking. Feedback control strategies are employed to follow predefined motion trajectories and to adjust the stimulation to the needs of the patient at all times.

The *Adaptive Systems Group*, headed by Verena Hafner (Humboldt-Universität zu Berlin), focuses on topics in cognitive and developmental robotics. One of the lab's current research questions is on sensorimotor learning and interaction, and approaches include internal models and exploratory behaviour with humanoid robots. Within the EU project *EARS* (Embodied Audition for RobotS), the group focuses on embodied cognition and interaction, active sensing and behaviour prediction. Other projects are on joint attention, behaviour recognition, sensorimotor learning as well as biorobotics (spatial cognition, navigation, and neural modelling). The group also regularly participates in the RoboCup standard platform league with their NaoTH team. We will demonstrate internal models for egonoise prediction on the humanoid robot Nao as well as learning mechanisms for a swimming spherical robot.

ReWalk™ Robotics is an innovative medical device company that is designing, developing and commercializing exoskeletons allowing wheelchair-bound individuals to stand and walk once again. Our mission is to fundamentally change the health and life experiences of individuals with spinal cord injuries. Current ReWalk™ designs are intended for people with paraplegia, resulting in complete or incomplete paralysis of the legs. The system uses patented motion sensing technology along with battery-powered motorized legs powering knee and hip movement which is controlled by proprietary on-board computers and software. Subtle changes in center of gravity restores self-initiated walking. Repeated body shifting generates a sequence of steps, which mimics natural gait at efficient and functional walking speed. The ReWalk™ systems allows the user to sit, stand, walk, turn and has the ability to climb and descend stairs* (*stairs function not available in the USA). ReWalk™ users are able to independently transfer in and out of the system and operate the device on their own. A ReWalker will demonstrate how to use and walk with the system during the exhibition.

Tour 3

Hamburg: Port of Hamburg - HHLA Container Terminal

Friday October 2	
17:30	Departure from CCH
20:30	Arrival at CCH

Eye to Eye with Giants

The “Gigantentour” is an enthralling tour through the Freeport of Hamburg.

The bus tour leads the group right through the heart of the Hamburg port, passing by big freighters, huge container bridges and high cranes. Where normally the access is forbidden, the guests experience the dynamic of a world port. All around the clock goods are handled – that means discharged, charged, sorted, packed and marked. The tour shows the new Harbour city and the warehouse complex, goes over the Köhlbrandbrücke bridge, and down to the Hansaport, Germanys biggest port terminal for coal and ore.

The group will visit the container port Altenwerder and then the bus will go directly to the Burchardtkai, which is the biggest dock site of the Hamburg port concerning size and the amount of containers. Visit the third largest harbour in Europe with an annual turnover of more than 9 million containers!

Please be aware that this tour enters a restricted customs area and the German customs authorities require every participant to register for this tour by name in advance and to provide a valid passport at departure. The registration process will be handled by the IROS-team, participants must be registered for the tour before September 25th!

Tour 4

Hannover: Leibniz University and Volkswagen

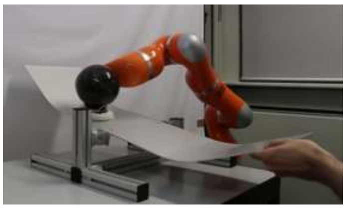
Friday October 2	
08:00	Departure from CCH
10:30–30:00	Leibniz University Hannover (Lunch)
13:30–15:00	Visit at Volkswagen
15:30–16:30	Royal Gardens (Lunch)
19:00	Arrival at CCH

Gottfried Wilhelm Leibniz University Hannover

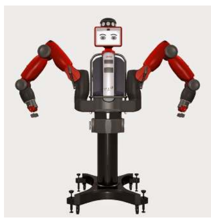
The great German mathematician and philosopher Gottfried Wilhelm Leibniz lived and worked in Hanover from 1676 until his death in 1716. In memory of his outstanding achievements and contributions, Hannover's university was named after this outstanding polymath. With more than 25,000 students in natural sciences and engineering, humanities and social sciences as well as in law and economics, LUH is the largest university of the State of Lower Saxony and member of the major German Technical Universities (TU9).

Robotics research and interdisciplinary research with medical sciences has a long-standing tradition in Hannover, where e.g. the first German dynamically walking biped was developed. LUH offers a highly interdisciplinary robotics and mechatronics program, where students can e.g. specialize in "automation and industrial robotics", "service robotics and autonomous systems", or "automatic control and systems dynamics". During the first part of the tour you will visit the robotics labs of LUH, which warmly welcome the IROS 2015 participants for the guided tours!

Sami Haddadin's lab



The Institute of Automatic Control (IRT) develops novel methods and intelligent robotic systems based on the tight interconnection of theories and algorithms from automatic control and dynamical systems, human motor control and machine learning. IRT's emphasis lies on safe physical human-robot interaction (pHRI), soft-robotics control, real-time motion and action planning, and the unification of model-based control concepts with state-of-the-art machine learning approaches.



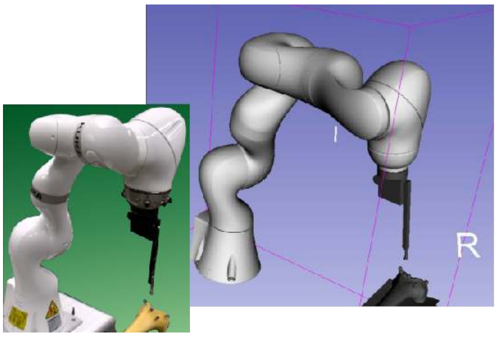
IRT's has e.g. pioneered in the field of high-speed collision detection, classification, and reflex reaction for torque-controlled robots, humanoids or flying systems. Further central research domains of IRT are the analysis of potential human injuries suffered from robot-human collisions, the understanding of human reflex mechanisms, and the systematic embodiment of these insights into new control and planning algorithms. During your visit at

IRT, you will have the chance to see latest results in unified force/impedance control embedded into a general framework for safe physical Human-Robot Interaction (pHRI) for several state-of-the-art robotic systems.

Furthermore, the embodiment of principles from human motor control into novel robot control algorithms for sensitive manipulation and self-protection will be presented. Finally, the tour will also cover semi-autonomous, assisted teleoperation of soft-robots for remote assistance via intuitive multi-modal HMIs.

Tobias Ortmaier's lab

The Institute of Mechatronic Systems (imes) deals with scientific questions and applications, which go beyond the limits of the involved technical disciplines and, therefore, require a holistic approach.



Our work on both fundamental research and application-oriented projects is characterized by a high degree of interdisciplinarity and requires the versed application of latest modeling, control theory, parameter identification, as well as numerical optimization techniques. The Institute is organized in three collaborating research groups: The Robotics & Autonomous Systems group is characterized by its expertise on multi-body dynamics modeling, model-based robot control, and optimal motion planning.

The Medical Systems & Vision group focuses on innovative projects in the field of instrument engineering and computer assisted high precision surgery in close cooperation with medical experts, engineers, and computer scientists. The Identification & Control group specifically works on advanced model-based control and identification approaches for versatile mechatronic systems including real-time state and parameter estimation methods. During the tour, guests will visit our research laboratories for industrial robotics and for medical technology including demonstrations of latest project advances. Optimal path planning methods for energy efficient control and vibration suppression of serial and parallel robots will be presented besides several applications in the field of computer and robot-assisted surgery. Additionally, the student RoboCup@Work team of the university will give an overview of our innovative practical teaching concept and their latest student research activities, e. g. in the fields of localization, navigation, collaboration, object recognition, and mobile manipulation.

Bernardo Wagner's lab

The Real Time Systems Group focuses on the following areas: planning of complex technical systems, modelling and analysis of event-discrete systems with formal methods, software development methods and devices in the automation technology as well as in the programming and testing of embedded, networked control devices under the aspect of real time, reliability and security. The respective applications range from systems automation with industrial, programmable logic controllers to event-discrete (reactive) control of autonomous, mobile robots with embedded micro-controls and real time operating systems like fair guides or autonomous forklifts.

Currently, the RTS research projects can be assigned to the following areas: Mobile Service Robots and Distributed Real-time and Automation Systems. During the visit at RTS newest results from different robotic projects in the area of multi-modal perception (including radar and thermal sensors) and disaster robotics (e.g. EU project SmokeBot) will be shown. We also present HANNA, an autonomous vehicle used during European land robot trials (Best Autonomy Award ELROB 2010).

Lunch at Royal Gardens of Herrenhausen

The second part of the tour will cover the Royal Gardens of Herrenhausen, a world-famous ensemble of garden arts and culture that ranks among the top historical gardens in Europe. On the way from the LUH lab tour towards the manufacturing site of Volkswagen Commercial Vehicles, you will have the unique chance to walk in and explore the royal gardens, while enjoying lunch in this magnificent environment.

Volkswagen Commercial Vehicles

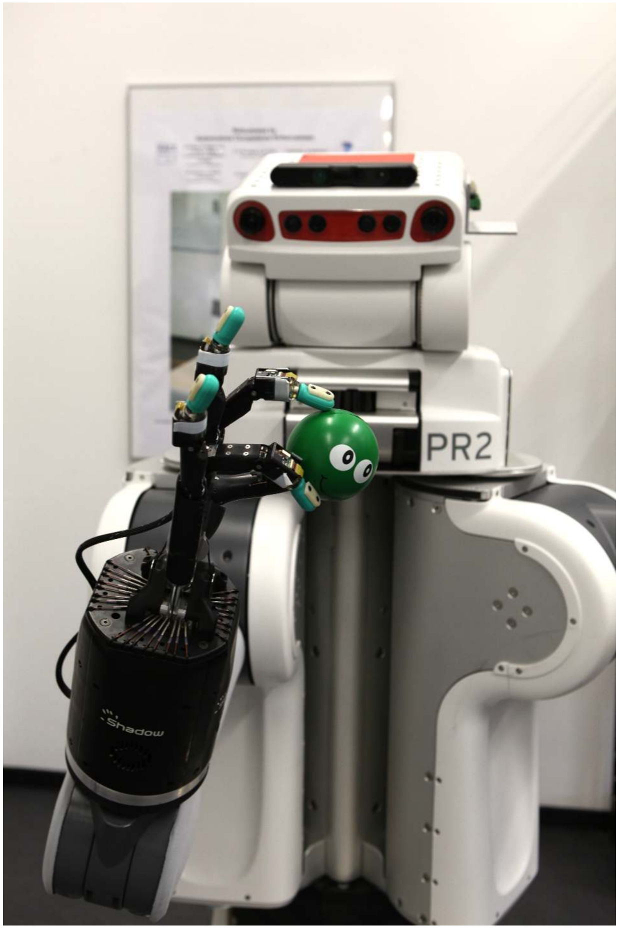
The final part of the tour will cover well-known German automobile manufacturing. The Volkswagen Group with its headquarters in Wolfsburg is one of the world's leading automobile manufacturers and the largest carmaker in Europe. In 2014, the Group increased the number of vehicles delivered to customers to 10.137 million (2013: 9.731 million). We will visit the Volkswagen Commercial Vehicles manufacturing site in Hannover, where among others, the 6th generation of the famous VW Transporter („Bulli") is manufactured.

Tour 5

Hamburg: Lab tour through the University of Hamburg – Robotics in the Department of Informatics

Friday October 2
Booking information and the schedule will be announced at the registration desk

Human Centered Computing

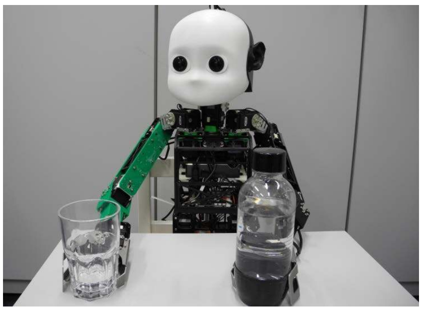


The Human Centered Computing (HCC) cluster of the Department of Informatics consists of four research groups: Technical Aspects of Multimodal Systems (TAMS), Knowledge Technology (KT), Human Computer Interaction (HCI), and Natural Language Systems (NatS). Within HCC, there has long been interest in combining forces and integrating common research interests with the guiding research theme formulated as "Intelligent Systems for Complex Applications and Domains".

Technical Aspects of Multimodal Systems

The *TAMS* group at the University of Hamburg is led by Jianwei Zhang and is dedicated to research in the fields of multimodal sensing and representation, knowledge-based robot control and learning, and robotic systems for mobile manipulation. In addition to its comprehensive experimental facilities, including a PR2 service robot, two Shadow dexterous hands (C5 air muscle and C6 smart motor versions) and several other manipulators, TAMS possesses extensive knowledge of robotic systems designed for dexterous manipulation, e.g., the approach of computing grasp synergies for a dexterous robot hand. Additionally, methods have been added to monitor human motions and gestures used for learning by demonstration.

Knowledge Technology



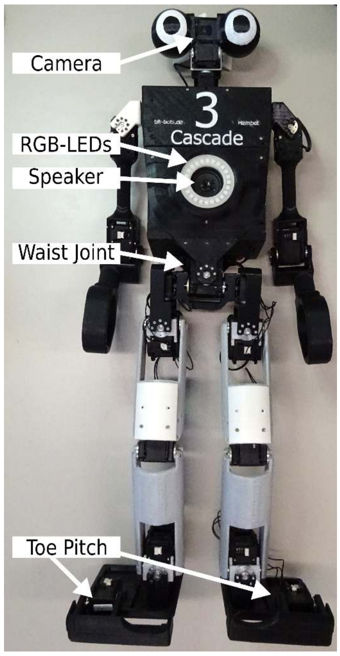
Knowledge Technology unites research areas of computer science with neuroscience, psychology and robotics. The objectives are to develop knowledge technologies for intelligent systems. Therefore nature-inspired, in particular hybrid neural and symbolic representations are studied, to build adaptive neural-evolutionary systems, understanding learning in multimodal neural agents and cognitive robots for human-robot interaction.

Human Computer Interaction

The *Human Computer Interaction* research group explores perceptually-inspired and (super-) natural forms of interaction to seamlessly couple the space where the flat two-dimensional (2D) digital world meets the three dimensions we live in. The mission of the HCI group is to develop user interfaces, which allow users to intuitively experience and interact with three-dimensional (3D) virtual environments (VEs).

In particular, research focuses on different modalities and forms of interaction in immersive virtual environments (IVEs) to support (super-) natural walking, touching, seeing and being, which are addressed in the scope of different research projects.

RoboCup Soccer

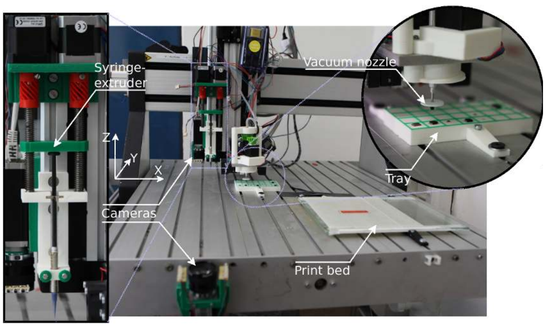


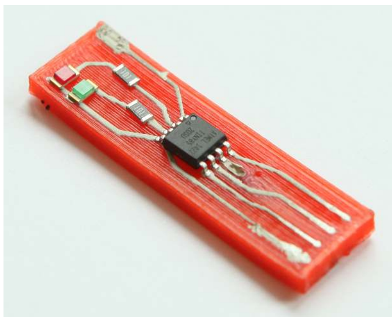
RoboCup is a student-organised workgroup from the Department of Informatics. They work independently, but receive broad support from the HCC research groups.

It was founded in 2011 and works with humanoid robots, "training" them to play soccer. Since 2012 the team "Hamburg Bit-Bots" participates in the Humanoid Kid Size League on national and international level. Besides all challenging algorithmic tasks to be handled when playing soccer, hardware selection and mechanical design of the platform is done as well. The "Hambot" was designed to give teams in the Humanoid League a low-cost possibility to upgrade from the currently used small robots to a larger platform. The whole robot was 3D printed with a consumer printer, thus making production and further development possible for everyone.

3D-Printing Lab

The department offers a *3D-Printing lab*, equipped with numerous 3D-printers and various useful tools for researchers and students. Besides software development for 3D printing, an ongoing research topic is conductive printing. This project aims at the full integration of complex electronic circuits into 3D-printed objects. In the first iteration, a large FDM 3D-printer has been modified to produce conductive traces with a second extruder during the printing process. SMD-components are then placed into the uncured conductive ink by a camera-guided pick and place system to complete the circuit.





Fun Tours

The following sightseeing tours can be booked on-site or via
`http://iros2015.org/index.php/program/fun-tours`

Harbor Cruise — including Warehouse district

Description

The cruise starts and ends at the pier „St Pauli Landungsbrücken". The guide uses a microphone to explain all activities concerning the container handling facilities. The typical Hamburg „Barkasse" (Barge) will pass by the largest container terminals of Hamburg's harbor. Experience one of the biggest harbors in the world during this boat ride on the river Elbe, or sail with us under the romantic bridges in the storage city (depending on the water level).

Travel aboard the agile barges through the port of Hamburg, to the channels of the storage city, and along the container loading stations. You will see the Ellerhof lock-gate system as well as the repair docks, the floating docks, and the dry dock plant Elbe 17 of Blohm+Voss. This is exactly the perfect tour to get to know the inner-workings of the port of Hamburg.

Schedule

September 28, 2015, 10:00–12:00

10:00	Departure from the Congress Center (CCH) and drive through harbour to Landungsbrücken (approx. 15 minutes)
10:15	Harbors cruise incl. cruise through the warehouse district of Hamburg for approx. 90 min
11:45	Return to Congress Center (CCH)

Quick Facts

Price per Person	€41,00
Min / Max	40 / 49 per tour

Alster Lake Cruise

Description

The cruise on the Alster lake and along the Alster-canals presents Hamburg from a totally different point of view: luxurious white villas surround by lush green parks, modern residential buildings, small garden plots and overgrown banks will be passed as the boat glides along the calm waters. The guide will explain all the beautiful highlights of Hamburg around the Alster lake with the use of a microphone.

Just around the corner from the inner city center, you will find yourself in a green oasis. Heading to the city park's lake, you will have an amazing view of the planetarium building. It is a nice alternative to get to know the green side of Hamburg!

Schedule

October 2, 2015, 10:00–12:00

10:00	Departure by coach from the Congress Center (CCH) and drive to the Jungfernstieg (approx. 10 minutes)
10:10	Alster lake and branch cruise for approx. 100 min
11:50	Return to Congress Center (CCH)

Quick Facts

Price per Person	€37,50
Min / Max	40 / 49 per tour

Hamburg City Walk

Description

Experience Hamburg up close and personal and take part in one of our tours around which leads you through the „Most beautiful city in the world".

For every tour that you choose, your group will be accompanied by someone who is familiar with the sights, the scenery and the city in general.

"Why is the Landungsbrücke (Debarkation Bridge) called this?"

"Why is the Reeperbahn also called the most sinful mile in the world?"

"Why does the Hamburg City Hall building look better in terrible weather than in lovely sunshine?"

"What is the Hamburg favorite, the Mö?"

We show you the quirky curiosities and secret tips of the city.

Schedule

October 2, 2015, 15:00–17:00

15:00	Departure directly from the Congress Center (CCH)
	Walking tour through Hamburg approx. 2 hours
17:00	Return to Congress Center (CCH) or individual end in the city center

Quick Facts

Price per Person	€11,90
Min / Max	15 / 20 per group

City Tour by Bike

Description

The tour starts directly at the hotel and is guided by an experienced guide. You can chose between a variety of tours, from the classic „Hamburg sightseeing tour" to the "Außenalster tour“ or the „Nature pure tour“, which will all be a unique experience.

In combination with a professional guide, the tour offers a change to your normal daily routine – hop on the latest bike trend to explore the city!

Schedule

October 2, 2015, 10:00–11:30

10:00	Departure directly from the Congress Center (CCH)
	City tour though Hamburg approx. 90 min
11:30	Return to Congress Center (CCH)

Quick Facts

Price per Person	€11,90
Min / Max	15 / 20 per group

City Tour by Bus — Hop-on / Hop-off

Description

Experience one of the most exciting places in the North! Culture, stage, history, modern architecture, nature, on land and on water: Hamburg has something to offer everyone, no matter your interests! This tour is the most traditional way to get a brief yet thorough understanding of the Hanseatic City of Hamburg.

The Line A route will bring you to all the familiar highlights of Hamburg, along the Speichernstadt, through the HafenCity and to the shopping mile of the city! Experience the splendid Villas in the Harvestehude region of Hamburg, the Außenalter (the larger of the two man-made lakes in Hamburg), the city hall, a multitude of meseums, the well-known Reeperbahn and the breath-taking Harbor backdrop. This tour will give you the best overview of Hamburg!

Schedule

Every Day

Departure directly from Hotel Radisson Blu (see map)
City tour through Hamburg approx. 95 min
Return to Hotel Radisson Blu or individual end in the city center

Quick Facts

Price per Person   €19,00

Bus schedule – Radisson Blue

Monday – Thursday							
10:26	10:46	11:26	11:46	12:26	12:46	13:26	13:46
14:26	14:46	15:26	15:46	16:26	16:46		
Friday, Saturday, Sunday, Bank Holiday							
09:56	10:16	10:26	10:46	10:56	11:16	11:26	11:46
11:56	12:16	12:26	12:46	12:56	13:16	13:26	13:46
13:56	14:16	14:26	14:46	14:56	15:16	15:26	15:46
15:56	16:16	16:26	16:46				

Around Hamburg

In case you have a day to spare, several touristic highlights in Northern Germany are within easy reach from Hamburg, either by public transport or with a rented car.

Lübeck

Just one hour by train from Hamburg, the Hanseatic City of Lübeck is famous (and UNESCO World Heritage site) for its unique historic town center that has kept its medieval appearance with old buildings and narrow streets. The town is dominated by seven church steeples, where the twin-towers of the Lübecker Dom (the city's cathedral) and the Marienkriche (St. Mary's) mark masterpieces of Brick Gothic architecture. In addition to the churches of St. Peter, St. Jacob, and St. Aegidien, the Gothic town hall and two of the old town gates (Holstentor and Burgtor) remain, as well as the hospital of the Holy Spirit and the Salzspeicher medieval warehouses.

Berlin

A two-hour train ride from Hamburg Central Station brings you to Berlin, the largest city in Germany and the undisputed capital of reunified Germany (see also Technical Tour 2). Visit places of historical and political interest, including Reichstag with the spectacular glass dome (visit requires online registration via `bundestag.de`), Brandenburger Tor, Checkpoint Charlie, and the remains of the Berlin wall.

Apart from fantastic landmarks like Gendarmenmarkt or Charlottenburg palace, the world-class museums on the museum island in the city centre avait your visit: Pergamon museum, New Museum including the Egyptian collection (queen Nefertiti bust), Old Museum with its collection of Greek and Roman sculptures, and the German National Gallery.
Just outside Berlin, the park of Sanssouci forms another World Heritage Site in Germany, including several palaces (Sanssouci, Orangerie, New Palace, Charlottenhof, Chinese Tea House), with Cecilienhof palace, the site of the 1945 Potsdam Conference.

Bremen

The old town of the Hanseatic City of Bremen (see also Technical Tour 1) is another touristic highlight, also listed as UNESCO World Heritage. The Marktplatz ensemble (Market square) includes the Renaissance Town Hall, Roland statue, the Schüttling Flemish-inspired guild hall, St. Peter's Cathedral, and Liebfrauenkirche (Our Lady's Church). Just south of the Market square, the Böttcherstraße is a rare example of Art Nouveau architecture. Other sights include the Universum Science Center and several museums.

Lunch Information

Street Food at the CCH

In front of the CCH you will find a set of varying Food Trucks serving “Slow-Food”, the high-quality alternative to everyday Fast-Food. Food Trucks are becoming more and more popular as they serve healthy and tasteful food and switch their selling point every day.

From Monday, September 28, until Friday, October 2, various Food Trucks will offer their products from all over the world. Food offered will include:

European food German *Bratwurst* and *Currywurst*; Polish specialties; local food; curd cheese with fruits; marinated meat on sticks

American food Premium Hot Dogs; Hamburgers; Pulled Meat sandwiches

Middle-American food Burritos; Mexican street food

Asian food Vietnamese Banh-mi sandwiches

A highlight is the typical north-German specialty *Fischbrötchen*, which will be offered on Wednesday and Thursday. Freshly caught, the fish is eaten pure, smoked or marinated in a freshly baked bread roll. The *Brücke 10*, which you can also find on the *Landungsbrücken* at the harbor, offer some of the best bread rolls with fish in town. The *Fischbrötchen* can be a quick snack in between or a healthy lunch.

Award Lunch

On Thursday, October 1, the award ceremony will be held during the lunch break. In order to give every participant the opportunity to attend the ceremony, lunch boxes will be given out on-site in the foyer of Hall 2, starting at 12:15. Additionally, the *Fischbrötchen*-Truck will be available for a quick snack outside.

Eating at the Dammtor train station

The Dammtor train station has a few fast food restaurants depending on the cuisine preferred. Here is a list with their opening times:

	Monday – Friday
Le Crobag (Bakery)	05:30–20:00
McDonald’s	06:00–01:00
Mr. Clou (Salad, Wraps, Juices)	06:00–20:30
AsiaHung (Asian/Chinese)	08:00–21:00
Starbucks	06:00–20:30
Dunkin’ Donuts	07:00–20:00
Bäckerei H. von Allwörden (Bakery)	06:00–19:00

Dinner Information

Colonnaden

The Colonnaden is one of the oldest pedestrian streets in Hamburg. A magnificent architecture and many glamourous shops adorn it. The architecture of the street is well worth seeing, many grand houses with Neo-Renaissance façades from the founding period are still intact. The arcades with their Venetian flair are the street's highlight. Exquisite shops offering fine teas, selected literature and handcrafted china tempt the visitor into spending hours inside the marble halls next to the water. The Colonnaden connects the Jungfernstieg with the Stephansplatz and Dammtorbahnhof that lies behind it. Another beautiful access to the Colonnaden is from the Gänsemarkt through the Gänsemarkt-Passage, where the junction forms a sort of a piazza. Near the huge Hamburg Opera House, you can take a break in one of the many cafés and coffee shops. From here it is only a few steps to Neuen Jungfernstieg and to the Binnenalster.

Surrounding Environment

The Colonnaden lies directly at the Jungfernstieg, which is Hamburg's most stylish promenade. Jungfernstieg also provides a beautiful view of the Alster lake, where after a tiring day, you can buy a drink or an ice-cream and relax at the lake, taking in the magnificent views. There are boat trips around the Inner and Outer Alster. You can also walk around the lake taking in its scenic views. Right at Jungfernstieg, the five-decked Europa Passage is the largest shopping centre in Hamburg's inner city. In addition to being a home to many of the world's biggest brands, various events are often held there. Many stores organize events, for example piano and guitar concerts, crash courses in jewellery designing and experimental acrylic painting. The Europa Passage also connects Jungfernstieg to Mönckebergstraße, which is the oldest shopping district in Hamburg.

Gastronomy

In the Colonnaden there are many restaurants and cafés. The variety of cuisines includes Italian (le pergola due colonnaden), Bavarian (Franziskaner), Portuguese (Pastelaria Caravela) and Japanese (Matsumi) to name just a few. Also popular are the many coffee shops, like Balzac-Coffee. The surrounding areas of Jungfernstieg are home to many restaurants. The oldest house on the square is the Alsterpavillon. Café Alex, right at the Alster, serves its customers salads, pasta, burgers, schnitzel, baguettes and wraps. The Alsterhaus offers great food choices at LeBuffet, or enjoy a snack on the terrace of the luxurious Vier Jahreszeiten hotel.

The *Bocksbeutel* is a charming wine bar in the middle of the Colonnaden, serving and selling excellent Franconian wines from 11:30 to 21:00. Finish off the evening with a delicious German wine or take home a bottle as a gift.

For those seeking coffee, in between there is a Starbucks coffeehouse or the bakery DAT BACKHUS. For burger and steak enthusiasts, Jungfernstieg has Jim Block and Block House.

How to get there

The Colonnaden can be reached on foot in about 10 minutes from the CCH. The Alster, Jungfernstieg and Europa Passage areas are also adjacent to each other and can be reached from Colonnaden within 5 minutes by foot. The public transport lines that connect to these places are:

- U2 — Exit at Gänsemarkt
- U1 — Exit at Stephansplatz
- U1, U2, S1, S2, S3 — Exit at Jungfernstieg

Landungsbrücken

Landungsbrücken is the beautiful port of Hamburg, situated on the Elbe river. Two towers with striking green domes characterize the 205-meter long terminal building at the jetties. One of the towers not only gives the time, but also updates on the water level of the North Elbe. The bell rings every half hour. Guests with a HVV ticket can take the "Fähre 62" ferry from "Brücke 3 (Bridge 3)".

The ferry starts every 15 minutes and goes along and across the Elbe and finally returns to Landungsbrücken after an hour. Guests can take in the lush beauty of the banks of the Elbe, the beach, a sight of the posh localities of Hamburg and finally the industrial area. At the ferry station "Dockland", guests can climb the ship-shaped building and get a brilliant scenic view of the entire industrial port area and the city of Hamburg.

Note: The last ferry from Landungsbrücken departs at 23:15 and this ferry does not return to Landungsbrücken.

Surrounding Environment

Flowing through Hamburg, the Elbe river connects the city of Hamburg to the North Sea. There are numerous ways to explore, including sightseeing boat tours and casual strolls along the banks of the river. When you walks to the left of Landungsbrücken while facing the river, you will reach the “Warehouse district”, “HafenCity”, the “Speicherstadt”, and the dramatic Elbphilharmonie building. All these form a significant part of the port of Hamburg. Whether it is the historical warehouse complex in Speicherstadt, or the currently under-construction Elbe Philharmonic Hall, or even the large passenger cruise ships in the docks, there is a lot to explore in the HafenCity quarter, located right on the river Elbe. While the Speicherstadt has long shaped Hamburg’s cityscape with its brick, neo-Gothic architecture, the new development area of HafenCity sits directly on the banks of the Elbe with an array of more modern designs.

Currently, HafenCity is the largest development project in Europe, and its figurehead is the Elbe Philharmonic Hall. Many eye-catching architectural buildings are already completed in HafenCity, particularly the Unilever building with its futuristic facade looking out directly onto the harbour, as well as the high-reaching Marco Polo Tower with its terraces at the front providing an excellent place to relax in the sun. Other places to explore include the “Magellan-Terrassen” and the “Vasco da Gama Platz”. Many places in the HafenCity were given international names due to Hamburg’s cosmopolitan nature. Another example one can find is the Shanghai bridge, which is a good point to admire the canals.

For a visit with an eye on the past, have a look around the Speicherstadt. The listed buildings now house leisure activities such as the Minatur Wunderland with fascinating toy railway worlds, and Hamburg Dungeon. In this attraction visitors take a ghostly journey through the metropolis’s history. Museums can also be found in the Speicherstadt. There is German Customs Museum (Deutsche Zollmuseum), which tells the tale of customs and smuggling in Hamburg, or the International Maritime Museum with thousands of ship models and nautical charts.

Gastronomy

Between Landungsbrücken and Venusberg stretches the Portugese quarter and gives Hamburg a high density of Portuguese Restaurants. In the summer, tables and benches are placed outside and the hustle and bustle on the streets create a Mediterranean holiday atmosphere. You will have a great time enjoying delicious food like fresh fish, paella, tapas or just a Galao. Right in the middle of the Portuguese quarter, on Reimarusstraße, is the Casa del Sabor. Classic dishes and tapas are the regulars at the small but tasty restaurant. The quality of food is consistently good and also an excellent choice for non-fish eaters. Or enjoy a giant seafood salad in the Restaurant Don José on Ditmar-Koel-Straße, in addition to a high-quality food. The staff is warm and accommodating. A special feature here is that the guest taps his beer himself. For a more traditional meal, with a simple decor and a relaxed atmosphere, you can feast on excellent Portuguese dishes at fair prices in Churrascaria O Frango on the Reimarusstraße. The Restaurante Porto has been around since 1984 in the Portuguese quarter, offering its guests authentic Portuguese cuisine. Located directly on the lively Ditmar-Koel-Strasse, you can feel the hospitality of a family business and enjoy classic Portuguese dishes.

How to get there

The public transport lines that connect to these places are:

- U3 — Exit at Landungsbrücken
- S1, S3 — Exit at Landungsbrücken

Sternschanze

Sternschanze or “Schanzenviertel” is Hamburg’s hip trendy area, boasting many small boutiques, restaurants, cafes and a party area with a unique charm. In recent years, the district has undergone many changes and renovations. The streets Schulterblatt, Schanzenstraße, Susannenstraße und Bartelsstraße form the center of the pop cultural district, with record stores, boutiques for browsing, pubs and cozy cafes inviting you to relax.

Surrounding Environment

The Schanzenpark is a popular recreational meeting place for the young and the old. In the middle of the park looms the imposing Schanzen Tower. It was completed in 1910 and served as the largest water tower in Europe until 1961. In 2005, the 60 meter high building was converted to the Mövenpick Hotel Hamburg. The Reeperbahn, Hamburg’s red-light and entertainment district and the district with many restaurants, bars, theatres and nightclubs, is about 15 minutes with the U3. In the 1960’s the Reeperbahn became a mecca for rock music with its “Große Freiheit” area. Everybody from the Beatles to the Searchers was performing in clubs like “Top Ten” or the “Starclub”. Grosse Freiheit branches just off the Reeperbahn. Here the Beatles had their first appearance on German soil in Club Indra. One can trace the Beatles’ footsteps to the Kaiserkeller, which is still running, as well as the site of the now-closed Star Club, where a plaque commemorates the venue. Beatles-Platz, a tribute to the band, is a circular plaza, painted black and modeled on a vinyl record. Both this and a sculpture of the band’s early members are located not too far from ’Beatlemania’, a dedicated Beatles museum.

Gastronomy

Sternschanze is jam-packed with cafes, bars and restaurants. One can find food and drinks to one's taste easily, when discovering this area.

How to get there

- U3 — Exit at Sternschanze
- S21, S31 — Exit at Sternschanze (Messe)

Grindel

The Grindel area is where the University of Hamburg is located. The Grindel district is also home to many restaurants, parks, theaters, handcraft shops and museums.

Surrounding Environment

You will find the main building of the University of Hamburg near the Dammtor railway station not far from the main campus with the "State and University Library Hamburg Carl von Ossietzky", the lecture hall and several other educational buildings. On the other side of Grindelallee more University buildings are grouped around the Martin-Luther-King-Platz. The conclusion of the University in the West is the Geomatikum near the underground station Schlump and the Zoological Museum. In the Schlüterstraße, on the eastern side of the University is the Post Office 13, the former Foreign Exchange Department of the City. Near the Schlüterstraße is Joseph-Carlebach-Platz where one can find the Synagogue Memorial. Finally, at the end of Grindelallee you will find the Grindelhochhäuser at Hallerstrasse 1, which was initially planned as the headquarters of the British occupation forces. Some of the most famous theaters in Hamburg are located here. The Abaton theater is considered the first cinema in Germany. In addition, the Grindel district is home to the Hamburger Kammerspiele (a theater), the Zoological Museum and the Mineralogical Museum of the University.

Gastronomy

The Grindelallee sports many international restaurants. You can find Indian, Pakistani, Turkish, Chinese, Thai, fast food and other cuisines very easily.

How to get there

Located north-west of Dammtor railway station / CCH, the Grindel district can be easily explored by foot. Additionally the bus lines "M4" in direction "Eidelstedt / Wildacker" or "M5" in direction "Lokstedt / A Burgwedel" can be used to explore the area. One can exit at the stop "Universität/Staatsbibliothek" or at "Grindelhof".

- M4, M5 — Exit at Universität/Staatsbibliothek or Grindelhof

Sponsors

Platinum++

www.kuka.com

Gold

www.dji.com

www.rethinkrobotics.com

Silver

www.bosch.com

english.siat.cas.cn

www.boozhong.com

Bronze

www.mobilerobots.com

www.automatica-munich.com

www.hit.edu.cn

www.asctec.de

www.optoforce.com

www.dstrobot.com

www.basystemes.com/en

www.rainbow-robot.com

www.sia.cas.cn

www.clearpathrobotics.com

www.nccr-robotics.ch

www.dyson.co.uk

www.sick.com

www.roboception.de

www.forcedimension.com

www.smokierobotics.com

www.lyusp.com

www.fzu.edu.cn

www.synapticon.com

www.huawei.com

www.google.com

www.ics.ei.tum.de

www.zjrob.com

www.irobot.com

www.echord.eu

www.redone-technologies.com

www.kustar.ac.ae

www.pan-robots.eu

www.festo.de

www.kinovarobotics.com

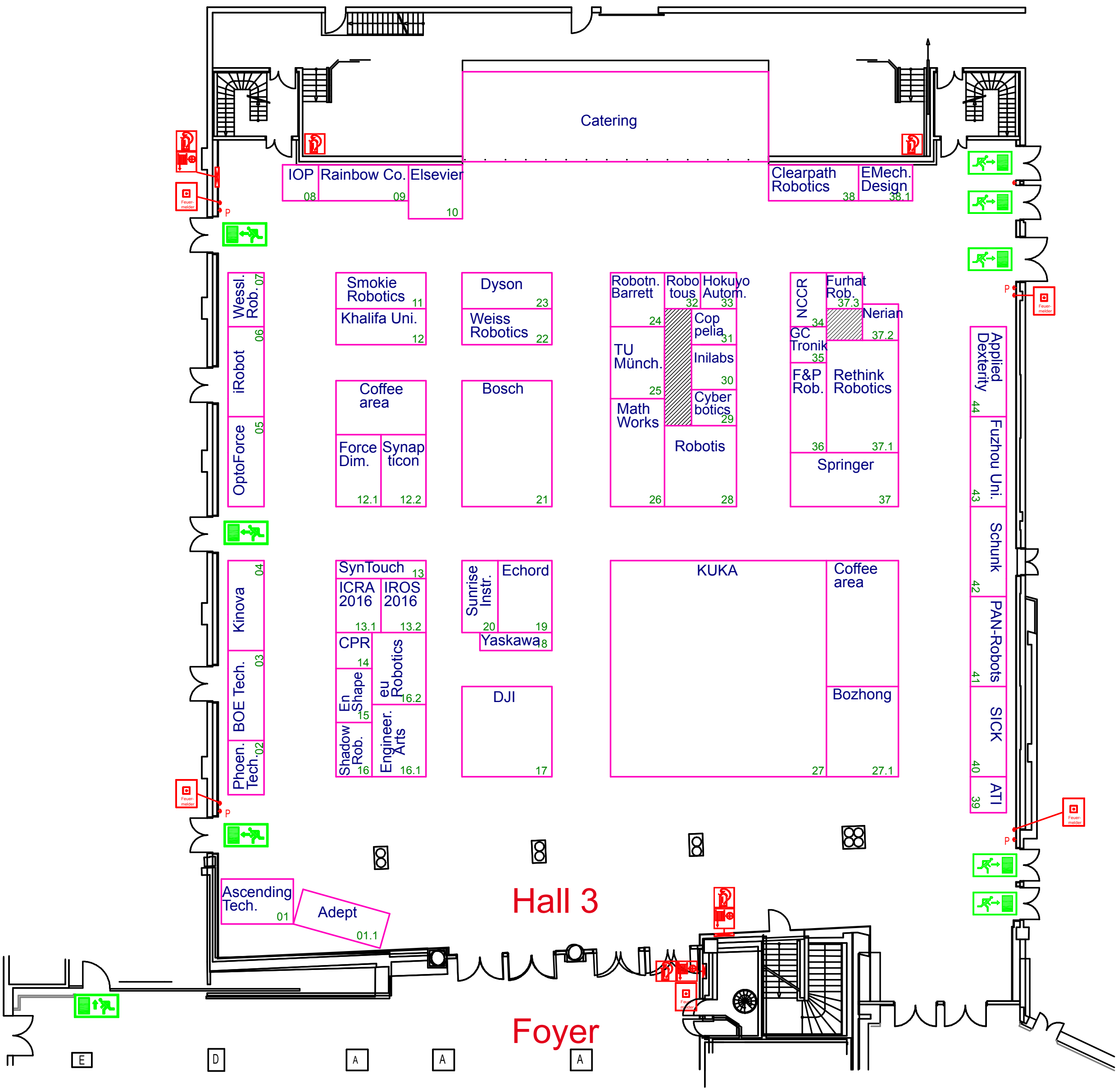
www.schunk.com

Exhibitors

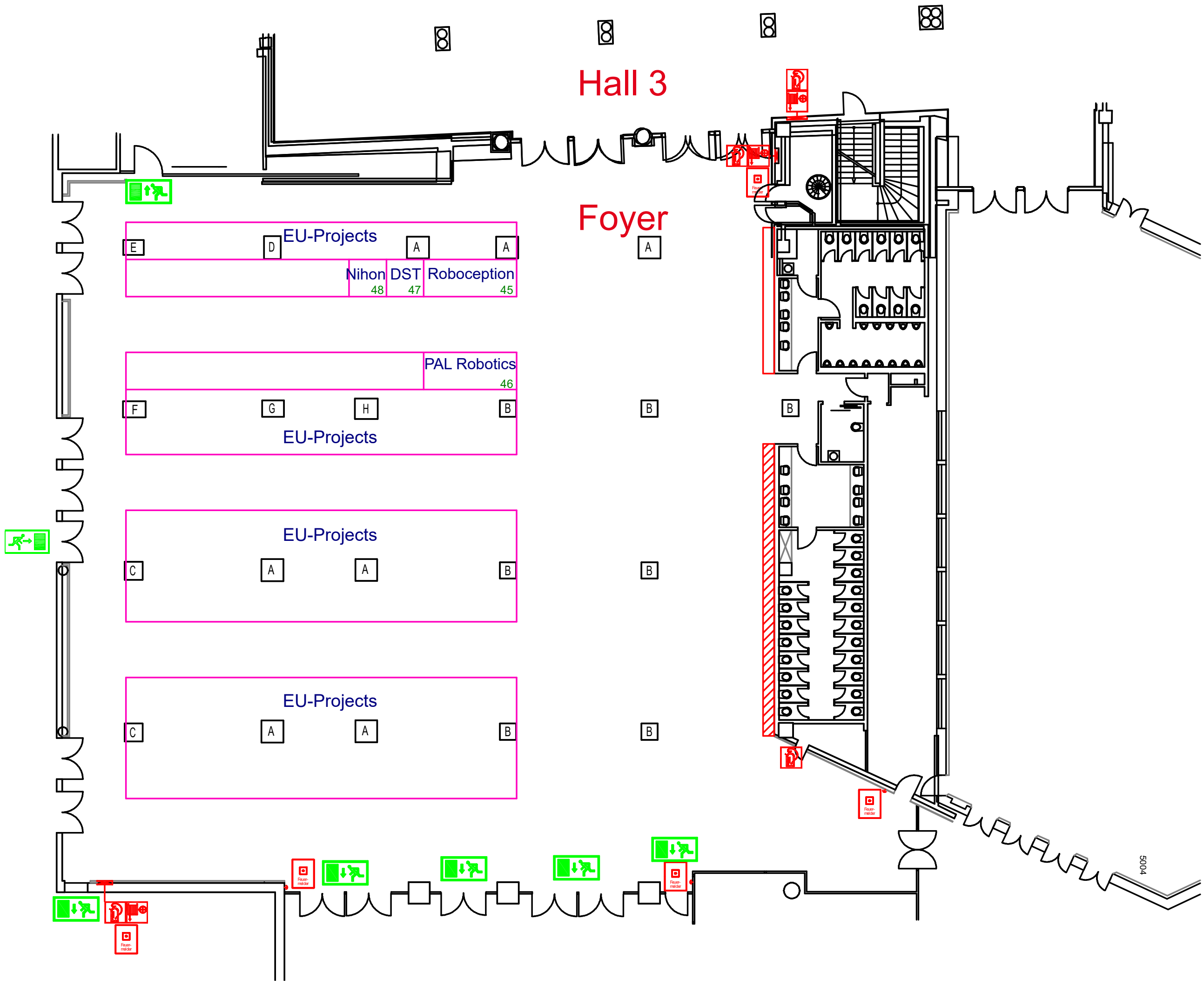
	Company	Website
A	Adept Mobile Robots	www.mobilerobots.com
	Applied Dexterity	www.applieddexterity.com
	Ascending Technologies	www.asctec.de
	ATI Industrial Automation	www.ati-ia.com
B	BOE Technology Group Co. Ltd.	www.boe.com.cn
	Bosch	www.bosch.com
	Bozhong (Suzhou) Precision Industry	www.boozhong.com
C	Clearpath Robotics Inc.	www.clearpathrobotics.com
	Common Place Robotics GmbH	www.cpr-robots.com
	Coppelia Robotics	www.coppeliarobotics.com
	Cyberbotics	www.cyberbotics.com
D	DJI	www.dji.com
	DST Robot	www.dstrobot.com
	Dyson Ltd.	www.dyson.co.uk
E	ECHORD++	www.echord.eu
	Elsevier	www.elsevier.com/computerscience
	Engineered Arts Ltd.	www.engineeredarts.co.uk
	EnShape GmbH	www.enshape.de
	euRobotics	www.eu-robotics.net
F	F&P Robotics	www.fp-robotics.com
	Force Dimension	www.forcedimension.com
	Furhat Robotics	www.furhatrobotics.com
	Fuzhou University	www.fzu.edu.cn
G	GCTronic	www.gctronic.com
H	Harmonic Drive AG	www.harmonicdrive.de
	Hokuyo Automatic Co. Ltd.	www.hokuyo-aut.jp
I	ICRA 2016	www.icra2016.org
	Inilabs	www.inilabs.com
	Institute of Electromechanical Design	www.emk.tu-darmstadt.de
	IOP Publishing	www.ioppublishing.org
	iRobot	www.irobot.com
	IROS 2016	www.iros2016.org
K	Khalifa University	www.kustar.ac.ae
	Kinova	www.kinovarobotics.com
	KUKA	www.kuka.com
M	MathWorks	www.mathworks.com

N	NCCR Robotics	www.nccr-robotics.ch
	Nerian Vision Technologies	www.nerian.com
	Nihon Binary Co. Ltd.	www.nihonbinary.co.jp
O	OptoForce Ltd.	www.optoforce.com
P	PAL Robotics	www.pal-robotics.com/en
	PAN-Robots Project	www.pan-robots.eu
	Phoenix Technologies Inc.	www.ptiphoenix.com
R	Rainbow Co.	www.rainbow-robot.com
	Rethink Robotics	www.rethinkrobotics.com
	Roboception GmbH	www.roboception.de
	Robotis Co. Ltd.	www.robotis.com
	Robotnik / Barrett	www.robotnik.eu
	Robotous Inc.	www.robotous.com
S	Schunk GmbH & Co. KG	www.schunk.com
	Shadow Robot Company	www.shadowrobot.com
	SICK AG	www.sick.com
	Smokie Robotics Inc.	www.smokierobotics.com
	Springer Verlag GmbH	www.springer.com
	Sunrise Instruments	www.srisensor.com
	Synapticon GmbH	www.synapticon.com
	SynTouch LLC.	www.syntouchllc.com
T	TU München; ICS	www.ics.ei.tum.de
W	Weiss Robotics GmbH & Co. KG	www.weiss-robotics.de
	Wessling Robotics	www.wessling-robotics.com
Y	YASKAWA Electric Corporation	www.yaskawa.co.jp

Exhibition Map – Hall 3



Exhibition Map – Foyer



	EU Projects	Website
A	ACAT	www.acat-project.eu
	ACTIVE	www.active-fp7.eu
	ARCAS & AEROWORKS	www.arcas-project.eu & www.aeroworks2020.eu
C	CASCADE	www.cascade-fp7.eu
	CENTAURO	www.centauro-project.eu
	CORBYS	www.corbys.eu
D	DLR HASY	www.dlr.de/rm
E	EARS	www.ears-project.eu
	EURATHLON	www.eurathlon.eu
	EUREYECASE	www.eureyecase.eu
	EuRoC	www.euroc-project.eu
F	FLOBOT	www.flobot.eu
	Flourish	
	Futura	www.futuraproject.eu
I	iCub (Koroibot / CODYCO / Tacman / Xperience)	www.icub.org (orb.iwr.uni-heidelberg.de/koroibot / codyco.eu / tacman.eu / xperience.org)
	I-SUR	www.isur.eu
M	MOnarCH	www.monarch-fp7.eu
P	PETROBOT	www.petrobotproject.eu
	POETICON++	www.poeticon.eu
R	RECONFIG	www.reconfig.eu
	REMEDI	www.remedi-project.eu
	RoboHow.Cog	www.robohow.eu
	ROBO-SPECT	www.robo-spect.eu
	RoCKIn	www.rockinrobotchallenge.eu
S	SAPHARI & SOMA	www.saphari.eu & www.softmanipulation.eu
	SHERPA	www.sherpa-project.eu
	SMErobotics	www.smerobotics.org
	SQUIRREL	www.squirrel-project.eu
	STIFF-FLOP	www.stiff-flop.eu
	SWEEPER	www.sweeper-robot.eu
T	TERESA	www.teresaproject.eu
	TRADR	www.tradr-project.eu
U	μRALP	www.microralp.eu
V	V-Charge	www.v-charge.eu
	VINEROBOT	www.vinerobot.eu
W	Walk-MAN	www.walk-man.eu
	WEARHAP	www.wearhap.eu
	WiMUST	www.wimust.eu
	WYSIWYD	www.wysiwyd.upf.edu
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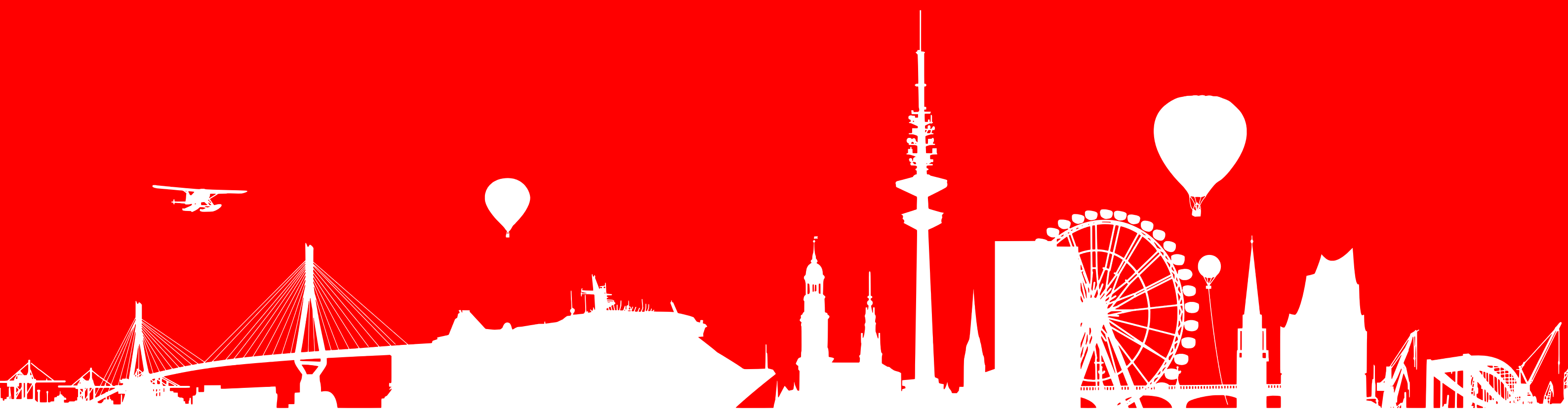
Technical Program



Plenary Talks

Practice makes Perfect? The Role of Place Dependent Expertise in Mobile Robotics

Paul Newman
Mobile Robotics Group
University of Oxford
Tuesday, September 29, 10:30–11:15
Hall 2

Abstract

Is it worth considering trading everywhere generality (mediocrity) for local, place specific excellence? This talk will make the case, that for some use-cases, the answer is "yes, we really should". If your robot is mobile but only in a local area then we might think of imbuing that machine with competencies that explicitly over-fit to its own workspace. This policy of learning to become the local expert forces us to think about learning spatially and temporally varying feature detectors, bespoke classifiers, rich temporally indexed visual models and even place dependent controllers. This talk will discuss how such competencies, wrapped up in a life long learning framework, can contribute to a delightful increase in performance in the place of work. Isn't that, sometimes, exactly what we want?

Biography

Paul Newman is the BP Professor of Information Engineering at the University of Oxford and an EPSRC Leadership Fellow. He heads and founded the Mobile Robotics Group within the Department of Engineering Science which has developed a strong reputation in mobile autonomy - developing machines and robots which map, navigate through, and understand their environments. His focus lies on pushing the boundaries of navigation and autonomy techniques in terms of both endurance and scale. He enjoys collaborations with many industrial partners which provide exploitation opportunities to drive the research. The group has developed a keen focus on intelligent transport.

He obtained an M.Eng. in Engineering Science from Oxford University, Balliol College in 1995. He then undertook a Ph.D. in autonomous navigation at the Australian Center for Field Robotics, University of Sydney, Australia. In 1999 he returned to the United Kingdom to work in the commercial sub-sea navigation industry. In late 2000 he joined the Dept of Ocean Engineering at M.I.T. where as a post-doc and later a research scientist, he worked on algorithms and software for robust autonomous navigation for both land and sub-sea agents. In early 2003 he returned to Oxford as a Departmental Lecturer in Engineering Science before being appointed to a University Lectureship in Information Engineering and becoming a Fellow of New College in 2005, Professor of Engineering Science in 2010 and BP Professor of Information Engineering and Fellow of Keble College in 2012. He was elected Fellow of the Royal Academy of Engineering and the IEEE in 2014 for contributions to robot navigation. He likes things to know where they are.

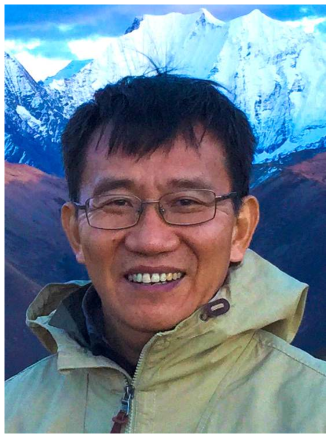
The New Robotics Age: The Challenge of Physical Tasks
Oussama Khatib
Artificial Intelligence Laboratory
Stanford University
Tuesday, September 29, 16:00–16:45
Hall 2

Abstract

The generation of robots now being developed will increasingly touch people and their lives. They will explore, work, and interact with humans in their homes, workplaces, in new production systems, and in challenging field domains. The emerging robots will provide increased operational support in mining, underwater, and in hostile and dangerous environments. While full autonomy for the performance of advanced tasks in complex environments remains challenging, strategic intervention of a human will tremendously facilitate reliable real-time robot operations. Human-robot synergy benefits from combining the experience and cognitive abilities of the human with the strength, dependability, competence, reach, and endurance of robots. Moving beyond conventional teleoperation, the new paradigm – placing the human at the highest level of task abstraction – relies on robots with the requisite physical skills for advanced task behavior capabilities. Such connecting of humans to increasingly competent robots will fuel a wide range of new robotic applications in places where they have never gone before. This discussion focuses on robot design concepts, robot control architectures, and advanced task primitives and control strategies that bring human modeling and skill understanding to the development of safe, easy-to-use, and competent robotic systems. The presentation will highlight these developments in the context of a novel underwater robot, Ocean One, called O2, developed at Stanford in collaboration with Google Robotics, and KAUST.

Biography

Oussama Khatib received his PhD from Sup'Aero, Toulouse, France, in 1980. He is Professor of Computer Science at Stanford University. His research focuses on methodologies and technologies in human-centered robotics including humanoid control architectures, human motion synthesis, interactive dynamic simulation, haptics, and human-friendly robot design. He is a Fellow of IEEE. He is Co-Editor of the Springer Tracts in Advanced Robotics (STAR) series and the Springer Handbook of Robotics, which received the PROSE Award for Excellence in Physical Sciences & Mathematics. Professor Khatib is the President of the International Foundation of Robotics Research (IFRR). He has been the recipient of numerous awards, including the IEEE RAS Pioneer Award in Robotics and Automation, the IEEE RAS George Saridis Leadership Award in Robotics and Automation, the IEEE RAS Distinguished Service Award, and the Japan Robot Association (JARA) Award in Research and Development.



From Geometry to Startups and to . . . Incubators

Zexiang Li
Robotics Institute
Hong Kong University of Science and Technology
Wednesday, September 30, 10:30–11:15
Hall 2

Abstract

Studies of a robotic system or a manufacturing research problem start usually with modeling the underlying configuration space and then use properties of the space for analysis and/or synthesis/design/control of the system or the problem. Traditionally, local (Euclidean) properties of the spaces and calculus on R^n are been used for these studies. More than 30 years ago, Roger Brockett introduced Lie group theory for global studies of robot kinematics. This effort was continued and expanded by Sastry's group at Berkeley and a number of other prominent researchers in the robotics community. In this talk, I will present major achievements and progresses of this research program.

First, I will review the basic concepts of differentiable manifolds and Lie group theory and then show how (unified) geometric models can be developed for robotic systems such as rigid body motion, open-chain and closed-chain manipulators, multi-fingered hand grasping and manipulation, bio-mechanic systems and robot calibration, and for manufacturing research problems such as workpiece localization and tolerancing formulation and verification. Finally, I will highlight how geometric properties of the modeling spaces and the corresponding calculus tools can be exploited for more efficient solutions of the underlying optimization problems.

From a different perspective, I will describe a few other innovations we introduced into our curriculum program that filled in the missing gap for commercialization of our research. Over the last 15 years or so, several startups, including Googol Technology, a leading motion control company in China, DJI,a global leader in drones products and Lie Group Automation (or QKM), a provider of innovative robot solutions to the massive C^3 (Computers, Communication and Consumer products) manufacturing industry in China, have spun off from my lab. Burrowing from L. Page's words, I credit this effort to "Geometry as inspiration".

Rapid prototyping and fast scaling ups are essential for any robotic startups to succeed. We benefited greatly from the amazing manufacturing eco-system of the Pearl River Delta (PRD) region (also known as the Hollywood of Makers) and believe that this resource is also sought-after by robotic startups elsewhere. We established the Songshan Lake Robotic Startup Facility (SSL RSF) at the heart of the PRD region to assist entrepreneurs of our community. I will highlight some key features of the SSL RSF.

Biography

Zexiang Li attended the South-Central University in 1978, received his BS (with honor) degrees in Electrical Engineering and Economics from Carnegie-Mellon University in 1983, his

MS degree in EECS in 1985, MA in mathematics and PhD in EECS in 1989, all from the University of California at Berkeley. He worked at ALCOA, the Robotics Institute of CMU and the AI Lab of MIT (89-90). He was an assistant professor at the Courant Institute of New York University (90-92). In 1992, he joined the Department of Electronic and Computer Engineering of the Hong Kong University of Science and Technology and is currently a professor of the department. He founded the Automation Technology Center (ATC) and the Robotics Institute (RI) of HKUST.

Zexiang Li received the ALCOA Foundation Fellowship in 1979, and the E. Anthony Fellowship in 1983. He was a recipient of the University Scholar award from CMU in 1983, the E.I. Jury award from UC Berkeley in 1989, the Research Initiation award from NSF (US) in 1990, the Outstanding Young Researcher award (Class B) from NSF China in 2000, the LEAD award from AMI, USA in 2001, and the Natural Science award (3rd class) from China in 1997. He became an IEEE Fellow in 2008.

Zexiang Li served as a panel member of the Hong Kong Research Grants Council (RGC), an overseas member of the Natural Science Foundation of China (NSFC), and an associate editor for the IEEE Trans. on Robotics and Automation. He was the general Chair for the 2011 IEEE International Conference on Robotics and Automation (ICRA).

Zexiang Li's research areas of interests include multifingered robotic hand, parallel manipulators, workpiece localization and inspection, motion control, precision assembly, and unmanned aerial vehicles (UAVs). He is the author of more than 100 journal and conference papers, and four books, including A Mathematical Introduction to Robotic Manipulation (CRC Press 1993), and Nonholonomic Motion Planning (Kluwer 1994).

Zexiang Li co-founded several companies with his colleagues and students from the Automation Technology Center, including Googol Technology, a leading motion control company in China, DJI, a global leader in drones products, Lie Group Automation (or QKM), ePropulsion, the Songshan Lake Robotic Startup Facility (SSL RSF) and the Clearwater Bay Venture Capital.

Robotic Governance: Paving the Way for Generation 'R'

Bernd Liepert
Chief Innovation Officer
KUKA AG
Wednesday, September 30, 16:00–16:45
Hall 2

Abstract

Guidelines and frameworks for a generation of robotic natives

Robotics will change the world! It will unleash at least the same disruptive and transformational power within the next 50 years as mainstream IT-technology and the Internet have in the last half of a decade.

This will not only apply to the steadily growing field of industrial robotics. Driven by a number of technological enablers, e.g. the broad availability of low cost but high performance sensor technologies, robotics will be unchained and liberated from its cells. It will conquer completely new domains until it permeates all areas of life, pervading all parts of the human experience realm.

The first seal has already been broken: establishing and fostering sensitive and safe robotics, the foundations for cooperative robotic systems and human-machine-interaction have been laid. In the past, robots were surrounded by heavy safety cages, locking humans out and machines in; these borders have now been obliterated for the first time. Workers can directly interact with automation systems as if they were colleagues.

Starting in the industrial domain, robots will enhance and augment human capabilities more and more over the years. This will help to solve some of mankind's biggest challenges of the next century, e.g., over-ageing of societies driven by demographic change and a hyperbolic growth in demand for products.

New markets will emerge due to the augmented demand resulting from exuberant worldwide population growth.

As the required technologies become available over time, the pervasion and assimilation of robotics in all fields and domains of the living environment will follow phases similar to those of the progression of mainstream IT-technologies, including the internet: Systems became smaller, mobile, ubiquitous and then even pervasive.

Nurtured and enabled by the technological breakthroughs in industrial automation, robotics will permeate other domains. In this near-future world, where robotic systems have become a commodity and facilitate peoples' lives, a new generation will grow up in a society that is enriched and augmented by robotics in every imaginable way. Robotics will be tailored into many everyday objects, becoming an integral part of all kinds of appliances.

This *Generation Robotics* will not be intimidated by direct interaction with any form of robotic and automated system. Self-driving cars, autonomous service robots, automatized logistics

and robotics in retail will be perceived as just as normal as the internet, smartphones and tablets are today.

Surely, this change will not happen by tomorrow, but I strongly believe that the children of our children will grow up as *Robotic Natives* and hence be the first *Generation 'R'* in the history of mankind.

However, in order to pave the way for this new generation, we need to discuss and establish a set of guidelines and frameworks to address questions about the ethical, juridical, social and political impact of robotics on our daily life. This *Robotic Governance* has to be developed and discussed by as many stakeholders as possible – in robotics and other interdisciplinary fields; in science and research, industry, politics and society.

Biography

Dr. Bernd Liepert is the Chief Innovation Officer of KUKA AG, a world leading manufacturer of industrial robots.

Dr. Liepert earned his diploma in mathematics in 1990 from the University of Augsburg and his honorary doctor degree from University of Magdeburg in 2011.

Since 1990 Dr. Liepert has worked in changing positions for KUKA. From 1990 to 1996 he worked as mathematician and developer at KUKA Schweissanlagen + Roboter GmbH before he took charge as head of development of the newly founded company KUKA Roboter GmbH until 1997. From 1998-1999 he was a member of KUKA Roboter GmbH Board of Management, responsible for development and design.

From 2000-2009 Dr. Liepert was the CEO of KUKA Roboter GmbH. From 2010 to January 2015 he was the CTO of KUKA AG, responsible for technology and development of the whole KUKA group.

As Chief Innovation Officer of KUKA AG, Dr. Liepert is now responsible for expanding innovations at KUKA where he can apply his vast robotics experience at the interface between technology and the market.

From 2008-2015 Dr. Liepert was President of EUROP, the European Robotics Technology Platform, and subsequently President of euRobotics AISBL – the European Robotics Association. euRobotics was founded in September 2012 and has become the private side of SPARC, the European Public-Private Partnership in Robotics in 2013. As president of these associations Dr. Liepert is leading the European robotics community and representing it at high political levels.

From Mimicry to Mastery: Creating Machines that Augment Human Skill

Gregory D. Hager
Johns Hopkins University

Thursday, October 1, 10:30–11:15
Hall 2

Abstract

We are entering an era where people will interact with smart machines to enhance the physical aspects of their lives, just as smart mobile devices have revolutionized how we access and use information. Robots already provide surgeons with physical enhancements that improve their ability to cure disease, we are seeing the first generation of robots that collaborate with humans to enhance productivity in manufacturing, and a new generation of startups are looking at ways to enhance our day to day existence through automated driving and delivery.

In this talk, I will use examples from surgery and manufacturing to frame some of the broad science, technology, and commercial trends that are converging to fuel progress on human-machine collaborative systems. I will describe how surgical robots can be used to observe surgeons “at work” and to define a “language of manipulation” from data, mirroring the statistical revolution in speech processing. With these models, it is possible to recognize, assess, and intelligently augment surgeons’ capabilities. Beyond surgery, new advances in perception, coupled with steadily declining costs and increasing capabilities of manipulation systems, have opened up new science and commercialization opportunities around manufacturing assistants that can be instructed “in-situ.” Finally, I will close with some thoughts on the broader challenges still be to surmounted before we are able to create true collaborative partners.

Biography

Gregory D. Hager is the Mandell Bellmore Professor of Computer Science at Johns Hopkins University. His research interests include collaborative and vision-based robotics, time-series analysis of image data, and medical applications of image analysis and robotics. He has published over 300 articles and books in these areas. Professor Hager is also Chair of the Computing Community Consortium, a board member of the Computing Research Association, and is currently a member of the governing board of the International Federation of Robotics Research. In 2014, he was awarded a Hans Fischer Fellowship in the Institute of Advanced Study of the Technical University of Munich where he also holds an appointment in Computer Science. He is a fellow of the IEEE for his contributions to Vision-Based Robotics, and has served on the editorial boards of IEEE TRO, IEEE PAMI, and IJCV. Professor Hager received his BA in Mathematics and Computer Science Summa Cum Laude at Luther College (1983), and his MS (1986) and PhD (1988) from the University of Pennsylvania. He was a Fulbright Fellow at the University of Karlsruhe, and was on the faculty of Yale University prior to joining Johns Hopkins. He is founding CEO of Clear Guide Medical.

Supercomputing the Loop of Biomechanics and Neuroscience

Yoshihiko Nakamura
University of Tokyo
Thursday, October 1, 16:00–16:45
Hall 2

Abstract

The human whole body is a complex and hierarchical multi-physics system. Computer simulation of the human whole body is in the grand challenge of robotics. The current focus of our study is on closing the loop of the neural system and the musculoskeletal system.

Although the knowledge of the biomechanical structure of human body in every scale is well documented in anatomy, we do not know how the whole system works through their hierarchical and horizontal interactions. Mechanics and dynamics in robotics provide the tools for describing the complex system, while optimization and algorithm in robotics offer the means for solving the results of interactions.

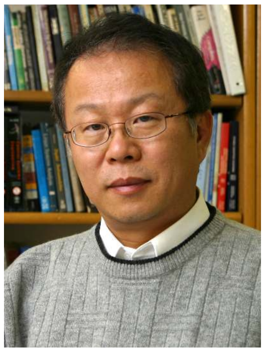
Study of brain science discovered the structure of neural system. The brain anatomy also shows the knowledge of the structure and of the connection among the local areas with interpretation of their functions. However, the pictures are still and static. While dynamics of neurons is mathematically well modelled, dynamical behavior of the neuron pool remains unexplored.

What kind of dynamic views will show up by connecting and closing the loop of the two dynamical systems, namely, the neural anatomy and the body anatomy? This talk will introduce our approach on modeling for the human whole body simulation under the national super computer project of Japan in collaboration with neuroscientists, medical doctors, and scientists in computational mechanics.

Biography

Yoshihiko Nakamura is Professor at Department of Mechano-Informatics, University of Tokyo. He received Doctor of Engineering Degree from Kyoto University. For 1987-1991, he worked at University of California, Santa Barbara, as Assistant and Associate Professor. Humanoid robotics, cognitive robotics, neuro musculoskeletal human modeling, biomedical systems, and their computational algorithms are his current fields of research. He is Fellow of JSME, Fellow of RSJ, Fellow of IEEE, and Fellow of WAAS. Dr. Nakamura serves as President of IFToMM (2012-2015). Dr. Nakamura is Foreign Member of Academy of Engineering Science of Serbia, and TUM Distinguished Affiliated Professor of Technische Universität München.

Keynotes



What We Learned from Darpa Robotics Challenge

Jun Ho Oh
Humanoid Robot Research Center
Korea Advanced Institute of Science and Technology
Tuesday September 29, 16:50–17:20
Hall 2

Abstract

The DARPA Robotics Challenge consisted of increasingly demanding competitions over two years. The DRC challenged participating robotics teams and their robots to complete a difficult course of eight tasks relevant to disaster.

25 teams from around the world participated in this demanding challenges but only three of them completed the mission in the specified time limit of one hour. Even the first place winner, team KAIST, took 44 minutes to complete. Many teams struggled a lot in operating their robots. Most of the robot experienced real ‘disastrous’ situation as falling down before entering the disaster scene or during the tasks. Some of them were from mechanical failure, the others were from operator’s mistakes or from bipedal walking difficulties, etc.

Prof. Jun Ho Oh will review the DRC final process and discuss about what the difficulties were, what happened and what we learned from the challenge. He will also explain some details and winning strategy about the robot ‘DRC Hubo’.

Biography

Prof. Jun Ho Oh received his B.S. and M.S. degree from Yonsei University, Seoul, Korea in 1977 and 1979, respectively. After short working at Korea Atomic Energy Research Institute as a researcher from 1979 to 1981, he received Ph.D. degree in mechanical engineering in the field of automatic control at U.C., Berkeley in 1985. He is now a distinguished professor of mechanical engineering and the director of Humanoid robot research center(Hubo Lab) at Korea Advanced Institute of Science and Technology (KAIST).

He performed many industry and government research projects in motion control, sensors, microprocessor applications, and robotics, etc. He is especially interested in mechatronics and system integration. In the recent ten years, he completed unique humanoid robot series KHR-1, KHR-2, Hubo and Hubo 2. He also developed Albert Hubo and Hubo FX-1. Recently, he leaded team KAIST and won Darpa Robot Challenge final as first in 2015. He is currently studying to improve the performance of humanoid robot for faster and more stable walking, robust robot system integration and light weight design, etc. He is a member of ASME and IEEE. And he also is a member of the National Academy of Engineering of Korea.

Robotics: Enter Deep Learning

Patrick van der Smagt
Biomimetic robotics and machine learning
Technische Universität München
Tuesday September 29, 17:20–17:50
Hall 2

Abstract

The introduction of light-weight drive concepts, impedance control, and variable-impedance actuation has significantly increased the pace of development and applicability of robots. However, even today the integration of robots with their sensors in complex tasks remains a research topic, typically not being able to cope with real-world scenarios.

Advances in machine learning in the last years is about to radically change this situation. The efficiency and generalising behaviour of deep learning now allows us to perform end-to-end learning on complex tasks. By combining deep learning with reinforcement learning and exploration, actions can be swiftly learned using raw sensory data. These new methodologies no longer require explicit modelling of the movement in state space, configuration space, or task space; instead, all representations will be efficiently created in latent spaces in the neural networks.

In my talk I will explore the very recent literature on this topic, and demonstrate the power of deep learning in the interpretation of complex sensory signals in a robotic setting. I will furthermore demonstrate how to efficiently generalise between latent spaces and configuration or task spaces.

Biography

Patrick van der Smagt received an M.Sc. in computer science at the Vrije Universiteit Amsterdam and a Ph.D. in Computer Science and Mathematics from the University of Amsterdam. He is professor for computer science at TUM and researcher at fortiss Munich, and directs a joint lab on machine learning for biomimetic robotics. Besides publishing numerous papers and patents on machine learning, robotics, and motor control, he has won various awards, including the 2013 Helmholtz-Association Erwin Schrödinger Award, the 2014 King-Sun Fu Memorial Award, and the 2013 Harvard Medical School/MGH Martin Research Prize. He is founding chairman of a non-for-profit organisation for Assistive Robotics for tetraplegics and co-founder of various companies. His most recent startup focuses on machine-learning methodologies for robotics and data processing, in particular focussing on deep learning and recurrent neural networks.

Robots, Politics, and Ethics: How Autonomous Driving Transforms Our Way of Thinking About Machines

Björn Giesler
Head of Driver Assistance
Elektrobit Automotive GmbH
Tuesday, September 29, 17:50–18:20
Hall 2

Abstract

Highly intelligent robots have been a trope of science fiction literature since the genre's inception. In reality, robots have so far been confined to strictly-controlled factory and warehouse floors, and the tasks assigned to them were tailored to their low level of intelligence. This is changing drastically as the Automotive Industry and some software companies are starting to bring about the advent of the Autonomous Vehicle in public traffic. Universities, research labs and development centers worldwide are working hard on the intelligence level necessary to release a self-driving car into the streets, and the first results will certainly improve traffic safety on average. But it is clear that the self-driving car will be inferior to a human driver for a very long time when it comes to dealing with difficult, unforeseeable situations that require creativity to avert accidents. As a result, autonomous cars will cause harm to humans in traffic, even if statistically much less than human drivers. This clashes with the way we think about machines as tools to make our lives easier and most importantly safer, not on average but individually. To be able to accept the statistical improvement on safety that self-driving cars promise, we need to change our way of thinking about machines.

Biography

Björn Giesler received the M.Sc. degree in Computer Science in 2000 and his PhD in Engineering in 2005, both from the University of Karlsruhe. While at University, his research interests included augmented reality, computer vision, self-localization of and creating maps with sensor systems (simultaneously if possible), autonomous robots, human-machine interfaces and large software structures. He joined AUDI AG in 2005 to develop self-driving cars. On the path to this goal he worked on time-of-flight cameras, multi-camera stereo and motion stereo, automotive computer vision, camera self-calibration, sensor data fusion, and trajectory planning and control, as well as system architectures and functional safety. He spent the last three years developing what will be the first highly-automated driving system for the consumer market. He initiated and co-ordinated the student contest "Audi Autonomous Driving Cup (AADC)", first held in 2015. He recently joined Elektrobit Automotive GmbH, a company working on software architectures, systems, and components for the Automotive industry, to head the department for Driver Assistance and Highly Automated Driving.

Micro/Nano Robotics Enabled Technology
for Nano Device Assembly and Drug Discovery

Lianqing Liu
Shenyang Institute of Automation (SIA)
Chinese Academy of Sciences
Wednesday September 30, 16:50–17:20
Hall 2

Abstract

The micro/nano robotics provides new enabling technology for people to explore the world down to the nano meter scale. Although micro/nano robotics has achieved great progress, the problem of lacking practical applications is still a bottleneck that hindering its further development. In this talk, two multidiscipline researches of Micro/Nano Robotics with Nano Device Assembly and Drug Discovery will be introduced. For Nano Device Assembly, the traditional method with AFM, SEM or DEP based manipulation often costs several minutes for only one device assembly. While with newly developed robotic manipulation technology, thousands of nano devices can be assembled in a couple of seconds, which increases the efficiency over thousand times. For Drug Discovery, nano robotics provides many unique functions to facilitate the process of new drug discovery. As examples, how to use nano robotics to study mechanosensitive ion-channel and investigate efficacy difference of lymphoma targeted therapy will be presented. These researches show that micro/nano robotics is full of potential to bring breakthroughs for current scientific research, and as a result, new applications in turn will pull the technology into a higher level.

Biography

Lianqing Liu received his Ph.D. degree in Pattern Recognition and Intelligent System from university of Chinese Academy of Sciences, China in 2008, and B.S. degree in Industry Automation from Zhengzhou University, China in 2002. He started his career in 2006 at Shenyang Institute of Automation, Chinese Academy of Sciences, and holds the position of Assistant Professor (2006-2008), Associate Professor (2009-2010) and Professor (2011 to now) respectively. Liu has published more than 150 journal and conference papers and book chapters and led more than 20 funded research projects as Principal Investigator. He has served as guest editor for Sensors, TIMC, as Organizing Chair of IEEE-CYBER 2015, as organizing committee member of IEEE-NANO2015, IEEE-ICRA 2014, IEEE-IROS 2009 and so on. He was awarded Outstanding Young Scientist of Chinese Academy of Sciences in 2014, the Early Career Award by the IEEE Robotics and Automation Society in 2011, Lu Jiaxi Young Scientist Award of the Chinese Academy of Sciences in 2011, and President Award of the Chinese Academy of Sciences in 2009. Currently his research interests include Nanorobotics, Intelligent control, Biosensors.

Robot Ethics in the Era of Self-Driving Automobiles
George Bekey
University of Southern California, Los Angeles
Wednesday September 30, 17:20–17:50
Hall 2

Abstract

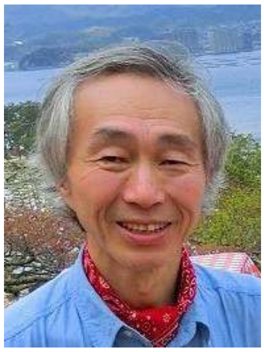
During the past decade discussions of robot ethics have been largely theoretical, involving "what if" scenarios focused mainly on military robots. At present, as autonomous cars approach deployment in several countries, ethical issues are being discussed with increasing frequency. Among these are such issues as:

- responsibility and legal liability for accidents involving self-driving cars (which may include injury to humans and property damage),
- job displacement (e.g., for truck drivers and taxi drivers),
- protection of privacy,
- needed changes in vehicle driving rules,
- responsibility of human passengers,
- changes in laws involving police and legal authorities,
- liability of vehicle owners and manufacturers.
- the ability of police to override the controls of a self-driving car performing illegal moves and control it remotely, and, if so, then
- "hacker" possibly taking over the vehicle's controls and using it for illegal purposes.

This presentation will review these and other legal and ethical issues involving autonomous cars.

Biography

Dr. George Bekey is an emeritus professor of computer science, electrical engineering and biomedical engineering at the University of Southern California, and a research scholar in residence at California Polytechnic University at San Luis Obispo. He received the M.S. and Ph.D. degrees in Engineering from UCLA. His area of research is robotics, with specializations in robot ethics and applications of robotics in biology and medicine. He is the author of *Autonomous Robots: from Biological Inspiration to Implementation and Control* (MIT Press, 2005) and author or co-author of two other books and over 250 technical papers in robotics, computer simulation and biomedical engineering. He is also a co-editor of *Robot Ethics* (MIT Press, 2012). He is the founder of the USC Robotics Laboratory and one of the founders of the IEEE Robotics and Automation Society. He was the Founding Editor of the *IEEE Transactions on Robotics* and of the journal *Autonomous Robots*. Prof. Bekey is a member of the U.S. National Academy of Engineering and a Fellow of the IEEE, AAAI and AAAS. He has received a number of awards from universities and professional societies.



Application of the Robot Systems and Technologies for Natural Disaster Response and Infrastructure Maintenance in Japan

Shin'ichi Yuta
Shibaura Institute of Technology
Wednesday, September 30, 17:50–18:20
Hall 2

Abstract

When we attempt to use field robots or apply robot technologies, the purpose is to solve a problem in society, and the robots are just the means or the tools for this purpose. To solve the practical problem with robots, we first have to analyze the task in order to understand the particular problem. And if the problem is expected to be solved by robotic machines, which can perform the necessary tasks and replace or support the humans'work, we can use whole robotic systems. In these cases, the functions realized by robotic machines are like human working ability, (work done by human hands, or using their mobility). The expected roles of the robotic systems are generally: (1) decreasing the strenuous load of human workers and reducing working costs, (2) increasing accuracy, or upsizing in order to handle more heavy weight materials, (3) expand the working environment to cover hazardous or dangerous sites.

For field robots, technical importance is the ability to cope with the variety of environment conditions. The set of the environment conditions covered by a robotic system should be defined for each practical problem. So, even though robotics research aims at generality or versatility, first we have to solve each particular problem and in each possible working conditions. In this talk, I will report on unmanned construction by remote operated heavy equipment for building erosion-control dams after big landslides or volcanic eruption, and also on inspection of large structure without using temporal scaffold for safety, and cost reduction in the infrastructure maintenance. I will also introduce recent Japanese activities on technical development and attempt on social implementation of field robots technology.

Biography

Shin'ichi Yuta completed his Ph.D. in Electrical engineering at Keio University in 1975. In 1978–2012, he was at University of Tsukuba, where he served as the vice-president for research in 2004–2006, and as director of Tsukuba Industrial Liaison and Cooperative Research Center in 2006–2010. In March 2012, he retired from University of Tsukuba, and he is now a professor at Shibaura Institute of Technology, Tokyo. He is now also serving as a Project Leader of "Robot and Sensor System Development Project for Infrastructure Maintenance" at NEDO, Committee member of "Practical Test and Evaluation of the Robot System for Infrastructure" at MLIT, and as Director of New Unmanned Construction Technology Research Association. In Tsukuba, he conducted an autonomous mobile robot project and published more than 500 technical papers in this field. Recently, his interest has been shifted to the field robotic technology for the natural disaster response and the maintenance of the infrastructures. He is a fellow of RSJ and IEEE.

Reconstructed Brain Models for Virtual Bodies and Robots

Marc-Oliver Gewaltig
The Blue Brain Project
Ecole polytechnique fédérale de Lausanne
Thursday October 1, 16:50–17:20
Hall 2

Abstract

The Human Brain Project (HBP) is a 10 year initiative with the goal to build a large-scale computing infrastructure for simulation based neuroscience and related research. An important part of this infrastructure is the HBP Neurorobotics Platform, a research platform for high-fidelity virtual robotics, that will allow scientists from all over the world to connect reconstructed brain models to virtual bodies and robots and test them in realistic dynamic environments.

I will shortly present the HBP Neurorobotics Platform and illustrate the chances and challenges of virtual robotics on the example of an integrated sensory-motor model of a mouse. The virtual mouse includes a brain, reconstructed from high-resolution imaging data, as well as a body, composed of a skeleton with muscles, skin, and sensory organs. If the mouse is embedded in a simulated environment with realistic physics it can be used in a wide range of in silico experiments while researchers can observe its entire neural activity. Finally, I will illustrate how such closed-loop sensory motor experiments can be used to inform and refine bottom-up reconstructed brain models.

Biography

Marc-Oliver Gewaltig co-directs the Neurorobotics subproject of the European “Human Brain Project” and leads the Neurorobotics Section of the Blue-Brain Project at the EPFL in Lausanne, Switzerland. In his research, Marc-Oliver Gewaltig investigates the computational properties of biologically derived brain models in closed action-perception loops. Before joining the EPFL in 2011, Marc-Oliver Gewaltig was Principal Scientist (2003-2011) and Project Leader (1998-2002) at the Honda Research Institute Europe in Offenbach, Germany, where he worked on detailed columnar models of information processing in the primate visual system (Schrader et al., 2009) as well as on learning and plasticity (Knoblauch et al. 2012). Marc-Oliver Gewaltig received his PhD in Physics in 1999 for his work on activity propagation in cortical networks (Gewaltig et al 2001, Diesmann et al 1999).

Optimization for Robust Motion Planning and Control
Russ Tedrake
Robot Locomotion Group
Massachusetts Institute of Technology
Thursday October 1, 17:20–17:50
Hall 2

Abstract

I dream of making robots capable of executing extremely aggressive dynamic motions – like the speeder bikes in the Star Wars' Forest of Endor – out in the real world. These systems must plan in real time in novel environments, and be robust enough to deal with uncertainty from perception, imperfect actuators, and model errors. Moreover, I want to achieve this performance in legged robots and robot manipulation, where contact with the environment plays a central role in the dynamics.

Achieving this performance reliably requires a focus on robustness, which has natural formulations using optimization. Making these optimizations tractable requires exploiting sparsity and convexity in our robot equations, and making informed relaxations. In this talk, I will review our best attempts to date and give examples with fast UAV flight through clutter and whole-body planning and control for humanoids.

Biography

Russ is the X Consortium Associate Professor of Electrical Engineering and Computer Science, Aeronautics and Astronautics, and Mechanical Engineering at MIT, the Director of the Center for Robotics at the Computer Science and Artificial Intelligence Lab, and the leader of Team MIT's entry in the DARPA Robotics Challenge. He is a recipient of the NSF CAREER Award, the MIT Jerome Saltzer Award for undergraduate teaching, the DARPA Young Faculty Award in Mathematics, the 2012 Ruth and Joel Spira Teaching Award, and was named a Microsoft Research New Faculty Fellow.

Russ received his B.S.E. in Computer Engineering from the University of Michigan, Ann Arbor, in 1999, and his Ph.D. in Electrical Engineering and Computer Science from MIT in 2004, working with Sebastian Seung. After graduation, he joined the MIT Brain and Cognitive Sciences Department as a Postdoctoral Associate. During his education, he has also spent time at Microsoft, Microsoft Research, and the Santa Fe Institute.

Research, Development and Field Test of Robotic Observation Systems for Sctive Volcanic Areas in Japan

Keiji Nagatani
Field Robotics Laboratory
Tohoku University
Thursday, October 1, 17:50–18:20
Hall 2

Abstract

After 3.11 (The Great East Japan Earthquake 2011), we have been observing increased volcanic activity in Japan. Volcano eruptions cause damages to habitants by volcanic bomb, volcanic ashes, lava stream, and debris flow. To protect lives, robotic technologies are now expected to be applied to observe volcanic activity in restricted areas close to the craters. Based on the above background, ministry of land, infrastructure, transport and tourism (MLIT) in Japan organized some robotics projects to apply to natural disaster observation and infrastructure surveillance, and our research group is now a part of them. Our objective is to forecast debris flow with multi-rotor UAVs, and our current challenges are to obtain a 3D-map of the target environment, and to enable soil sampling from restricted areas. In this talk, I will introduce recent robotics projects for natural disaster response in Japan, and present our practical research activities in volcanic areas.

Biography

Keiji Nagatani received his Ph.D. degree from the University of Tsukuba, in 1997. He was a Postdoctoral Fellow at Carnegie Mellon University, from 1997 to 1999, and he was a Lecturer at Okayama University, from 1999 to 2005. From 2005 to current, he is an Associate Professor at Tohoku University. His research interest focuses on field robotics, in particular tele-operation of tracked vehicles for search and rescue missions, as well as development of mobile robots to explore volcanic areas. He is a Member of RSJ, SICE, JSME, and IEEE.

Special Forums

Government Forum

Tuesday Sep. 29, 11:30–16:00	Hall 2
Organizer	Seth Hutchinson, University of Illinois UC Alois Knoll, Technische Universität München Jianwei Zhang, Universität Hamburg

Government agencies have historically been the dominant source of funding for robotics research, both in universities and in industry. In recent years, as robotics technologies have begun to move beyond their traditional strongholds in industrial and manufacturing applications, government agencies have adapted their funding models, introducing new programs and providing increasing funding for interdisciplinary and international collaborations. Examples include the National Robotics Initiative (NRI) of the U.S. National Science Foundation, the Horizon 2020 (H2020) program of the European Union, and Japan's Robot Revolution initiative. The purpose of this Government Forum is to bring together researchers and government policy makers in a continuing dialog about new funding opportunities, new possibilities for international collaborations, and lessons learned from ongoing efforts, building on the success of the Forum that was held at the 2015 ICRA (`http://icra2015.org/conference/forums/11-conference/47-government-forum`).

The Forum will consist of two sessions, punctuated by a lunch break. In the first session, policy makers from funding agencies in Asia, Australia, North America and Europe will discuss government funding priorities and government policy as it relates to robotics, with a particular emphasis on opportunities for interdisciplinary and international research collaborations. In the second session, researchers will discuss emerging challenges and opportunities. This will include a discussion of characteristics that can either contribute to, or impede, successful research collaborations, including discussion of the kinds of research project that are likely to succeed only when confronted by international collaborative teams. The lunch break, which will occur between the two sessions, will provide an opportunity for researchers and policy makers to interact informally, potentially raising issues to be addressed in the second session. The Forum will conclude with a panel discussion.

Agenda	
11:30	Representatives from government funding agencies
13:00	Lunch Break
14:00	Researchers from academia and industry
15:30	Panel Discussion

Futurist Forum

Wednesday Sep. 30, 11:30–16:00 Hall 2

Organizer Dominik Bösl, Corporate Innovation Office, KUKA AG

Shaping a united vision for the future of robotics

Robotics will change the world! It will unleash the same if not an even more disruptive and transformational power within the next 50 years as mainstream IT-technology and the Internet have in the last half of a decade.

But what will this future look like?

You will have the chance to discuss this question with a lineup of internationally renowned experts from different interdisciplinary fields out of science, research, industry and politics at the *1st IEEE IROS Futurist Forum*!

The goal of the *Futurist Forum* is to provide a first draft of a “north star” for the robotics community: A *universally shared vision of the future* that will be refined and detailed over the next few years. It will provide a holistic view on the future and its arising challenges, *serving future robotic research as motivation and guidance*.

Nurtured by technological breakthroughs in industrial automation, robotics will permeate other domains. Hence, a new generation of *Robotic Natives* will grow up in a society that is enriched and enhanced by robotics in every imaginable way. Robotics will be tailored into many everyday objects, thus becoming an integral part of all kinds of appliances.

The direct interaction with any form of robotic and automated system will not intimidate this *Generation Robotics*. It will perceive self-driving cars, autonomous service robots, automatized logistics and robotics in retail as just as normal as the internet, smartphones and tablets are today.

This change will not be limited to the steadily growing field of industrial robotics. Due to a number of technological enablers, e.g. the broad availability of low cost but high performance sensor technologies, robotics will be unchained and liberated from its cells. It will conquer completely new domains until it pervades all areas of life, permeating all parts of the human experience realm.

How will our world, the global economy and societies change? Which impact will these changes have and what needs will arise in the near future? And how can robotics and automation technologies help address some of these issues?

These questions are essential, since the first seal has already been broken: by establishing and fostering sensitive and safe robotics, the foundations for cooperative robotic systems and human-machine-interaction have been laid. In the past, robots were surrounded by heavy safety cages, locking humans out and machines in; for the first time, these borders have now been obliterated. As if they were colleagues, workers can directly interact with automation systems.

The collaborative vision of the future is crucial for paving the way for this new Generation *R*: the need to discuss and establish a set of guidelines and frameworks to address questions about the ethical, juridical, social and political impact of robotics on our daily life will arise. The *Futurist Forum* can lay the foundations for an elaborate debate on *Robotic Governance* in which stakeholders from diverse domains have to be involved – from robotics and other interdisciplinary fields; from science and research, industry, politics and society.

Agenda	
11:30	Keynote
12:30	Future Research (Industry)
13:00	Short Lunch break
13:30	Future of Society and Cognition (Epistemology)
14:00	Future of Robotics (Robotics Research)
14:30	Future of Government (Government)
15:00	Future of Work (Social Studies / Union)
15:30	Panel Discussion

Entrepreneurship Forum & Start-up Competition (EFSC)

Thursday Oct. 1, 11:30–16:00 Hall 2

Organizer Raj Madhavan, IEEE RAS VP, Industrial Activities Board
Erwin Prassler, runfun Inc., Germany
Oliver Brock, Technische Universität Berlin, Germany
Tim Tingqiu Yuan, Huawei Technologies Co., Ltd.

To foster the entrepreneurial spirit and to provide a platform to encourage researchers and practitioners to transition ideas and prototypes to commercializable products, the IEEE Robotics and Automation Society (IEEE RAS) is inviting the robotics and automation community to participate in an Entrepreneurship Forum and Start-up Competition (EFSC) at the 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS'15) in Hamburg (`http://iros2015.org/`). The event is intended to inspire, educate, enable, and empower researchers, students, young professionals, and anyone else who has the 'start-up bug' in starting companies of their own but is not sure of how to go about it. We also believe that this event will create an ecosystem that will provide the much-needed support for start-ups to launch their initiatives while being realistic about their envisioned ideas and products. Previous IEEE RAS events centered on the entrepreneurship topic have been held at IROS'13 (Tokyo) and IROS'14 (Chicago) and served as starting points for discussions on identifying gaps and building bridges between industry, academia, government, and end-users (see `http://www.iros2013.org/industry-forum.html` and `http://www.iros2014.org/program/industry-forum`).

In addition to invited talks centered on entrepreneurship in robotics and automation, the start-up competition at IROS'15 will consist of three stages:

- In the first stage, submitted applications will be down-selected to arrive at a pool of qualified applicants based on a defined set of criteria developed by the organizers (see 'Application Form' information below).
- This will be followed by a remote stage where the selected applicants will be paired with coaches based on the proposal content and the expertise of the coaches. The coaches will then critique, and provide technical and professional assistance to refine the idea/product pitches.
- The final stage would allow for the refined pitches and content to be presented in front of a distinguished panel of venture capitalists, industry, and academic experts who have successfully funded, transitioned and have experience in commercialization of robotics and automation technologies.

Travel support will be provided for all qualified applicants invited to IROS'15 and awards will be given for the top 3 finishers (totaling $45k). We gratefully acknowledge the support of IEEE and KUKA for their generous financial support of this event.

Additional information is available from `http://iros2015.org/index.php/program/entrepreneurship-forum-start-up-competition/`.

Citizen Forum

Friday Oct. 2, 9:00–12:00 & 14:00–17:00 Hall 2

Organizer Rüdiger Dillmann, Karlsruhe Institute of Technology
Tamim Asfour, Karlsruhe Institute of Technology
Karsten Berns, TU Kaiserslautern
Horst-Michael Gross, Ilmenau University of Technology
Joachim Hertzberg, Osnabrück University

The purpose of the IROS 2015 Citizen Forum is to inform and to discuss recent progress as well as future visionary research and development towards a robot technology which allows robots to autonomously interact closely with each other and with humans, in risky and challenging scenarios with different needs and societal impact. Such robots may have various different shapes and functions, cognitive capabilities, and in addition, natural and intuitive man-machine interfaces.

Today's robots are mostly used in industrial manufacturing, maintenance, inspection and transportation. However, new robot shapes and bionic principles have emerged which allow robots to fly, to dive, or to walk in uneven, rough and dangerous terrain, performing tasks which cannot be carried out directly by humans. Others are designed for highly risky applications like surgery, man-made and natural environmental disasters or in space. All of these robots need to perceive and understand the environment to fulfill the requirements of the scenario they are designed for. When cooperating with people, the robots must adapt their behaviour to the needs of the humans, considering each individual's personal capabilities, stature and mental status.

The interest in such systems is rapidly growing, as current robot technology is available at a reasonable price and becoming part of our daily life. Robots are being connected to the Internet, to other robots, autonomous mobile systems and to various sensors and other devices within future smart urban environments.

In addition to the conference participants, the IROS 2015 Citizen Forum addresses all interested citizens, pupils, students, teachers, artists and others. In short, all people interested in future and upcoming emerging technology which may strongly influence our daily life and our societies. Attendence is free and open to all. The program of the Forum includes talks and discussions by a unique selection of outstanding speakers, which survey recent technological progress towards advanced robots and explain the impact on various new upcoming application fields.

Speakers	
Dario Floreano	EPFL, Lausanne
Roland Siegwart	ETH Zürich
Darwin Caldwell	IIT, Genova
Sami Haddadin	Universität Hannover
Oussama Khatib	Stanford University
Heinz Wörn	KIT, Karlsruhe
Kazuhito Yokoi	AIST, Tsukuba
Wolfram Burgard	University of Freiburg

Call for Robots — Open Playground

Foyer Hall G

Organizer	Alois Knoll, Technische Universität München Hannes Bistry, Universität Hamburg

Discussing the latest progress on your project on a conference is a great thing, but showing it and playing around with it together with other researchers and developers takes the experience to a different level. To meet this demand, the IROS 2015 introduces the concept of an open *Playground*. The Playground is a marked field in the foyer in front of Hall G. Every participant is invited to bring and show robots or prototypes without prior registration. The idea is to assemble a community around the open field to create an atmosphere for lively discussions, inspirations and communication.

We kindly ask you to drop a short mail to playground@iros2015.org if you plan to bring any Hardware for the Playground, to help us to estimate the amount of interest and required space.

Rules & Facts

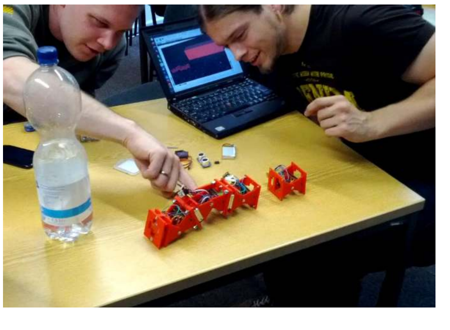
The Playground will be open during the three main conference days: Tuesday, Wednesday and Thursday. We will provide a number of tables and power supplies.

The Playground rules are quite simple:

- The Playground is open for everyone (student, researcher, startups, ...).
- Robots on the playground must neither damage other robots nor harm humans. If your robot has any special safety requirements, please contact us in advance.
- Be careful with Wifi networks. Extensive use of multiple Wifi hot-spots may interfere with the conference network and other playground users.
- Be fair! Don't occupy the playground for long times in case other people are waiting.
- The use of small UAVs is possible, depending on the situation.

We hope to see many innovative devices and have interesting discussions.
See you at the "Playground"!

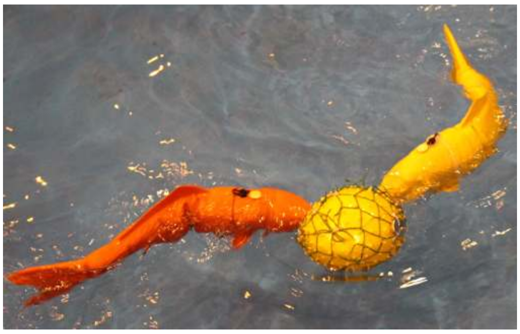




Robotic Fish Water Polo Competition

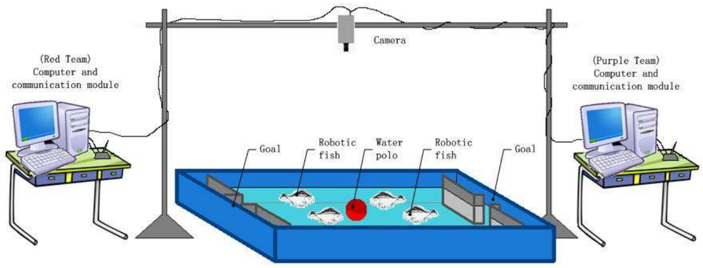
Foyer Hall G

Organizer Jorge M. Dias, University of Coimbra
Guangming Xie, Peking University
Kaspar Althoefer, KCL London
Jingtai Liu, Nankai University
Rong Xiong, Zhejiang University



Over 70% of the earth is covered in water and the ocean is a very important resource for human society. Many manual or automatic machines, including robots, are being developed for all kinds of underwater work and services. Developing more effective underwater robots is becoming an attractive field of robotic technology. Today, various robotic competitions are being organized, such as robot football, rescue robots, service robots at home. However, all of these are only taking place on land. The time has come for holding underwater robot competitions. By introducing appropriate games, more people will be attracted to the field of underwater robotics and, therefore underwater robots and their cooperation techniques will improve.

A water polo competition with robotic fish is currently being constructed at Peking University, China. It focuses on the problem of intelligent underwater multi-agent cooperation and control in a highly dynamic environment with a hybrid centralized system. The game involves two teams of robotic fish with difference colors. A camera over the pool catches the images of the fish and ball. On an off-field PC, the positions of the fish are obtained in real time and the control commands are generated and sent to the fish by WiFi. The team with the most goals at the end of the game wins the match.



The question of how to track multiple robotic fish on a water surface in real-time and how to control the fish to push the ball efficiency and precisely are the two key challenges in the game. Teams from China, Germany, the Netherlands, and Norway will attend the competition.

Awards

The best papers of the conference will be awarded. Aside the best paper award of the conference, multiple sponsored awards will be granted. The award ceremony will be held in the lunch break on Thursday, October 1 in Hall 2. Lunch boxes will be given out in the foyer of Hall 2, starting at 12:15.

NTF Award for Entertainment Robots and Systems

This award is to encourage research and development of "entertainment robots and systems" and new technologies for future entertainment. Sponsored by the New Technology Foundation.

JTCF Novel Technology Paper Award for Amusement Culture

This award recognizes practical technology contributing to toys, toy models, and amusement culture. Sponsored by the Japan Toy Culture Foundation.

RoboCup Best Paper Award

For work in localization, navigation, mobility, and teamwork technologies, with applications to areas such as team sports, search and rescue, personal and home robotics, education, and others. Sponsored by the RoboCup Federation.

ICROS Best Application Paper Award

Sponsored by the Institute of Control, Robotics, and Systems (ICROS).

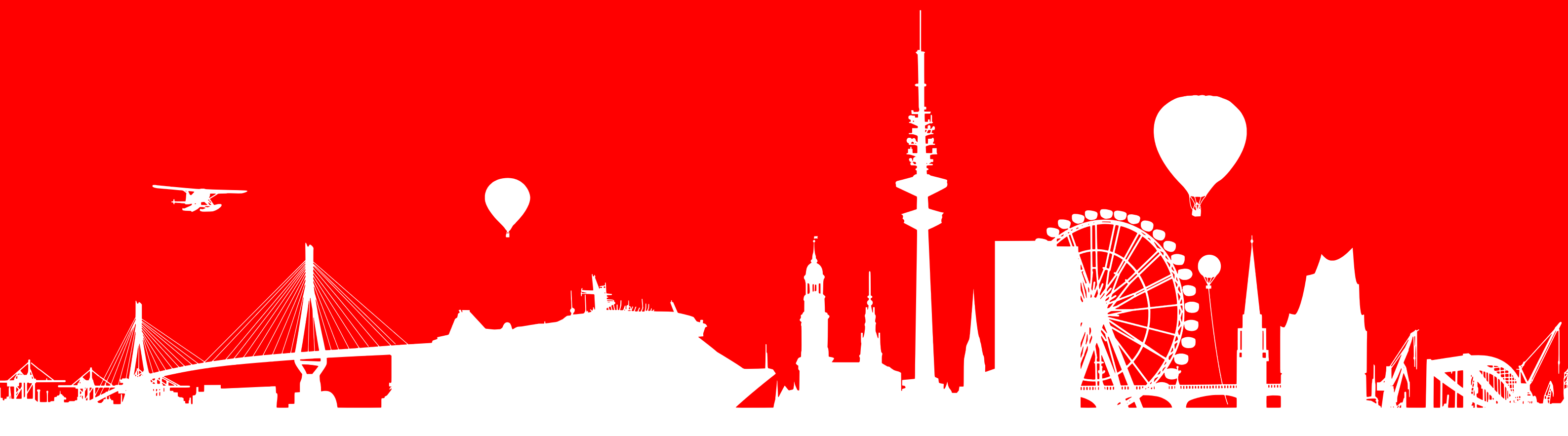
ABB Best Student Paper Award

This award recognizes the most outstanding paper authored primarily by, and presented by, a student. Sponsored by ABB.

Best Paper Award

This award recognizes the most outstanding paper presented at the conference.

Program at a Glance



Full-Day Workshops

MoWS-01	MoWS-02	MoWS-03	MoWS-04	MoWS-05	MoWS-06	MoWS-7	MoWS-8	MoWS-9	MoWS-10	MoWS-11	MoWS-12
Hall F 8:30–18:00 7th Workshop on Planning, Perception and Navigation for Intelligent Vehicles	Hall A4 8:30–18:00 MiRoR: Miniaturised Robotic systems for holistic in-situ Repair and maintenance works in restrained and hazardous environments	Hall C1 8:30–18:00 Semantic Policy and Action Rep- resentations (SPAR) for Autonomous Robots	Hall C2 8:30–18:00 Designing and Evaluating Social Robots for Public Settings	Hall C3 8:30–18:00 Multimodal Semantics for Robotic Systems (MuSRobS)	Hall 12 8:30–18:00 Towards Standardized Experiments in Human- Robot Interactions	Hall 15 8:30–18:00 Unconven- tional Computing for Bayesian Inference	Hall B1 8:30–18:00 From Plants and Animals to Robots: Movements, Sensing, and Control. Two worlds in comparison	Hall C4 8:30–18:00 The 6th International Workshop on Domain- Specific Languages and Models for Robotic Systems (DSLRob'15)	Hall E 8:30–18:00 Robotic co-workers: methods, challenges and industrial test cases	Hall D 8:30–18:00 Learning object affordances: a fundamental step to allow prediction, planning and tool use?	Hall 8 8:30–18:00 Bridging user needs to deployed applications of service robots

MoWS-13	MoWS-14	MoWS-15	MoWS-16	MoWS-17	MoWS-18
Hall 14 8:30–18:00 Real-time Cognitive Computing for Service Robots	Hall 11 8:30–18:00 Hyper Bio Assembler for 3D Cellular Innovation	Hall 13 8:30–18:00 Open forum on evaluation of results, replication of experiments and bench- marking in robotics research	Hall B4 8:30–18:00 Robotic endoscopic capsule for gastro- intestinal screening, diagnosis and therapy: achieve- ments and future challenges	Hall B3 8:30–18:00 Towards truly human-like bipedal locomotion: the role of optimization, learning and motor primitives	Hall B2 8:30–18:00 Cognitive Mobility Assistance Robots: Scientific Advances and Perspectives

Half-Day Workshops

MoWSM-20	MoWSM-21	MoWSM-22
Hall A3 8:30–12:30 Embodied-Brain Systems Sciences	Hall A1 8:30–12:30 Cooperative vehicles and robotic systems for industrial applications	Hall 7 8:30–12:30 Robot Competitions: What did we learn?
MoWSA-20	**MoWSA-21**	**MoWSA-22**
14:00–18:00 See and Touch: Multimodal sensor-based robot control for HRI and soft manipulation	14:00–18:00 Spatial Reasoning and Interaction for Real-World Robotics	14:00–18:00 2nd International Workshop on Aerial Open Source Robotics

IROS 2015 Technical Program — Tuesday September 29, 2015

Keynotes and Forums	Track T1	Track T2	Track T3	Track T4	Track T5	Track T6	Track T7
08:30–10:00 Hall 2 Opening							
Coffee Break							
10:30–11:15 Hall 2 – Plenary session TuBT16 Paul Newman Practice makes Perfect? The Role of Place Dependent Expertise in Mobile Robotics							
11:30–15:30 Forum Hall 2 Government Forum	11:20–12:50 TuCT1 Hall B3 Physical Human-Robot Interaction 1	11:20–12:50 TuCT2 Hall D Unmanned Aerial Systems 1	11:20–12:50 TuCT3 Hall E Robot Vision 1	11:20–12:50 TuCT4 Hall F Slam 1	11:20–12:50 TuCT5 Hall B2 Biological Applications of Micro Robots	11:20–12:50 TuCT6 Hall 7 Surgical Robotics 1	11:20–12:50 TuCT7 Hall C1+C2 Manipulation Planning and Control 1
Lunch Break							
11:30–15:30 Forum Hall 2 Government Forum	14:00–15:30 TuDT1 Hall A1 Surveillance Systems	14:00–15:30 TuDT2 Hall D Unmanned Aerial Systems 2	14:00–15:30 TuDT3 Hall E Robot Vision 2	14:00–15:30 TuDT4 Hall F Slam 2	14:00–15:30 TuDT5 Hall B2 Micro/Nano Robots 1	14:00–15:30 TuDT6 Hall 7 Surgical Robotics 2	14:00–15:30 TuDT7 Hall C1+C2 Manipulation Planning and Control 2
Coffee Break							
16:00–16:45 Hall 2 – Plenary session TuET16 Oussama Khatib The New Robotics Age: The Challenge of Physical Tasks							
16:50–18:20 Keynotes Hall 2 16:50–17:20 Keynote Session 1 17:20–17:50 Keynote Session 2 17:50–18:20 Keynote Session 3	16:50–18:20 TuFT1 Hall B3 Human-Robot Interaction 1	16:50–18:20 TuFT2 Hall D Unmanned Aerial Systems 3	16:50–18:20 TuFT3 Hall E Robot Vision 3	16:50–18:20 TuFT4 Hall F Slam 3	16:50–18:20 TuFT5 Hall B2 Micro/Nano Robots 2	16:50–18:20 TuFT6 Hall 7 Surgical Robotics 3	16:50–18:20 TuFT7 Hall C1+C2 Mobile Manipulation

OC & CPRB Dinner
(Miniatur Wunderland)

Tuesday September 29, 2015 — Conference Day

Track T8	Track T9	Track T10	Track T11	Track T12	Track T13	Track T14	Track T15

08:30–10:00
Hall 2
Opening

Coffee Break

10:30–11:15
Hall 2 – Plenary session TuBT16
Paul Newman
Practice makes Perfect? The Role of Place Dependent Expertise in Mobile Robotics

Track T8	Track T9	Track T10	Track T11	Track T12	Track T13	Track T14	Track T15
11:20–12:50 TuCT8 Hall A3 Sensor Fusion 1	11:20–12:50 TuCT9 Hall 8 Biologically-Inspired Robots 1	11:20–12:50 TuCT10 Hall B4 Humanoid and Bipedal Locomotion 1	11:20–12:50 TuCT11 Hall B1 Swarm Robotics	11:20–12:50 TuCT12 Hall A1 Learning from Demonstration	11:20–12:50 TuCT13 Hall C4 Grasping 1	11:20–12:50 TuCT14 Hall A4 Field Robots 1	11:20–12:50 TuCT15 Hall C3 Haptics and Haptic Interfaces 1

Lunch Break

Track T8	Track T9	Track T10	Track T11	Track T12	Track T13	Track T14	Track T15
14:00–15:30 TuDT8 Hall A3 Sensor Fusion 2	14:00–15:30 TuDT9 Hall 8 Biologically-Inspired Robots 2	14:00–15:30 TuDT10 Hall B4 Humanoid and Bipedal Locomotion 2	14:00–15:30 TuDT11 Hall B3 Physical Human-Robot Interaction 2	14:00–15:30 TuDT12 Hall B1 Marine Robotics 1	14:00–15:30 TuDT13 Hall C4 Soft-Bodied Robots 1	14:00–15:30 TuDT14 Hall A4 Field Robots 2	14:00–15:30 TuDT15 Hall C3 Haptics and Haptic Interfaces 2

Coffee Break

16:00–16:45
Hall 2 – Plenary session TuET16
Oussama Khatib
The New Robotics Age: The Challenge of Physical Tasks

Track T8	Track T9	Track T10	Track T11	Track T12	Track T13	Track T14	Track T15
16:50–18:20 TuFT8 Hall C3 Force and Tactile Sensing 1	16:50–18:20 TuFT9 Hall 8 Biologically-Inspired Robots 3	16:50–18:20 TuFT10 Hall B4 Humanoid and Bipedal Locomotion 3	16:50–18:20 TuFT11 Hall A1 Compliance and Impedance Control 1	16:50–18:20 TuFT12 Hall B1 Marine Robotics 2	16:50–18:20 TuFT13 Hall C4 Soft-Bodied Robots 2	16:50–18:20 TuFT14 Hall A4 Joint/Mechanism Design	16:50–18:20 TuFT15 Hall A3 Software and Architecture

OC & CPRB Dinner
(Miniatur Wunderland)

IROS 2015 Technical Program — Wednesday September 30, 2015

Keynotes and Forums	Track T1	Track T2	Track T3	Track T4	Track T5	Track T6	Track T7
	08:30–10:00 WeAT1 Hall D Human-Robot Interaction 2	08:30–10:00 WeAT2 Hall A4 Unmanned Aerial Systems 4	08:30–10:00 WeAT3 Hall E Robot Vision 4	08:30–10:00 WeAT4 Hall F Slam 4	08:30–10:00 WeAT5 Hall A3 Micro/Nano Robots 3	08:30–10:00 WeAT6 Hall 7 Surgical Robotics 4	08:30–10:00 WeAT7 Hall C1+C2 Motion and Path Planning 1
Coffee Break							
10:30–11:15 Hall 2 – Plenary session WeBT16 Zexiang Li From Geometry to Startups and to ... Incubators							
11:30–15:30 Forum Hall 2 Futurist Forum	11:20–12:50 WeCT1 Hall D Human-Robot Interaction 3	11:20–12:50 WeCT2 Hall A4 Unmanned Aerial Systems 5	11:20–12:50 WeCT3 Hall E Robot Vision 5	11:20–12:50 WeCT4 Hall F Localization 1	11:20–12:50 WeCT5 Hall A1 Networked Robots	11:20–12:50 WeCT6 Hall 7 Medical Robots and Systems 1	11:20–12:50 WeCT7 Hall C1+C2 Motion and Path Planning 2
Lunch Break							
11:30–15:30 Forum Hall 2 Futurist Forum	14:00–15:30 WeDT1 Hall D Human-Robot Interaction 4	14:00–15:30 WeDT2 Hall A4 Calibration and Identification 1	14:00–15:30 WeDT3 Hall E Visual Navigation 1	14:00–15:30 WeDT4 Hall F Localization 2	14:00–15:30 WeDT5 Hall A1 Parallel Robots	14:00–15:30 WeDT6 Hall 7 Medical Robots and Systems 2	14:00–15:30 WeDT7 Hall C1+C2 Motion and Path Planning 3
Coffee Break							
16:00–16:45 Hall 2 – Plenary session WeET16 Bernd Liepert Robotic Governance: Paving the Way for Generation 'R'							
16:50–18:20 Keynotes Hall 2 16:50–17:20 Keynote Session 4 17:20–17:50 Keynote Session 5 17:50–18:20 Keynote Session 6	16:50–18:20 WeFT1 Hall D Human-Robot Interaction 5	16:50–18:20 WeFT2 Hall A4 Calibration and Identification 2	16:50–18:20 WeFT3 Hall E Visual Navigation 2	16:50–18:20 WeFT4 Hall F Localization 3	16:50–18:20 WeFT5 Hall B3 Mechanism Design 1	16:50–18:20 WeFT6 Hall 7 Medical Robots and Systems 3	16:50–18:20 WeFT7 Hall C1+C2 Motion and Path Planning 4

Conference Banquet
(Fischauktionshalle)

Wednesday September 30, 2015 — Conference Day

Track T8	Track T9	Track T10	Track T11	Track T12	Track T13	Track T14	Track T15
08:30–10:00 WeAT8 Hall C3 Force and Tactile Sensing 2	08:30–10:00 WeAT9 Hall C4 Biologically-Inspired Robots 4	08:30–10:00 WeAT10 Hall 8 Humanoid Robots 1	08:30–10:00 WeAT11 Hall B3 Compliance and Impedance Control 2	08:30–10:00 WeAT12 Hall B1 Marine Robotics 3	08:30–10:00 WeAT13 Hall B4 Grasping 2	08:30–10:00 WeAT14 Hall A1 Flexible Arms	08:30–10:00 WeAT15 Hall B2 Cooperative Manipulators
Coffee Break							
10:30–11:15 Hall 2 – Plenary session WeBT16 Zexiang Li From Geometry to Startups and to ... Incubators							
11:20–12:50 WeCT8 Hall C3 Force and Tactile Sensing 3	11:20–12:50 WeCT9 Hall C4 Biologically-Inspired Robots 5	11:20–12:50 WeCT10 Hall 8 Humanoid Robots 2	11:20–12:50 WeCT11 Hall B2 Multi-Robot Coordination	11:20–12:50 WeCT12 Hall B1 Learning Control	11:20–12:50 WeCT13 Hall A3 AI Reasoning Methods	11:20–12:50 WeCT14 Hall B4 Gripper and Hand Design	11:20–12:50 WeCT15 Hall B3 Distributed Robot Systems
Lunch Break							
14:00–15:30 WeDT8 Hall C4 Cellular and Modular Robots	14:00–15:30 WeDT9 Hall C3 Climbing Robots	14:00–15:30 WeDT10 Hall 8 Humanoid Robots 3	14:00–15:30 WeDT11 Hall B2 Multi-Agent Coordination	14:00–15:30 WeDT12 Hall B1 Model Learning	14:00–15:30 WeDT13 Hall A3 Formal Methods in Robotics and Automation	14:00–15:30 WeDT14 Hall B3 Industrial Robots	14:00–15:30 WeDT15 Hall B4 Intelligent Transportation Systems
Coffee Break							
16:00–16:45 Hall 2 – Plenary session WeET16 Bernd Liepert Robotic Governance: Paving the Way for Generation 'R'							
16:50–18:20 WeFT8 Hall C4 Biomimetics	16:50–18:20 WeFT9 Hall C3 Range Sensing	16:50–18:20 WeFT10 Hall 8 Humanoid Robots 4	16:50–18:20 WeFT11 Hall A1 Optimal Control	16:50–18:20 WeFT12 Hall B1 Nonholonomic Motion Planning	16:50–18:20 WeFT13 Hall A3 Gesture, Posture, Social Spaces and Facial Expressions	16:50–18:20 WeFT14 Hall B2 Dynamics	16:50–18:20 WeFT15 Hall B4 Wheeled Robots

Conference Banquet
(Fischauktionshalle)

IROS 2015 Technical Program — Thursday October 1, 2015

Keynotes and Forums	Track T1	Track T2	Track T3	Track T4	Track T5	Track T6	Track T7
08:30–10:00 ThAP Haal G1 Late Breaking Posters	08:30–10:00 ThAT1 Hall A1 Cognitive Human-Robot Interaction	08:30–10:00 ThAT2 Hall D Smart Robotics Application 1	08:30–10:00 ThAT3 Hall E Recognition	08:30–10:00 ThAT4 Hall C1+C2 Localization 4	08:30–10:00 ThAT5 Hall A3 Mechanism Design 2	08:30–10:00 ThAT6 Hall 7 Medical Robots and Systems 4	08:30–10:00 ThAT7 Hall B3 Perception for Grasping and Manipulation 1

Coffee Break

10:30–11:15

Hall 2 – Plenary session ThBT16

Gregory Hager

From Mimicricy to Mastery: Creating Machines That Augment Human Skill

Keynotes and Forums	Track T1	Track T2	Track T3	Track T4	Track T5	Track T6	Track T7
11:30–15:30 Forum Hall 2 Entrepreneur Forum	11:20–12:50 ThCT1 Hall A1 Collision Detection and Avoidance	11:20–12:50 ThCT2 Hall D Smart Robotics Application 2	11:20–12:50 ThCT3 Hall E Human Detection and Tracking	11:20–12:50 ThCT4 Hall C1+C2 Motion and Trajectory Generation	11:20–12:50 ThCT5 Hall A3 Reactive and Sensor-Based Planning	11:20–12:50 ThCT6 Hall 7 Rehabilitation Robotics 1	11:20–12:50 ThCT7 Hall B3 Perception for Grasping and Manipulation 2

13:00–14:00
Hall 2
Award Ceremony

Keynotes and Forums	Track T1	Track T2	Track T3	Track T4	Track T5	Track T6	Track T7
11:30–15:30 Forum Hall 2 Entrepreneur Forum	14:00–15:30 ThDT1 Hall D Motion Control	14:00–15:30 ThDT2 Hall A4 Space Robotics and Automation	14:00–15:30 ThDT3 Hall E Visual Servoing	14:00–15:30 ThDT4 Hall C1+C2 Motion Planning for Manipulators	14:00–15:30 ThDT5 Hall A3 Robot Audition 1	14:00–15:30 ThDT6 Hall 7 Rehabilitation Robotics 2	14:00–15:30 ThDT7 Hall B3 Dexterous Manipulation 1

Coffee Break

16:00–16:45

Hall 2 – Plenary session ThET16

Yoshihiko Nakamura

Supercomputing the loop of Biomechanics and Neuroscience

Keynotes and Forums	Track T1	Track T2	Track T3	Track T4	Track T5	Track T6	Track T7
16:50–18:20 Keynotes Hall 2 16:50–17:20 Keynote Session 7 17:20–17:50 Keynote Session 8 17:50–18:20 Keynote Session 9	16:50–18:20 ThFT1 Hall D Robot Companions and Social Human-Robot Interaction	16:50–18:20 ThFT2 Hall A4 New Actuators 2	16:50–18:20 ThFT3 Hall E Visual Tracking	16:50–18:20 ThFT4 Hall C1+C2 Navigation	16:50–18:20 ThFT5 Hall A3 Robot Audition 2	16:50–18:20 ThFT6 Hall 7 Rehabilitation Robotics 3	16:50–18:20 ThFT7 Hall B3 Dexterous Manipulation 2

Farewell Reception

(Congress Center, Foyer 2)

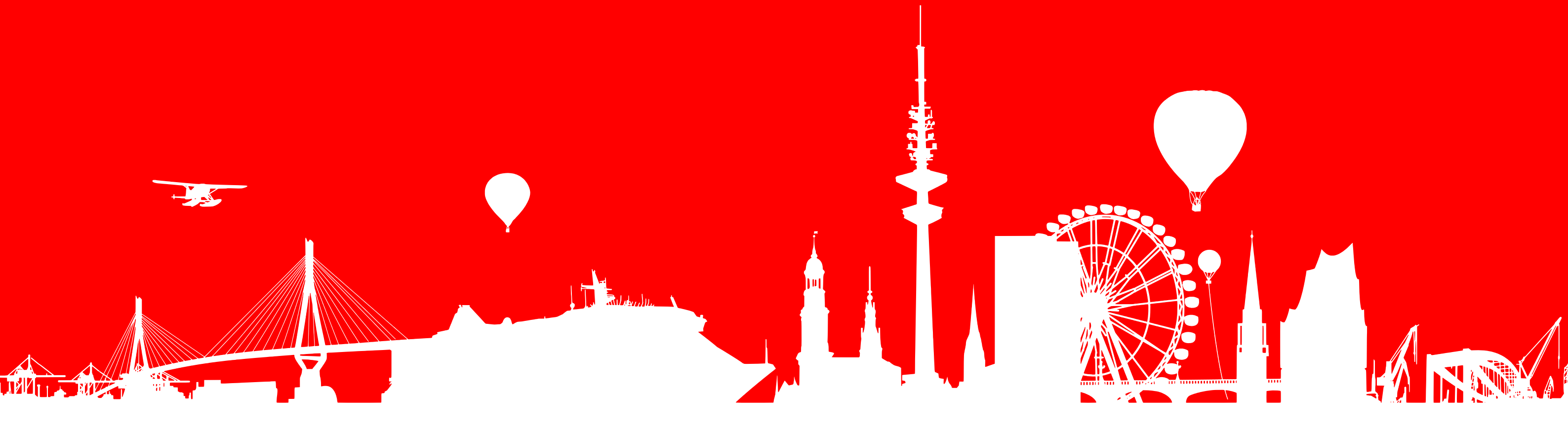
Thursday October 1, 2015 — Conference Day

Track T8	Track T9	Track T10	Track T11	Track T12	Track T13	Track T14	Track T15
08:30–10:00 ThAT8 Hall F Mapping 1	08:30–10:00 ThAT9 Hall B2 Legged Robots 1	08:30–10:00 ThAT10 Hall B4 Cloud Robotics	08:30–10:00 ThAT11 Hall B1 Telerobotics 1	08:30–10:00 ThAT12 Hall C3 Robot Learning 1	08:30–10:00 ThAT13 Hall 8 Path Planning for Mobile Robots or Agents	08:30–10:00 ThAT14 Hall C4 Robot Safety	08:30–10:00 ThAT15 Hall A4 New Actuators 1
Coffee Break							
10:30–11:15 Hall 2 – Plenary session ThBT16 Gregory Hager From Mimicricy to Mastery: Creating Machines That Augment Human Skill							
11:20–12:50 ThCT8 Hall F Mapping 2	11:20–12:50 ThCT9 Hall B2 Legged Robots 2	11:20–12:50 ThCT10 Hall B4 Autonomous Agents	11:20–12:50 ThCT11 Hall B1 Telerobotics 2	11:20–12:50 ThCT12 Hall C3 Robot Learning 2	11:20–12:50 ThCT13 Hall 8 Planning, Scheduling and Coordination	11:20–12:50 ThCT14 Hall C4 Wearable Robots	11:20–12:50 ThCT15 Hall A4 Animation and Simulation
13:00–14:00 Hall 2 Award Ceremony							
14:00–15:30 ThDT8 Hall F Mapping 3	14:00–15:30 ThDT9 Hall B2 Legged Robots 3	14:00–15:30 ThDT10 Hall B4 Human Centered Robotics	14:00–15:30 ThDT11 Hall B1 Integrated Planning and Control	14:00–15:30 ThDT12 Hall C3 Actuation and Mechanism	14:00–15:30 ThDT13 Hall 8 Sensor-Based Planning	14:00–15:30 ThDT14 Hall C4 Robotics in Construction	14:00–15:30 ThDT15 Hall A1 Tendon/Wire Mechanisms
Coffee Break							
16:00–16:45 Hall 2 – Plenary session ThET16 Yoshihiko Nakamura Supercomputing the loop of Biomechanics and Neuroscience							
16:50–18:20 ThFT8 Hall F Mapping 4	16:50–18:20 ThFT9 Hall B2 Legged Robots 4	16:50–18:20 ThFT10 Hall B4 Medical Systems, Healthcare, and Assisted Living	16:50–18:20 ThFT11 Hall B1 Integrated Task and Motion Planning	16:50–18:20 ThFT12 Hall C3 Robot Reinforcement Learning	16:50–18:20 ThFT13 Hall 8 Task Planning	16:50–18:20 ThFT14 Hall C4 Robotics in Agriculture and Forestry	16:50–18:20 ThFT15 Hall A1 Variable Stiffness Actuator Design and Control

Farewell Reception
(Congress Center, Foyer 2)

FrWS-01	FrWS-02	FrWS-03	FrWS-04	FrWS-05	FrWS-06	FrWS-07	FrWS-08	FrWS-09	FrWS-10	FrWS-11	FrWS-12
Hall 12	Hall C1	Hall 14	Hall F	Hall E	Hall C4	Hall 13	Hall C2	Hall 11	Hall D	Hall B3	Hall B4
8:30–18:00	8:30–18:00	8:30–18:00	8:30–18:00	8:30–18:00	8:30–18:00	8:30–18:00	8:30–18:00	8:30–18:00	8:30–18:00	8:30–18:00	8:30–18:00
Workshop on Task Planning for Intelligent Robots in Service and Manufac-turing	Navigation and Actuation of Flexible Instruments in Medical Applications	The Path to Success: Failures in Real Robots (FinE-R)	Transfer of Cognitive Robotics Research to Industrial Assembly and Service Robots	Physical Human-Robot Collabora-tion: Safety, Control, Learning and Applications	Sensorimotor Contingen-cies for Robotics	Second Machine Learning in Planning and Control of Robot Motion Workshop	2nd Workshop on the Role of Human Sensorimotor Control in Surgical Robotics	On-line Decision-Making in Multi-Robot Coordination	Vision-based Control and Navigation of Small, Lightweight UAVs	Agri-Food Robotics: Dealing with Natural Variability	Perception and Planning for Legged Robot Locomotion in Challenging Domains
FrWS-13	**FrWS-14**	**FrWS-15**	**FrWS-16**	**FrWS-17**	**FrWS-18**	**FrWS-19**	**FrWS-25**	**FrWSM-20**	**FrWSM-21**	**FrWSM-22**	**FrWSM-23**
Hall A4	Hall 8	Hall B1	Hall C3	Hall A2	Hall B2	Hall 15	Planten & B.	Hall 7	Hall A3	Hall A1	Hall 16
8:30–18:00	8:30–18:00	8:30–18:00	8:30–18:00	8:30–18:00	8:30–18:00	8:30–18:00	8:30–18:00	8:30–12:30	8:30–12:30	8:30–12:30	8:30–12:30
Bioinspired Underwater Robotics	2nd Workshop on Alternative Sensing for Robot Perception	Safety for Human-Robot Interaction in Industrial Settings	New Frontiers and Applications for Soft Robotics	Assistance and Service Robotics in a Human Environment	Social Norms in Robotics and HRI	ISACS 2015 Attention in Cognitive Systems	2nd Workshop on Robotics and Automation in Nuclear Facilities	TRS 2015: An Open-source Recipe for Teaching (and Learning) Robotics with a Simulator	Advances in Biologically-Inspired Brain-Like Cognition and Control for Learning Robots	Grounding Robot Autonomy: Emotional and Social Interaction in Robot Behaviour	Half-Day Hands-on Tutorial on Robotics System Toolbox from MathWorks
								FrWSA-20	**FrWSA-21**	**FrWSA-22**	
								14:00–18:00	14:00–18:00	14:00–18:00	
								ECHORD++: Urban Robotic Applications	Micro-Nano Assembly Reality Check: Customer Needs vs. Research Activities	How to Use ROS and Gazebo with the ROBOTIS OP2	

Workshops & Tutorials



Full Day Workshop MoWS-01 Mo, 28 Sep, 08:30-18:00, Hall F

7th Workshop on Planning, Perception and Navigation for Intelligent Vehicles

`http://ppniv15.irccyn.ec-nantes.fr/`

Organizers

P. Martinet (Ecole Centrale de Nantes), C. Laugier (INRIA), U. Nunes (Univ. of Coimbra), C. Stiller (KIT)

Abstract

The purpose of this workshop is to discuss topics related to the challenging problems of autonomous navigation and of driving assistance in open and dynamic environments. Technologies related to application fields such as unmanned outdoor vehicles or intelligent road vehicles will be considered from both the theoretical and technological point of views. Several research questions located on the cutting edge of the state of the art will be addressed. Among the many application areas that robotics is addressing, transportation of people and goods seem to be a domain that will dramatically benefit from intelligent automation. Fully automatic driving is emerging as the approach to dramatically improve efficiency while at the same time leading to the goal of zero fatalities. This workshop will address robotics technologies, which are at the very core of this major shift in the automobile paradigm. Technologies related to this area, such as autonomous outdoor vehicles, achievements, challenges and open questions would be presented.

Keynote Speakers

P. Bonnifait (Heudiasyc), M. Darms (Volkswagen), M. Althoff (TUM), P. Martinet (Ecole Centrale of Nantes)

Speakers

N. Chebrolu (ECN), H. Wang (NTU Singapore), S. Alsayed (INRIA), W. P. Sanberg (Eindhoven Univ. of Technology), C. Mendes (Univ. of Sao Paulo), S. Bayerl (TAS Munich), I. Dianov (TUM), S. Nobili (ECN), T. Kanji (Univ. of Fukui), P. Petrov (INRIA), D. A. Ridel (Univ. of Sao Paulo), T. Hebecker (Otto-von-Guericke-University), F. Leofante (Airbus Group Innovation), K. Matooka (Tokyo Institute of Technology), S. Michaud (Laval University)

MiRoR: Miniaturised Robotic Systems for Holistic in-situ Repair and Maintenance Works in Restrained and Hazardous Environments

http://www.miror.eu/

Organizers

Manuel Palomino García (Acciona Infraestructuras), David Herrador Muñoz (Acciona Infraestructuras), Prof. Dragos Axinte (Univ. of Nottingham), Dr. Salvador Cobos-Guzmán (Univ. of Nottingham),

Abstract

This workshop is organized by the EU funded MiRoR project and aims to present the development of a novel concept of a Miniaturised Robotic Machine (Mini-RoboMach) system that, equipped with ROS-based intelligence-driven and autonomous abilities, can perform holistic in-situ repair and maintenance of large and/or intricate installations such as those in aerospace, energy, construction and off-shore industries.

The workshop will be focused on summarizing the main achievements of the project accompanied by demonstrations and simulations of the hardware and software as follows:

- Novel concept of Mini-RoboMach, with unique complementary miniature systems:
  - Novel walking “free-leg hexapod”.
  - Original stiffness-controlled continuum robot with 24 DoF.
- Novel MiRoR ROS-based intelligent controller with which the Mini-RoboMach is utilised to perform self-positioning, reasoning and planning.
- Unique virtual test bench for the hardware and software.
- Demonstration of MiRoR system.

Speakers

Dragos Axinte, Salvador Cobos-Guzman, Xin Dongi, David Palmer, Adam Rushworth (Univ. of Nottingham), Aitor Olarra (IK4 Tekniker), Felix Messmer (Fraunhofer IPA), James Kell (Rolls-Royce)

Semantic Policy and Action Representations (SPAR) for Autonomous Robots

http://www.umiacs.umd.edu/~yzyang/spar.html

Organizers

Yezhou Yang (UMD), Neil T. Dantam (RICE), Eren Erdal Aksoy (KIT), Tamim Asfour (KIT)

Abstract

Observation and execution are dual problems for autonomous robots. A sensory-motor bridge from observation to execution of an action is essential for autonomous robots to learn from human demonstrations and generate dynamic policies to fulfill demonstrated goals. This requires not only imitation of human movements at the level of continuous signals, but moreover, semantic action representation to express the desired goals even in different scene contexts. The more expressive and structural the semantic representation, the greater the capabilities and reliability of the robot. The aim of this one-day workshop is two-fold. First, we will highlight recent developments in manipulation action semantic representations and semantic policy generation. We will also compare the state-of-the-art approaches for generic action and policy representations in both computer vision and robotics, looking for a common ground to combine assumedly disparate approaches for autonomous capability and reliability. A key goal is to reconcile and integrate various bottom-up and top-down approaches for semantic action perception.

Speakers

Benjamin Kuipers (Univ. of Michigan), Florentin Wörgötter (Univ. of Göttingen), Gordon Cheng (TUM), Hedvig Kjellström (KTH), Tamim Asfour (KIT), Yiannis Aloimonos (Univ. of Maryland), Yiannis Demiris (Imperial College London)

Designing and Evaluating Social Robots for Public Settings

http://iros15-desrps.chrisbevan.co.uk/

Organizers

Chris Bevan (Univ. of Bath), Paul Bremner (Bristol Robotics Laboratory), Danaë Stanton Fraser (Univ. of Bath), Hatice Gunes (Queen Mary University London)

Abstract

Social robotics has become increasingly important in HRI, yet robots are often still designed and evaluated using traditional lab-based experimental methods that derive from the AI roots of robotics as a field. Increasingly however, robotics researchers are considering the value of multi-disciplinary design and evaluation methods, including the mixed-methods lab-based designs used traditionally within the social sciences along with “in the wild” testing through field deployments in public settings. In this workshop, we will explore the challenges to both robotic design and evaluation methods that these hybrid methodologies create, and how these challenges might be harnessed to promote a more “human-centred” approach to HRI. The objective of this full day workshop is to bring together a multidisciplinary group of researchers to identify and address key challenges to the future study of social robotics in both lab and field. The workshop will include three guest speakers with backgrounds in a range of methodological approaches to HRI.

Speakers

Hideaki Kuzuoka (Univ. of Tsukuba), Astrid Weiss (Vienna Univ. of Technology), Laurel Riek (Univ. of Notre Dame)

Multimodal Semantics for Robotic Systems (MuSRobS)

https://musrobs-iros2015.appspot.com/

Organizers

Marco A. Gutiérrez (Univ. of Extremadura), Rafael E. Banch (A*STAR Institute for Infocomm Research, Singapore), Suraj Nair (TUM)

Abstract

Human learning and reasoning is a process that involves information obtained from a range of different senses combined to form an incredibly successful cognitive system. Artificial autonomous systems should also effectively process and combine different sensory information to compliment each other to produce better logical inferences.

Through semantic modeling of low level features within a scenario, robots can generate representation of such features in level of abstraction where logical reasoning methods could be applied to them for decision making. Furthermore, at such level more than one modalities can be fused to compliment each other and produce logical inferences. This creates the possibility of robust decision making even under scenarios where certain modalities underperform, such as generic task performances.

Lately heterogeneous cognitive systems have become quite popular among the research community, specially those using deep learning techniques over images and language sources, showing promising results. This workshop provides a uniquely focused forum for the discussion of the intersection of different fields like, audio, speech, language, images and some others into unique robotics systems that can auto-improve by learning and can be exploited through different reasoning techniques.

This workshop will bring together the foremost researchers from different fields of robotics sharing and unifying techniques that can be applied to different areas on where they are currently used. Along with the presentation of novel works in the field discussions will be encouraged to share latest advances among researchers. Finally prominent figures on the research of multimodal semantic systems will be invited to share their latest and most successful achievements and overviews on the field.

Towards Standardized Experiments in Human-Robot Interactions

clawar.org/towards-standarised-experiments-in-human-robot-interactions/

Organizers

Nicole Mirnig (Univ. of Salzburg), Paolo Barattini (Kontor 46, Torino), Dimitris Chrysostomou (Aalborg University), Lars Dalgaard (Danish Technological Institute), Maria Elena Giannaccini (Univ. of Salford), Manuel Giuliani (Univ. of Salzburg), Tamas Haidegger (Obuda University), Adriana Tapus (ENSTA-ParisTech), Gurvinder Singh Virk (Univ. of Gävle)

Abstract

This workshop aims to advance the topic of standardization of robot experiments in Human-Robot Interaction (HRI) scenarios. While the R&D community produces great amounts of scientific outputs on HRI, the results are scattered in a myriad of different approaches and ways of performing and testing the interaction; metrics which have been used include efficacy, effectiveness, users satisfaction, emotional impact and social components. The main consequence is that results are not comparable and benchmarking of the various approaches proposed is not possible. The community is still missing consensus tools to benchmark robot products (robot producer/industrial perspective) and robot applications (research/academic perspective). Models are required for the standardized assessment of robot products and applications in use in terms of safety, performance, user experience, and ergonomics. The benefit of agreed approaches and methods to the assessment of HRI is the production of results, so called “normative” data in the standardization community, meaning that they have been formulated via wide consultation in an open and transparent manner.

In this way, the results become widely acceptable, and can be exploited for the creation of international quality norms and standards which in turn would mean measurable robot performances in terms of HRI. We would like to draw from a wide set of experts from the industry, academy and standardization to focus on the key areas of industrial, personal care and medical robots. Together, we will work on establishing benchmarking scenarios and identifying suitable metrics common to HRI in these central and related robotics domains. As a result we aim for providing metrics and scenarios for robot producers and HRI researchers to evaluate their robots and robot systems and setups on a comparable level. Reproducible and comparable results and interoperable systems should be a long-term goal that will be a valuable contribution to our community.

Unconventional Computing for Bayesian Inference

http://ap.isr.uc.pt/events/UCBI_iros2015

Organizers

Jorge Lobo (Univ. of Coimbra), João Filipe Ferreira (Univ. of Coimbra)

Abstract

Contemporary robots and other cognitive artifacts are not available to autonomously operate in complex environments. The major reason for this failure is the lack of cognitive systems able to efficiently deal with uncertainty when behaving in real world situations. One of the challenges of robotics is endowing devices with adequate computational power to dwell in uncertainty and decide with incomplete data, with limited resources and power, as we and biological beings have done for a long time. To deal with incompleteness and uncertainty probabilistic Bayesian approaches have been pursued, with outstanding results. However, all these works, even if they propose probabilistic models, still rely on a classical computing paradigm that imposes a bottleneck on the performance and scalability. Improved and novel electronic devices have opened the spectrum of devices available for computation, such as GPUs, FPGAs, hybrid systems, allowing unconventional approaches to better explore parallelization and tackle power consumption. The flexibility of current reprogrammable logic devices provides a test bed for novel stochastic processors and unconventional computing. The workshop will address recent advances and future directions of probabilistic computing for robotics, with keynote speakers on Bayesian inference for autonomous robots, and insights from computational biology, as well as presentations of submitted works, setting the floor for fruitful discussions and insights in this bridge topic.

Speakers

Jacques Droulez (ISIR-UPMC), Pierre Bessière (ISIR-UPMC), João Filipe Ferreira (Univ. of Coimbra), Jorge Dias (Univ. of Coimbra), Christos Bouganis (Imperial College London)

From Plants and Animals to Robots: Movements, Sensing, and Control. Two Worlds in Comparison

http://mbr.iit.it/about/workshops/ws-iros-2015.html

Organizers

Barbara Mazzolai (IIT), Lucia Beccai (IIT)

Abstract

Robots today are expected to operate in a variety of scenarios, being able to cope with uncertain situations and to react quickly to changes in the environment. A strong relationship between nature and technology plays a major role, with the winning approach of evaluating natural systems to abstract principles for new designs. As starting point of the event PLANTOIDS, ANIMALOIDS and HUMANOIDS robotic platforms are discussed. Under this scientific and technological umbrella, we will compare ideas, biological features, and technological translations coming from the two Kingdoms and related to areas of interest in robotics: movement, sensing and control. Movement, usually ascribed to animals, is also pertinent to plants which move in a very efficient way. New actuators and materials, muscle- or not muscle-like, will be discussed, together with bioinspired tactile sensing systems, these including: the stick insect sensory system focusing on active touch; flow sensing in fish lateral line systems, and plant inspired tactile sensing. Control "with and without brain" is the concluding part, involving: plants, as information-processing organisms with complex communication, where the "command center" is mainly at root apex, for new signaling modeling and distributed networks; octopus, with distributed control in its peripheral nervous system, for new distributed embodied control models; and, computational models of Central Pattern Generators, will be presented for locomotion control in quadruped robots. The discussion sessions during the whole workshop will be chaired and guided by a professional science communicator, Sabine Hauert, who will give a view "out of the box" of biorobotics and its future impacts on the society.

Speakers

Lucia Beccai (IIT), Federico Carpi (Queen Mary Univ. of London), Massimo De Vittorio (IIT), Volker Dürr (Univ. of Bielefeld), Dario Floreano (EPFL), Auke Ijspeert (EPFL), Cecilia Laschi (SSSA), Stefano Mancuso (Univ. of Florence), Virgilio Mattoli (IIT), Barbara Mazzolai (IIT), Giorgio Metta (IIT), Roger Quinn (Case Western Reserve University), Leonardo Ricotti (SSSA), Claudio Semini (IIT)

The 6th International Workshop on Domain-Specific Languages and Models for Robotic Systems (DSLRob'15)

http://www.doesnotunderstand.org/public/DSLRob2015

Organizers

Christian Schlegel (Hochschule Ulm), Ulrik P. Schultz (Univ. of Southern Denmark), Serge Stinckwich (UMI UMMISCO), Sebastian Wrede (Bielefeld University)

Abstract

A domain-specific language (DSL) is a programming language dedicated to a particular problem domain that offers specific notations and abstractions, which, at the same time, decrease the coding complexity and increase programmer productivity within that domain. Models offer a high-level way for domain users to specify the functionality of their system at the right level of abstraction. DSLs and models have historically been used for programming complex systems. They have however recently garnered interest as a separate field of study; this workshop investigates DSLs and models for robotics. Robotic systems blend hardware and software in a holistic way that intrinsically raises many crosscutting concerns (concurrency, uncertainty, time constraints, etc.), for which reason traditional general-purpose languages often lead to a poor fit between the language features and the implementation requirements. DSLs and models offer a powerful, systematic way to overcome this problem. The DSLRob series of workshops is devoted to promoting the systematic use of DSLs in robotic systems; this year's DSLRob program includes paper presentations and discussions, invited talks, and reports on DSL-related activities in the robotics community.

Speakers

Herman Bruyninckx (Univ. of Leuven), Markus Völter (itemis AG Stuttgart)

Robotic Co-Workers

http://home.deib.polimi.it/zanchettin/IROS2015/

Organizers

Hao Ding (ABB), Andrea Maria Zanchettin (Politecnico di Milano)

Abstract

To quickly and efficiently adapt to production changes, future working environments will be populated by both humans and robots, sharing the same workspace. This scenario entails a series of issues and open topics, such as safety, optimal tasks allocation and scheduling, learning and error recovery, which are uncommon in today's industrial settings. These topics are still open for more reliable solutions and further investigations, possibly taking inspiration by successful industrial test cases. This workshop aims at bringing together academic and industrial points of view on the field of human robot collaboration, and update the discussion concerning their respective expectations, key success factors, and open topics.

Speakers

Bjoern Matthias (ABB), Brian Benoit (Rethink Robotics), Esben Østergaard (Universal Robots), Rainer Bischoff (KUKA Roboter), Fabrizio Flacco (Univ. of Rome), Sami Haddadin (Univ. of Hannover) and others.

Learning Object Affordances: A Fundamental Step to Allow Prediction, Planning and Tool Use?

http://objectaffordances.blogspot.pt

Organizers

Lorenzo Jamone (Univ. of Lisbon), Emre Ugur (Innsbruck University), Angelo Cangelosi (Univ. of Plymouth), José Santos-Victor (Univ. of Lisbon)

Abstract

Are object affordances a pre-requisite for prediciton and planning? Are the basic mechanisms involved in the learning of affordances similar to ones that lead to tool use? What are the algorithm and strategies that can support the emergence of this knowledge in robots? Can affordances enable generalisation (and even creativity) in cognitive robots?

The goal of this full-day workshop is to try to answer these questions (and more!) while depicting the current state of the art concerning the modeling of affordances and motor cognition in animals and robots, standing from a multi-disciplinary point of view, and to sketch the main challenges and future directions of the field.

Speakers

Alex Kacelnik (Oxford University), Jaqueline Fagard (University Paris Descartes), Luciano Fadiga (Univ. of Ferrara), Sinan Kalkan (Middle East Technical University), José Santos-Victor (Univ. of Lisbon), Giorgio Metta (IIT), Luc de Raedt (KU Leuven), Justus Piater (Innsbruck University), Norbert Krüger (Univ. of Southern Denmark), Yannis Aloimonos (Univ. of Maryland)

Bridging User Needs to Deployed Applications of Service Robots

robot-era.eu/robotera/index.php?pagina=pagine_personalizzate&blocco=92&id=261

Organizers

Fabio Bonsignorio, Filippo Cavallo, Paolo Dario (SSSA)

Abstract

Future service robotics will be machines that will primarily help and assist persons of all ages in daily activities at home, in their workplace and in other environments. They will be able to perform a multitude of roles thanks to their capabilities to act and interact physically, emotionally, socially and safely with humans, providing for an easier and healthier life. Despite the progress of research in the field of service robotics, there are various issues that should be addressed and solved for a wide deployment in the real daily life world and for the creation of a real market. Fundamental aspects as reliability, availability, adaptability, safety, security and maintainability (these attributes are the basis of the dependability paradigm) should be addressed and appropriately evaluated in a unique situation in order to demonstrate a consolidated technical feasibility. In addition to the technical evaluation, issues like acceptability and usability of technologies and the economic, ethical, legal and social implications, as well as standardization aspects should be strongly taken into account. The aim of this workshop is to provide a structured approach from user needs to the deployment of intelligent robot and system solutions to improve the quality of life of elders, impaired persons and everybody else by augmenting mobility, manipulation and cognitive capabilities of the users. If you are a researcher interested to turn your research results into a solution to a real need of the real life of real people, or if you are an entrepreneur willing to improve the quality of life of the greater possible number of people by making easier any activity of daily life of ordinary people, you will need a coherent set of methodologies, software, hardware and physical validation infrastructures. In this workshop we will propose a bridging approach with reference to real use-cases of service robots in a town setting. Generalizing the experience gained in a number of FP7, AAL-JP and H2020 projects, each step of the process will be discussed by leading experts with reference to cutting edge real world experiences where service robot platforms have been tested with more than 100 real users, in different locations.

Real-Time Cognitive Computing for Service Robots

http://arch.naist.jp/~yaojun/IROS-WS-CognitiveComputing.html

Organizers

Jun Yao (Huawei Tech), Nancy Amato (Texas A&M Univ.), Jun Takamatsu (NAIST), Andreas Mäder (Univ. of Hamburg)

Abstract

The goal of this workshop is to give a quick review of the rapidly evolving high-accurate machine learning and other cognition technologies, and explore the adaptability with the current and future service robots. Particularly, we start from the machine learning or statistical learning technologies that are particularly relevant to mobile robotic agents in providing them with an adaptive decision-making capability. The complexity of the related mechanisms will be then considered under the battery-life constraints that a mobile platform usually experiences. Therefore, we borrow the concept of efficiency, measured as performance per power, to measure this possible adaptability. The acceleration of the complex deep-learning tasks, such as, the convolutional neural networks, will be discussed in detail by all aspects of software, hardware and their collaboration. Meanwhile, since the machine learning techniques are usually heuristic, safety issues including false-positive and false-negative handling are also covered in our scope. We will address all these issues while discussing cutting-edge technologies in both cognitive computations and service robot planning and control systems.

Speakers

Jun Yao (Huawei), Jun Takamatsu (NAIST), Yongsheng Ou (CAS, China), Nancy Amato (Texas A&M Univ.), Kishore Konda (Goethe Univ. Frankfurt), Junyoung Park (KAIST), Chiara Bartolozzi (IIT)

Hyper Bio Assembler for 3D Cellular Innovation

http://bio-asm.jp/ws/iros2015_ws/

Organizers

Tatsuo Arai (Osaka University), Toshio Fukuda (Meijo University), Fumihito Arai (Nagoya University), Masayuki Yamato (Tokyo Women Medical University), Makoto Kaneko (Osaka University)

Abstract

The main purpose of this workshop is to discuss a new and innovative methodology: Bio Assembler. This methodology is intended for creating 3D cellular systems such as functional tissue in vitro environments, in which active functional cells selected from a living organism are used to create the 3D cellular system. This new methodology will bring innovation to the next generation of tissue engineering and will become the world's first creation of 3D cellular system in vitro environments. This innovation will be achieved by developing a methodology of hyper micro-nano measurement and control. The outcome of this innovation will bring great technological advancements to both engineering and life science field.

Speakers

Tatsuo Arai (Osaka University), Toshio Fukuda (Meijo University), Fumihito Arai (Nagoya University), Makoto Kaneko (Osaka University), Yuya Morimoto (Univ. of Tokyo), Dong Sung Kim (POSTECH), Jürgen Rühe (Univ. of Freiburg), Stéphane Regnier (ISIR, UPMC Paris), Michaël Gauthier (FEMTO-ST institute), Satyandra K. Gupta (Univ. of Maryland)

Open Forum on Evaluation of Results, Replication of Experiments and Benchmarking in Robotics Research

`http://www.heronrobots.com/EuronGEMSig/gem-sig-events/open-forum-on-evaluation-of-results-iros2015`

Organizers

Fabio P. Bonsignorio (SSSA), Elena Messina (NIST), Angel P. del Pobil (Univ. Jaume I)

Abstract

In Robotics Research the replicability of results and their objective evaluation and comparison is very difficult to put into practice.

This workshop aims to gather researchers active in the academia and the industry to share the ideas so far developed and discuss the challenges still ahead. The best contributions will be invited to submit to a refereed edited book or special issue on an high impact robotics journal. Robotics is a broad science and though we will try to cover different aspects of the discipline, the emphasis of the workshop will be on principles, methods, and applications in terms of cognitive capabilities and autonomy. We will address the issue of how to define and measure system level characteristics like autonomy, cognition or intelligence. Another key topic will be a capability-led understanding of cognitive robots: how to define shared ontologies or dictionaries to discuss robotic cognitive systems in terms of their performance, relationships between different cognitive robotics capabilities, requirements, theories, architectures, models and methods that can be applied across multiple engineering and application domains, detailing and understanding better the requirements for robots in terms of performance, the approaches to meeting these requirements and the trade-offs in terms of performance. Finally, epistemological issues in robotics research and its evaluation will be presented and discussed, related to performance measurement, methods for the objective comparison of different algorithms and systems, and the replication of published results.

Speakers

Pedro Lima (IST), Gurvinder Virk (Univ. of Gävle), Daniele Nardi (Sapienza Univ. of Rome), Matteo Matteucci (Politecnico di Milano), Maria Gini (Univ. of Minnesota), Olivier Michel (Cyberbotics Ltd.), Adriana Tapus (ENSTA-ParisTech), Vincent C. Mueller (Amerikaniko Kollegio Anatolia), Amit Kumar Pandit (Aldebaran Robotics), Fabio Bonsignorio (SSSA), Elena Messina (NIST), Angel P. Del Pobil (Univ. Jaume I)

Robotic Endoscopic Capsules for Gastrointestinal Screening, Diagnosis and Therapy: Achievements and Future Challenges

http://sssa.bioroboticsinstitute.it/workshops/REC2015

Organizers

Gastone Ciuti (SSSA), Jorge Manuel Miranda Dias (Khalifa University)

Abstract

Gastrointestinal endoscopy dates back to the 1860s, but many of the most significant advancements have been made within the past decade. Wireless capsule endoscopy (WCE), a revolutionary clinical alternative to traditional flexible scopes, enables inspection of the digestive system with minimal discomfort for the patient or the need for sedation, mitigating some of the risks of flexible endoscopy. Although WCE has entered the medical scene as a disruptive technology, it presents a number of limitations, e.g., the impossibility to actively control locomotion and camera orientation, which leads to low diagnostic specificity and false-positive results. Therefore, the natural evolution of clinical WCE consists of integrating mechanisms for closed-loop active locomotion and providing the capsule with sensors and tools for diagnosis and therapy. We propose addressing a wide range of open challenges about robotic endoscopic capsule in a dedicated workshop at IROS. Ranging from active locomotion mechanisms to sensing and therapeutic modules, the topics of interest will cover key aspects of smart robotic devices for gastrointestinal procedures. In the morning, a keynote presentation is followed by three technical sessions: i) capsules and novel flexible endoscopic devices, ii) robotic locomotion for active endoscopic capsules and iii) sensing and therapeutic modules. To represent the current research trends, we design a combination of invited talks: invited speakers will include researchers with an engineering and medical background, but also industries.

Speakers

P. Dario (SSSA), M. Keuchel (Bethesda Krankenhaus Bergedorf), A. Arezzo (Univ. of Turin), A. Koulaouzidis (The Royal Infirmary of Edinburgh), L. J. Sliker, (Univ. of Colorado at Boulder), Jong-Oh Park (Chonnam National University), G. Kosa (Tel Aviv University), G. Ciuti (SSSA), D. Iakovidis (Technological Educational Institute of Central Greece), M. Visentini-Scarzanella (Kagoshima University), M.Q.-H Meng (The Chinese Univ. of Hong Kong), V. Seetohul (Univ. of Dundee), M. Vatteroni (EYE-TECH company), and T. Nowak (MEDTRONIC company)

Towards Truly Human-like Bipedal Locomotion: The Role of Optimization, Learning and Motor Primitives

http://orb.iwr.uni-heidelberg.de/koroibot/?page_id=674

Organizers

Katja Mombaur (Univ. of Heidelberg), Diego Toricelli (CSIC, Madrid)

Abstract

Understanding human walking and teaching humanoid robots to walk in a human-like way is a challenging task in robotics. It is also one of the central goals of the European projects KoroiBot and H2R as well as the DARPA robotics challenge. To improve humanoid walking it is crucial to identify the essential characteristics of human movement and transfer it to robots. Different geometries and inertial properties of the human and humanoid systems including different kinematic and dynamic constraints have to be taken into account in this transfer.

The aim of this workshop is to present the different advantages of all these approaches as well as many promising works on combining them. Optimization or optimal control can be performed on robot and human models of different complexity taking different constraints into account, in both offline and online context. It is very useful for exploiting the physical limits of a system, but solutions might have to cope with model-reality mismatches which have to be addressed. Reinforcement learning can work without any model, iterating over reality, but in the contact of complex systems and motions that easily fail, it requires good starting data. Different types of movement primitives, such as kinematic or dynamic primitives (in different senses) provide a good approach to standardize motions taking into account constraints. Neural primitives do not refer to the explicit motion but to the signal processing side of movement.

Speakers

Philippe Souères (LAAS-CNRS) and Albert Mukovskiy (Univ. of Tübingen), Debora Clever (Univ. Heidelberg) and Dominik Endres (Univ .Marburg), Ivan Koryakovskiy (TU Delft) and Manuel Kudruss (Univ. Heidelberg), Jose Gonzalez (CSIC, Madrid) and Massimo Sartori (Göttingen), Katja Mombaur (Univ. Heidelberg) and Diego Torricelli (CSIC, Madrid), Florentin Wörgötter (Univ. Göttingen), Oussama Khatib (Stanford University), Tamar Flash (Weizmann Institute), Tamim Asfour (KIT), Karsten Berns (TU Kaiserslautern), Giovanni de Magistris (JRL CNRS-AIST, Tsukuba), Vittorio Lippi (Univ. Freiburg)

Cognitive Mobility Assistance Robots: Scientific Advances and Perspectives

robotics.ntua.gr/IROS2015-Workshop-Cognitive-Mobility-Assistance/

Organizers

Costas S. Tzafestas (National Technical Univ. of Athens), Petros Maragos (NTUA), Angelika Peer (Univ. of the West of England), Klaus Hauer (Agaplesion Bethanien Hospital Heidelberg)

Abstract

Mobility disabilities are prevalent in our ageing society and impede activities important for the independent living of elderly people and their quality of life. Designing and controlling robotic devices that can assist frail elderly people and generally people with mobility impairments constitutes an emerging research field in robotics. Many challenging scientific and technological problems need to be addressed in order to build efficient and effective assistive robotic systems, including: (i) human motion tracking, action and intention recognition fusing multimodal sensorial data, (ii) analysing and modelling human behaviour in the context of physical and non-physical human-robot interaction, (iii) developing context-aware, human-centred robot control systems that can act both proactively and adaptively in order to optimally combine physical, sensorial and cognitive assistance modalities, (iv) fostering intuitive and natural human-robot communication ultimately achieving assistive robotic behaviours that emulate the way a human carer would operate while taking into account social interaction and ethical constraints.

This workshop aims to gather researchers covering different topics within this multi-disciplinary and challenging research field. The objective is to provide a review of recent scientific and technological advancements in the field, as well as to highlight novel application perspectives, both from a clinical and an industrial viewpoint, that may have a significant societal impact in the near future.

Speakers

Rajiv Dubey (Univ. of South Florida), Naohisa Hashimoto (AIST), Yasuhisa Hirata (Tohoku University), Barbara Klein (Frankfurt Univ. of Applied Sciences), Cristina Santos (Univ. of Minho), Batłomiej Stańczyk (ACCREA Engineering, Poland)

Full Day Workshop MoWS-19: moved to Friday, 02 Oct, see FrWS-25 on page 147

Embodied-Brain Systems Science

http://embodied-brain.org/eng/iros2015workshop

Organizers

Jun Ota (U. Tokyo), Eiichi Naito (NICT), Shin-ichi Izumi (Tohoku U), Toshiyuki Kondo (TUAT)

Abstract

As the society ages rapidly, we experience a significant increase in the number of motor dysfunctions. The key to establishing effective rehabilitation techniques is to elucidate the mechanisms by which the brain adapts to changes in body functions. However, abnormalities in somatognosia can occur even in diseases that do not cause motor dysfunction. This indicates that we create/maintain an internal representation of the body in the brain. Accordingly, interdisciplinary research to investigate the neural mechanisms of the body representation in the brain and its plasticity mechanism, and to apply these findings to rehabilitation interventions is highly expected. This workshop aims to have an opportunity to bring together neuroscientists, clinicians and robotics researchers who are interested in the embodied-brain systems science and to discuss about related research topics and future direction in the field.

Speakers

Jun Ota (U. Tokyo), Hiroshi Imamizu (ATR), Hajime Asama (U. Tokyo), Tetsunari Inamura (NII), Enrico Paggelo (U. Padova), Luca Tonin (U. Padova), Kazuhiko Seki (NCNP), Ryosuke Chiba (Asahikawa Med. U.), Kahori Kita (Chiba U.)

Cooperative Vehicles and Robotic Systems for Industrial Applications

http://multirob-iros15.sciencesconf.org/

Organizers

L. Sabattini, C. Secchi (Univ. of Modena and Reggio Emilia), G. D. Tipaldi (Univ. of Freiburg)

Abstract

Recent advances in multi-robot systems offer the potential to significantly improve quality for manufacturing and other industrial applications. Advances in control systems, embedded processor, sensor, communication and networking technology in the last few decades, that have made individual autonomous systems more practical, have enabled the research on and the development of cooperative systems, where capabilities are expressed by the team rather than by a super-capable individual. This makes it possible to address challenges that are relevant for industrial applications, where typical operations often include complex tasks that require capabilities that are varied in both quantity and difficulty, such as goods transportation, distributed assembly, and infrastructure inspection. This workshop aims at bringing together experts, both from the academia and from the industries, in the field of cooperative vehicle and robotic systems exploited for solving real world industrial problems.

Speakers

K. Fuerstenberg (SICK AG), R. Bischoff (Kuka), J. Durham (Amazon Robotics), P. Martinet (IRCCYN), G. D. Tipaldi (Univ. of Freiburg), P. Rocco (Polytechnic Univ. of Milan), A. J. Lilienthal (Orebro Univ.)

Robot Competitions: What Did We Learn?

http://ap.isr.uc.pt/events/WSCompetitions_iros2015/

Organizers

Jorge Dias (Univ. of Coimbra & Khalifa University), Kaspar Althoefer (Kings College of London), Pedro Lima (Instituto Superior Técnico, Lisbon)

Abstract

This workshop aims to bring together experts active in areas of applied robotics to review past robot competitions and to find out what can be learnt from such competitions and to what extent these competitions underpin and further robot research. As an outcome, the workshop will attempt to create guidelines for future robot competitions and how those can be improved so that tangible results useful for future research and technological development can be extracted. The workshop will explore the synergies that will arise from robotic competitions for education, for the advance of modern robots and robotic technologies and/or to promote practical applications, such as rehabilitation, medical robotics, care of the elderly, search and rescue, factories of the future, etc.

Presentations and round table discussions will focus on obstacles and challenges and the future direction of robot competitions. The workshop will also act as a platform for wider discussions and aims at establishing guidelines/recommendations for future robot competitions.

See and Touch: 1st Workshop on Multimodal Sensor-based Robot Control for HRI and Soft Manipulation

http://www.lirmm.fr/IROS15_wk_Visio-haptic_control

Organizers

Andrea Cherubini (LIRMM, Université de Montpellier), Youcef Mezouar (Institut Pascal, Aubière), David Navarro-Alarcon (The Chinese Univ. of Hong Kong), Mario Prats (Google, Mountain View)

Abstract

Multimodal robot control is crucial in many applications. For instance, human-robot interaction often relies on force/tactile feedback to transmit the user intention to the robot. However, the robot should recognize the intention even without direct contact between the two. A possible solution comes from visual data, which should then be combined with haptics to obtain the best result. The automatic manipulation of soft materials represents a second case study. For all these reasons, adaptive sensor-based methods directly linking perception to action, can provide better solutions in unpredictable scenarios, than traditional planning and model-based techniques, requiring a priori models of the environment.

Speakers

Joris De Schutter (KU Leuven), Anh-Van Ho (Ryukoku University Kyoto), Jaeheung Park (Seoul National University), Eris Chinellato (School of Computing, Univ. of Leeds), Stefan Escaida Navarro, (Karlsruhe Institute of Technology), Philippe Martinet (IRCCYN, Nantes)

Spatial Reasoning and Interaction for Real-World Robotics

http://iros2015spatial-workshop.lsr.ei.tum.de/

Organizers

Dirk Wollherr (TUM), Verena Rieser (Heriot Watt University, Edinburgh)

Abstract

The aim of this workshop is to bring together researchers working in the field of cognitive robotics with special interest in spatial reasoning, in particular experts in situated HRI and NLP (including semantic grounding, dialogue, multi-party interaction, etc.) and experts in autonomous mobile robotics (Navigation in dynamically changing environments, moving obstacle recognition, motion estimation and path planning, multi-robot systems).

Speakers

John Kelleher (Dublin Institute of Technology), Mary Ellen Foster (Univ. of Glasgow), John Bateman (Universität Bremen), Dimitra Gkatzia (Heriot Watt University, Edinburgh), Daniele Nardi (Sapienza Universita di Roma), Wolfram Burgard (Univ. of Freiburg), Diedrich Wolter (Universität Bamberg), Christian Landsiedel (TUM), Dirk Wollherr (TUM), Verena Rieser (Heriot Watt University, Edinburgh)

2nd International Workshop on Aerial Open Source Robotics

https://pixhawk.org/iros2015

Organizers

Markus Achtelik, Lorenz Meier (ETH Zürich), Brandon Basso (3D Robotics)

Abstract

With ever increasing levels of autonomy and system complexity, open source collaboration has become an important factor in robotics research. Whether structured in an environment with managed software packages like ROS or by simply sharing code as ZIP file on the personal website of a researcher, the ability to push the boundaries of autonomous robots often depends on the availability of existing work to build on.

Open source robotics is by now well established in ground robotics. As aerial robotics is moving from tackling relatively self-contained navigation tasks like the flight in GPS denied environments towards addressing dynamic scenes and more challenging dynamic obstacles, open source is equally important in this field.

This workshop is providing participants a solid overview of the current state of the art in aerial robotics research. It will also provide an overview of open source solutions ranging from SLAM packages for onboard companion computers to better motor controllers for multirotors.

It will also give participants the opportunity to provide direct feedback on desired hardware and software features, and allow them to meet core developers of some popular ROS aerial robotics stacks and autopilots.

Task Planning for Intelligent Robots in Service and Manufacturing

http://www6.in.tum.de/Main/WorkshopIros2015TaskPlanning

Organizers

Andre Gaschler (fortiss Gmbh & TUM), Ron Petrick (Univ. of Edinburgh), Esra Erdem (Sabancı University)

Abstract

One of the main motivations for robot task planning is to allow intelligent robots to solve complex, real-world tasks in service and industry. While substantial progress has been made in recent years in developing many of the components needed for building such systems—symbolic reasoning, path planning, grasp planning, and trajectory generation—and powerful algorithms for solving problems in individual areas are available, the general problem of robot task planning nevertheless remains a challenge. One reason for this difficulty is that realistic task planning problems require a hybrid search in the combined symbolic action and continuous motion spaces. Only recently has this problem started to receive substantial attention in the two distinct communities of symbolic AI planning and robot motion planning, which have started working on hybrid approaches aimed at solving hard, real-world tasks in service and manufacturing robotics. This workshop invites participants from symbolic planning, robot motion planning, and related fields of research to share their ideas and findings, and to foster cooperation towards the common scientific goal of intelligent robot systems.

Speakers

Tomás Lozano-Pérez (MIT), Siddharth Srivastava (United Technologies Research Center, Berkeley), Gerhard Lakemeyer (RWTH Aachen), Volker Krüger (Aalborg University), Dinesh Manocha (Univ. of N. Carolina at Chapel Hill)

Navigation and Actuation of Flexible Instruments in Medical Applications

http://www.cross.uni-hannover.de/iros2015

Organizers

Jessica Burgner-Kahrs (Leibniz Universität Hannover), Alexander Schlaefer (Technische Universität Hamburg Harburg)

Abstract

Minimally invasive interventions are a key motivation for medical robotics. Particularly, small and flexible instruments as well as needles are a promising alternative as those devices combine less trauma and high precision for diagnosis and treatment. Placing the probe or treatment device directly into the target tissue may result in superior focality and fewer side effects. However, the access via natural orifices and cavities or through soft tissue is challenging, particularly as the properties of the tissue are patient specific and often not precisely known in advance. Typically, deformation and forces have to be considered during placement of the instrument. The workshop addresses a wide range of challenges when developing actuated flexible instruments for medical applications. Ranging from motion planning to image guidance and navigation, the topics of interest cover key aspects of intelligent robotic systems. A keynote presentation will highlight the requirements from the medical perspective, followed by a poster teaser session. Sessions on steerable flexible instruments, flexible robots, and navigation, sensing, and motion planning will each present an overview and recent research work in these areas. We encourage participants to discuss progress and challenges illustrated by the talks. A poster session will offer a platform to present recent novel work and work in progress.

Speakers

Ron Alterovitz (Univ. of North Carolina at Chapel Hill), Samuel Au (Intuitive Surgical Inc.), Jenny Dankelmann (Univ. of Delft), Jaydev Desai (Univ. of Maryland), Hubertus Feußner (University Hospital Klinikum rechts der Isar, TUM, Munich), Sungchul Kang (KIST, Korea), Sarthak Misra (Univ. of Twente), Allison Okamura (Stanford University), Ferdinando Rodriguez y Baena (Imperial College), Emmanuel Vander Poorten (KU Leuven), Michael Vogele (iSYS Medizintechnik GmbH), Robert J. Webster III (Vanderbilt University), Heinz Wörn (KIT)

The Path to Success: Failures in rEal Robots (FinE-R)

http://finer-iros2015.appspot.com/

Organizers

Luis Fernando D'Haro, Andrea Niculescu (A*STAR - Institute for Infocomm Research, Singapore), Aravindkumar Vijayalingam (TUM CREATE, Singapore)

Abstract

Along the history there are many important discoveries that resulted from long trials and error processes (e.g. the electric light bulb from Edison) or from analyzing 'failed' results (e.g. the Michelson-Morley experiment). In each case, the key contributor for the final success was the willingness to learn from previous mistakes and to share the gained experience with the research community. The path to progress in the field of robotics is not free of failures and caveats. These failures provide valuable lessons and insights on future approaches by analyzing errors and finding methods to avoid them. As such, the robotics community could benefit from the experience of those who had faced and overcome similar failures before. The objective of this workshop is to provide a forum for researchers to share their personal experiences on their "failure to success" stories, to present what they have learnt, what others should avoid while experimenting in similar context, providing tips for better research practices and for creating more successful robots that meet people's expectations. In addition, well known speakers in robotics will be invited to the workshop to share their experiences, how they avoid failures, and their recommendations for creating more robust and successful robots. Finally, the panel session will provide the right environment for attendees to learn and discuss good practices in the robotics area to avoid failing to satisfy people's expectations around robots.

Speakers

Michael Loughlin (Nelmia - Robotics Insight, Spain), Ivan Lundberg (ABB), Ryad Chellali (Nanjing Tech University)

Transfer of Cognitive Robotics Research to Industrial Assembly and Service Robots

http://caro.sdu.dk/iros15-workshop-cognitive-transfer

Organizers

Norbert Krüger (Univ. of Southern Denmark), Ales Ude (Jozef Stefan Institute), Tamim Asfour (KIT), Henrik G. Petersen (Univ. of Southern Denmark)

Abstract

In the last decade, the number of robots used in industrial production has increased by approx. 10% per year. Also, industrial robot applications frequently exploit sensorial information, in particular vision and in quite some industrial robot installations, humans operate in the vicinity of the robot. In service robotics, new kinds of robots surface on the market, most of them with rather simple sensing and actuation. The two areas – industrial robotics and service robotics - differ in the sense, that robots in industrial production are used since the 1960s, while service robots are just now entering a newly formed market with large growth potential. As a consequence, the open problems as well as the next steps for development of industrial robots can be quite well formulated while the field of commercial service robots just emerges, leaving space for fundamentally new ideas and products.

The workshop 'Transfer of Cognitive Robotics Research to industrial Assembly and Service Robots' intends to reflect on the impact of cognitive robotic research on industrial applications as well as service robotics by showing examples of successful transfer from research to application. This will allow for the analysis of the actual transfer process in both domains. In addition, today's needs of industry will be formulated by industrial partners as well as commercial potentials in the service robotic domain will be outlined.

Speakers

Henrik Christensen (Georgia Institute of Technology), Eichii Yoshida (National Inst. of Advanced Industrial Science and Technology), Ales Ude (Jozef Stefan Institute), Rüdiger Dillmann (KIT), Ulrich Reiser (Fraunhofer, IPA), Troels Oliver Vilms Pedersen (Danish Technological Institute), Dirk Kraft (Univ. of Southern Denmark)

Full Day Workshop FrWS-05 Fr, 02 Oct, 08:30-17:30, Hall E

Physical Human-Robot Collaboration: Safety, Control, Learning and Applications

http://www.idiap.ch/workshop/ws-iros2015/

Organizers

Andrej Gams (Jožef Stefan Institute), Freek Stulp (ENSTA-ParisTech), Sylvain Calinon (Idiap Research Institute)

Abstract

Recent advances in robotic hardware and control now enable robots to interact physically with humans. The interaction places challenging requirements on the safety, robustness and adaptivity on robots. But what exactly are the safety requirements on such robots? And how can such requirements be formalized? How can compliance and force control be best exploited to enable physical interaction? Should we sacrifice accurate tracking? Which forms of imitation learning should be used? And how can we associate the correct solution with a given task context? Finally, what are relevant and profitable applications for physical human-robot collaboration? In which cases is it beneficial over fully automated solutions? How can it facilitate customization of products in assembly lines? Can it also be used in medical applications? Can technologies for physical human-robot collaboration be extended to wearable robots and prosthetics? These and other questions will be addressed in lectures and an expert panel discussion.

Speakers

Sami Haddadin (Leibniz Universität Hannover), Jae-Bok Song (Korea University), Heni Ben Amor (GeorgiaTech), Matthias Bjoern (ABB Corporate Research), Kazuhiro Kosuge (Tohoku University), Sandra Hirche (TUM), Alin Albu-Schäffer (DLR Institute of Robotics and Mechatronics), Michael Mistry (Univ. of Birgmingham)

Sensorimotor Contingencies for Robotics

http://www.iri.upc.edu/groups/perception/sensorimotorIROS15/

Organizers

Ricardo Téllez (Spanish National Research Council), Guillem Alenyà (Spanish National Research Council), Cecilio Angulo (Technical Univ. of Catalonia), Kevin O'Regan (National Center for Scientific Research, France)

Abstract

The sensorimotor approach to cognition states that the key to bring semantics to the world of a robot requires making the robot learn the relation between the actions that the robot performs and the change it experiences in its sensed data because of those actions. Those relations are called sensorimotor contingencies (SMC).

The SMC approach breaks completely the classic sense-plan-act pipe that rules most of today's autonomous robots, by mixing sensation with action, aiming to bridge the gap between symbolic data and semantics for robots. The goal is to build robots with a more robust behavior in real environments.

This workshop aims to explore practical formalizations and computational models of the SMCs and their direct application to robot control and autonomy. Theoretical frameworks will also have their space on a relation of 1/3rd of the accepted papers.

Speakers

Frank Guerin (Univ. of Aberdeen), Alexander Maye (Univ. of Hamburg), David Vernon (Univ. of Skövde), Giorgio Metta (IIT), Giulio Sandini (IIT), Alexander Terekhov (Institute for Intellectual Systems and Robotics, France)

Second Machine Learning in Planning and Control of Robot Motion Workshop

http://kormushev.com/MLPC-2015/

Organizers

Aleksandra Faust (Sandia National Laboratories), Maria Gini (Univ. of Minnesota), Petar Kormushev (IIT), Marco Morales (Instituto Tecnológico Autónomo de México), Ivana Palunko (Univ. of Dubrovnik), Angela P. Schoellig (Univ. of Toronto)

Abstract

Modern robots are expected to perform complex, unsafe, or difficult tasks. Planning and executing the motions required for these tasks is difficult due to factors such as high-dimensional configuration spaces and changing environmental conditions. Moreover, uncertainty in robot dynamics and environment makes it impossible to know ahead of time how to operate best. Recent success has been made through the integration of planning methods with tools from Machine Learning (ML). For example, clustering, reinforcement learning, and intelligent heuristics have adaptively solved planning problems in complex planning spaces, automatically identified appropriate trajectories for robots with complex dynamics, and reduced the amount of time required for planning motions.

It is the goal of this workshop to explore methods and advancements afforded by the integration of ML for the planning and execution of robot motion. Because these methods are often heuristic, issues such as safety and performance are critical. Also, learning-based questions such as problem learnability, knowledge transfer among robots, knowledge generalization, long-term autonomy, task formulation, demonstration, role of simulation, and methods for feature selection define problem solvability. We will address these issues while discussing current and future directions for intelligent planning and execution of motions for robotics systems.

Speakers

Lucian Busoniu (Technical Univ. of Cluj-Napoca), Danica Kragic (Royal Institute of Technology, KTH), Matteo Leonetti (Univ. of Texas, Austin), Jan Peters (Technische Universität Darmstadt)

2nd Workshop on the Role of Human Sensorimotor Control in Surgical Robotics

www.bgu.ac.il/~nisky/Second_Motor_Control_RAMIS_workshop.htm

Organizers

Ilana Nisky (Ben-Gurion Univ. of the Negev), Anthony Jarc (Intuitive Surgical)

Abstract

Surgery is a highly complex sensorimotor task requiring surgeons to precisely control surgical instruments to operate on patients. In tele-operated robot-assisted minimally invasive surgery (RAMIS), the surgeon manipulates a pair of master manipulators that control the movement of instruments that are inserted into the patient via small incisions. The design and control of RAMIS platforms may enhance the ability of the surgeon to perform a safe and effective surgery. A comprehensive understanding of surgeon sensorimotor behaviour is fundamental to continuing innovations and improvements of surgical robots. The tele-operative nature of RAMIS allows measurement of underlying surgeon behavior, and this research is resulting in new and exciting findings that not only improve surgical robotics but also suggest a novel, applied, and real-life environment to study basic human sensorimotor control. In this workshop, we seek to foster a dialogue between researchers in the fields of: (1) computational modelling of neural control of movement, sensorimotor behaviour, and motor learning; (2) human-robot interaction, tele-operation, and surgical robotics; and (3) surgical training and skill assessment. By bringing together researchers from these fields, we hope to gain insights on future directions to improve surgical robotics as well as to advance our understanding of basic human behaviour.

Speakers

Guillaume Morel (CNRS), Peter Konig (Univ. of Osnabrück), Sam Vine (Univ. of Exeter), Giancarlo Ferrigno (Politechnico Milano), Yuichi Kurita (Hiroshima University), Daniel Braun (Max Planck Institute for Biological Cybernetics), Max Berniker (Univ. of Illinois at Chicago)

On-line Decision-Making in Multi-Robot Coordination

http://robotics.fel.cvut.cz/demur15/

Organizers

Jan Faigl (Czech Technical University in Prague), Olivier Simonin (INSIA Lyon, Francois Charpillet (INRIA), Geoffrey A. Hollinger (Oregon State University)

Abstract

On-line decision making is an important part of robotic problems where mobile robots operate in unknown or partially known dynamic environments in order to acquire information about some studied phenomena. This problem can be found in the robotic problems like autonomous data collection, environment monitoring, and robotic exploration missions that can be generally considered as variants of robotic information gathering. The key aspect of these problems is that the overall mission performance can be evaluated after the mission is completed and efficient decision-making depends on local in-situ decisions made according to the information acquired during the mission. The main goal of the workshop is to discuss and share ideas and approaches related to the on-line (in-situ) decision-making to coordinate a team of mobile robots to fulfil a global mission objective by individual actions performed by particular team members.

Speakers

Jen Jen Chung (Oregon State University, Frank Ehlers (Maritime Technology and Research), Antonio Franchi (Centre National de la Recherche Scientifique / CNRS), Benjamin Charrow (Univ. of Pennsylvania) (tentative)

Full Day Workshop FrWS-10 Fr, 02 Oct, 08:30-16:45, Hall D

Vision-Based Control and Navigation of Small, Light-Weight UAVs

http://www.seas.upenn.edu/~loiannog/workshopIROS2015uav/

Organizers

Giuseppe Loianno (Univ. of Pennsylvania), Davide Scaramuzza (Univ. of Zurich), Vijay Kumar (Univ. of Pennsylvania)

Abstract

Autonomous micro Unmanned Aerial Systems (UAVs) start to play an important role in tasks like search and rescue, environment monitoring, security surveillance, transportation and inspection. However, to deal with such operations, GPS based navigation is not sufficient. Small scale size vehicles have to fast and autonomously navigate in narrow outdoor and indoor environments, in cities or other dense environments and able to actively explore unknown areas while avoiding collisions and creating maps. This involves a number of perception and control challenges that still have to be solved. This workshop will address UAVs navigation solutions in GPS denied environments and the algorithmic and software design challenges that arise in the settings of small-scale, fast navigation in three-dimensional environments.

This full-day workshop at IROS '15 brings together researchers from academia and industry in the area of closed-loop control and navigation of Unmanned Aerial Vehicles working in indoor and outdoor GPS-denied environments, using passive vision sensors as the main sensory modality. The convergence of the consumer electronics industry and the robotics industry has opened up opportunities and solutions that did not exist a few years ago. The interest in this area of research is large and, as such, we expect to have an heterogeneours audience in terms of expertise and interests. While most previous workshops have attempted to address the fundamental problems of perception, control and communication for aerial vehicles, this workshop will instead focus on the systems challenges for small-scale, fast vehicles where the size, weight and payload constraints only allow light-weight sensors like cameras, and the operating conditions of high speeds require perception over longer ranges and shorter time scales.

Agri-Food Robotics: Dealing with Natural Variability

http://agrifoodroboticsworkshop.com/

Organizers

Gert Kootstra (Wageningen University and Research Centre), Yael Edan (Ben-Gurion Univ. of the Negev), Eldert van Henten (Wageningen University), Marcel Bergerman (Carnegie Mellon University)

Abstract

This IROS workshop focuses on the intersection between robotic systems and the agricultural sector, with emphasize on food production (agri-food robotics). One of the main challenges in this field is to deal with the huge natural variability in agricultural products and environments, and the need for flexibility to perform different tasks. The main focus of this workshop will be on presenting and discussion scientific and applied research to ensure that robots are equipped with the robustness and flexibility to deal with the variability. The workshop furthermore aims to give an overview of the state-of-the-art in the field and to discuss future direction, as well as to increase awareness of the scientific and societal challenges among robotic researchers, engineers, and practitioners in general.

Speakers

Salah Sukkarieh (Univ. of Sydney), Joachim Hertzberg (Osnabrück University), Qin Zhang (Washington State University), Richard van der Linde (Lacquey BV), and a selection of oral and poster presentations from submitted papers.

Perception and Planning for Legged Robot Locomotion in Challenging Domains

https://iros2015wsperceptionandplanning.wordpress.com

Organizers

D Kanoulas (IIT), I Havoutis (IDIAP), M. Fallon (Univ. of Edinburgh), E. Yoshida (AIST)

Abstract

In real-world unstructured environments legged robots need to locomote on very uneven and rough terrain under significant uncertainty. Exteroceptive perception is crucial for detecting foothold and handhold affordances in the environment, and generating agile motions accordingly. This workshop will provide a platform for researchers from perception and planning in legged robotics to disseminate and exchange ideas, evaluating their advantages and drawbacks. This will include methods for detecting footholds and handholds on uneven and rough surfaces for legged robots including bipeds and quadrupeds. The goal is to show various ways from sensing the environment to finding contacts and planning the body and limb trajectories for achieving agile and robust locomotion.

Speakers

S. Chung, O. Khatib (Stanford University), M. Fallon (Univ. of Edinburgh), N. Mansard, O. Stasse (LAAS-CNRS), J. Buchli (ETH Zurich), S. Behnke (Univ. of Bonn), I. Havoutis (IDIAP Research Institute), P. Karkowski, M. Bennewitz (Univ. of Bonn), D. Clever, K. Mombaur (Heidelberg University), A. Stumpf, S. Kohlbrecher, O. von Stryk (TU Darmstadt), K. Byl (Univ. of California, Santa Barbara), P. Fankhauser, M. Hutter (ETH Zurich)

Bioinspired Underwater Robotics

www.kustar.ac.ae/pages/bioinspired-underwater-robotics-workshop

Organizers

Cesare Stefanini (Khalifa University and SSSA), Federico Renda (Khalifa University)

Abstract

The research in the field of underwater robots is triggered by highly demanding applications such as exploration, inspection, maintenance and repairing in submerged areas in which interventions are essential but extremely complex, dangerous or expensive for humans. Sea or extreme underwater environments can actually be compared to a near planet, where operation is prevented by hazardous or impractical environmental conditions and by range and communication limitations. Underwater robots have been developed following two main approaches: ROVs (remotely operated vehicles) and AUVs (autonomous underwater vehicles). To date however, usable solutions for extended operation in underwater confined and complex environments, subsea installations, cavities and caves are very limited. There is need of new robotic systems that are affordable, adaptive, versatile, efficient and suitable to a wide spectrum of uses. Promising bioinspired approaches are being adopted worldwide at research level, allowing high energy efficiency in locomotion, robust multi-agent operation, advanced sensing and communication, adaptive behaviour. By taking inspiration from living marine organisms, bioinspired underwater robots adopt elegant solutions overcoming the limitations encountered by traditional engineering approaches, ranging from the exploitation of flexible bodies to the use of autonomous neuro-inspired control. Advanced prototypes are today reproducing the energy efficiency, agility and adaptability of marine creatures, providing effective and safe interaction with the environment.

Speakers

Rudolph Bannasch (EvoLogics GmbH, Berlin), Frederic Boyer (IRCCyN), Graziano Ferrari (SSSA), Tianjiang Hu (NUDT, Changsha), Auke Ijspeert (EPFL), Serge Kernbach (Cybertronica GmbH), Maarja Kruusmaa (TUT, Tallin), David Lane (Heriot-Watt Univ., Edinburgh), Cecilia Laschi (SSSA), Kin Huat Low (Nanyang Technological Univ., Singapore), Stefano Mintchev (EPFL), Thomas Schmickl (Univ. of Graz)

2nd Workshop on Alternative Sensing for Robot Perception

http://www.rit.edu/iros15workshop/

Organizers

Thierry Peynot (QUT), Sildomar Monteiro (RIT), Teresa Vidal-Calleja (UTS), Peter Corke (QUT)

Abstract

Robotic perception based on conventional sensing (color cameras and LIDAR) has lead to significant realizations in relatively restricted situations, while showing important limitations in challenging environments. The future of robotic perception lies in “alternative sensing modalities” and their intelligent combination and fusion. Examples of alternative sensing modalities include: radars, sonars and other acoustic sensors, cameras sensing outside of the visible spectrum (e.g. thermal cameras or hyperspectral/multispectral cameras), cameras using alternative acquisition processes (e.g. event-based or light-field cameras), odor sensors, etc. Operating at distinct electromagnetic frequencies, or sensing other physical properties altogether, alternative sensors have recently opened many new possibilities for robotics, such as: automatic geological analysis using hyperspectral cameras, obstacle detection through smoke or heavy dust using mm-wave radar, or robotic deep-sea exploration with sonars. This workshop aims at exploring and discussing how alternative sensing and original combinations of sensor data induce new perspectives and challenges, which may require rethinking conventional perception and data fusion algorithms, and how they will open new robotic applications and put the next great robotic achievements within reach. It follows up on a first workshop held at the Robotics: Science and Systems (RSS) 2012 conference, and a special issue of the Journal of Field Robotics published in January 2015.

Speakers

Martin Adams (Universidad de Chile), Kazuhiro Nakadai (Honda Research Institute), Davide Scaramuzza (Univ. of Zurich)

Safety for Human-Robot Interaction in Industrial Settings

http://fourbythree.eu/iros2015/

Organizers

Kaspar Althoefer (King's College London), Iñaki Maurtua (Tekniker, Spain), Hongbin Liu (King's College London), Helge Wurdemann (King's College London), José de Gea Fernández (DFKI, Robotics Innovation Center)

Abstract

This workshop aims to bring together experts active in the field of human-robot interaction with particular emphasis on safety. The sector experiences a paradigm shift from the traditional heavy-duty robot operating separated from the human worker in a fenced area to robots that work close to the human, adapting to the movements of the human and possibly even interacting with them. The workshop will explore the potential, opportunities and risks of robots operating in a modern factory environment where human-robot interaction is used as a means to pave the path for accelerated manufacturing whilst reducing costs.

Speakers

Thomas Pilz (Pilz GmbH & CO), Sami Haddadin (Leibniz Univ. of Hannover), Alessandro De Luca (Sapienza Universita di Roma), José de Gea Fernández (DFKI, Robotics Innovation Center), José Saenz (Fraunhofer IFF), Iñaki Maurtua (Tekniker, Spain), Federico Vicentini (CNR-ITIA), Kaspar Althoefer (King's College London)

New Frontiers and Applications for Soft Robotics

http://www.robosoftca.eu/events/iros-2015-workshop

Organizers

Matteo Cianchetti (SSSA), Helmut Hauser (Univ. Bristol), Fumiya Iida (Univ. Cambridge), Jonathan Rossiter (Univ. Bristol), Laura Margheri (SSSA), Cecilia Laschi (SSSA)

Abstract

The full day Workshop on “New Frontiers and Applications for Soft Robots” will attract experts across multiple fields in the soft robotics community and will be a unique occasion to gather the most prominent scientific actors of the field and industrial representatives. Soft robotics research is providing interesting achievements and there is a general opinion that it can find application in several industrial sectors. Thus this workshop is extremely timely to help focus on the needs from industry and services, that may find responses from soft robotics and to fill the gap between laboratory and industrial products. To this aim, invited speakers not only from academia but also from industry will present and discuss real world issues and possible applications where soft robotics can represent a game changer. The workshop is organized to be part of a series of scientific events planned in the framework of RoboSoft Coordination Action (EU funded project, under the FET open scheme, www.robosoftca.eu) aiming at advancing soft robotics and its marketing.

Speakers

Kyujin Cho (Seoul National University), Yong-Lae Park (Carnegie Mellon University), Daniela Rus (MIT), Kaspar Althoefer (King’s College of London), Oliver Brock (Technische Universität Berlin), Li Wen or Tianmiao Wang (Beihang University), Rich Walker (Shadow Robot), Benno Pichlmaier (AGCO), John Amend (Empire Robotics)

Assistance and Service Robotics in a Human Environment

http://lissi.fr/iros-ar2015/doku.php

Organizers

Yacine Amirat (LISSI-UPEC), Samer Mohammed (LISSI-UPEC), David Daney (INRIA Bordeaux), Anne Spalanzani (INRIA Rhone-Alpes), Norihiro Hagita (ATR Lab Kyoto), Abdelghani Chibani (LISSI-UPEC), Ren C. Luo (NTU)

Abstract

This workshop will focus on assistance and service robotics in a human environment in different contexts of human life. This major research issue will affect our lives in the near future. The integral assistance systems are robotic modules and technological aids in general for personal assistance, such as robots, mobile bases, electric wheelchairs, soft robot manipulator arm. They can support disabled and elderly people with special needs in their living environment. Assistive and Service Robotics covers a broad spectrum of research topics ranging from intelligent robots acting as a servant, secretary, or companion to intelligent robotic functions such as autonomous wheelchair navigation, embedded robotics, ambient intelligence and smart spaces. Some international industrials already think that smart houses or smart buildings (with sensors, actuators and computer capabilities) can be already considered as “static robots”. According to this vision, adding a mobile robot inside the house or the building could endow the whole system with “mobility capabilities”. This workshop will focus on the assistance in terms of mobility, social interaction, as well as everyday chores that are particularly relevant to the elderly. Topics related to social interaction, smart homes, mobility assistance, healthcare and wellbeing would be covered. Fundamental and technological research, in particular, the one related to autonomous indoor vehicles, sensor and actuators networks, wearable and ubiquitous technologies, and human-robot interaction, will be addressed.

Speakers

A. J. Ijspeert (EPFL), N. Hagita (ATR, Japan), M. Chetouani (UPMC), L. Marchal-Crespo (ETH Zurich), H. Kose (Istanbul Technical University), K.C. Kong (Sogang University), P. Salvini (SSSA), Y. Demiris (Imperial College London), J.P. Merlet (INRIA Sophia Antipolis), K. Kamei (ATR), M. Bhatt (Univ. of Bremen)

Social Norms in Robotics and HRI

http://www.spencer.eu/irosws.html

Organizers

Kai O. Arras (Univ. of Freiburg), Rudolph Triebel (TUM), Achim J. Lilienthal (Örebro University), Rachid Alami (CNRS-LAAS, Toulouse), Vanessa Evers (Univ. of Twente)

Abstract

While robots are increasingly good at solving the basic tasks of perception, navigation, and planning, designing interactive and collaborative human-robot behavior is becoming a key factor for the success of robots in human environments. Research in robotics, cognitive science and human-robot interaction (HRI) has typically focussed on the understanding and modeling of individual or pair-wise human-human or human-robot behavior. Social norms, the customary rules that govern behavior in groups, provide an extensively studied framework from the social sciences to represent socially compliant or noncompliant behavior. Enabling robots to understand these concepts is highly relevant for the design of effective and self-improving interactive and collaborative behavior. Ultimately, the workshop is driven by the prospect that the two goals of social compliance (subjective behavior goals) and task efficiency (objective behavior goals) are not mutually contradictory but actually belong together for robots to be successful in human environments.

Example tasks that involve socially normative constraints include perception and analysis of groups of people, multi-party human-robot interaction, navigation through crowds adhering to pedestrian/car traffic rules, or planning joint actions towards shared goals (see also Topics).

The workshop is coorganized by researchers of the FP7-project SPENCER, "Social situationaware perception and action for cognitive robots". We will have a project-internal review process to identify the most relevant research activities within SPENCER to be presented in the workshop. Two slots are reserved for this purpose, marked as "SPENCER talk".

Speakers

Takayuki Kanda (ATR, Osaka), Bill Smart (Oregon State University), Greg Trafton (Naval Research Laboratory), Julie A. Shah (MIT), Luis Merino (Seville University)

ISACS 2015 - Attention in Cognitive Systems

http://isacs2015.joanneum.at/

Organizers

Lucas Paletta (Joanneum Research), Simone Frintrop (Univ. of Bonn), Bilge Mutlu (Univ. of Wisconsin–Madison)

Abstract

The capacity to attend to the relevant has been part of Artificial Intelligence (AI) systems since the early days of the discipline. Currently, with respect to the design and computational modeling of artificial cognitive systems, selective attention has again become a focus of research, and one sees it important for the organization of behaviors, for control and interfacing between sensory and cognitive information processing, and for the understanding of individual and social cognition in humanoid artifacts. While visual cognition obviously plays a central role in human perception, findings from neuroscience and cognitive psychology have informed us on the perception-action nature of cognition. In particular, the embodiment in sensory-motor intelligence requires a continuous spatio-temporal interplay between interpretations from various perceptual modalities and the corresponding control of motor activities. In addition, the process of selecting information from the incoming sensory stream, in tune with contextual processing on a current task and global goals, becomes a challenging control issue within the viewpoint of focused attention. Seemingly attention systems must operate at many levels and not only at interfaces between a bottom-up driven world interpretation and top-down driven information selection.

TRS 2015: An Open-source Recipe for Teaching (and Learning) Robotics with a Simulator

Setup a Laptop in 5 Minutes, Write a Control, Navigation, Vision or Manipulation Program in 100 Lines of Code

http://teaching-robotics.org/trs-iros2015/

Organizers

Renaud Detry (Univ. of Liege), Peter Corke (Queensland Univ. of Technology), Marc Andreas Freese (Coppelia Robotics)

Abstract

This tutorial presents a cross-platform robot development and simulation environment that can be installed in five minutes and that allows students to write control, navigation, vision or manipulation algorithms in a hundred lines of Matlab or Python code. The tutorial relies on the V-REP robot simulator, and on the Matlab Robotics Toolbox (RTB). The key feature of this combination is its ease of use – both tools are trivial to install. The tutorial is intended for teachers and students. Students will install the simulation environment on their laptop and learn everything they need to know to start implementing and testing robot algorithms. Teachers will return home with a ready-to-use recipe for organizing a master-level robotics project. This event follows our successful tutorial at IROS 2014. In this instance, we will focus on providing hands-on experience to the audience with an hour-long practice session.

This event follows our successful tutorial at IROS 2014. The tutorial is intended for both teachers and students. In this instance, we will focus on providing hands-on experience to the audience with an hour-long practice session where participants will be given a chance to write a controller that allows the youBot to safely navigate a human environment.

Speakers

Renaud Detry (Univ. of Liege), Peter Corke (Queensland Univ. of Technology), Marc Andreas Freese (Coppelia Robotics)

Advances in Biologically Inspired Brain-Like Cognition and Control for Learning Robots

http://www.neurorobotics.net/workshop/iros-workshop/

Organizers

Florian Walter (TUM), Florian Röhrbein (TUM), Stefan Ulbrich (FZI), Rüdiger Dillmann (KIT)

Abstract

In recent years, new theoretical insights and increasingly cheap processing power have brought new momentum to the field of neural networks, which has evolved into two tracks of research with different goals and methods. Both of them are actively investigated robotics. In the emerging discipline of neurorobotics, the focus is on a close correspondence to experimental findings from neuroscience. In contrast, other approaches like deep learning techniques build on the theory of classical artificial neural networks but apply it at larger scales or to novel network architectures. This workshop highlights advances in biologically inspired brain-like cognition and control for robotics by bringing together experts from the fields of neurorobotics, artificial neural networks and machine learning, making it a must-attend event for everyone interested in a fresh view on cognitive robotics.

Speakers

Joni Dambre (Ghent University), Manfred Hild (Beuth Hochschule für Technik), Auke Jan Ijspeert (EPFL), Herbert Jäger (Jacobs University), Jason Yosinski (Cornell University)

Grounding Robot Autonomy: Emotional and Social Interaction in Robot Behaviour

http://cognitionreversed.com/iros-emotion-workshop/

Organizers

Robert Lowe (Univ. of Skövde), Emilia Barakova (Eindhoven Univ. of Technology), Erik Billing (Univ. of Skövde), Joost Broekens (Univ. of Delft)

Abstract

The aim of this workshop is to capture emerging trends and common problems related to the interaction autonomy of social robots. In the past, issues related to the constitutive autonomy of social robots have focused on safe interaction with the environment, and with humans. Today, we see a shift towards social robots that act in human environments and to a larger degree need to act in relation to social and emotional aspects. A nursing robot must not only interact safely with its environment, it should act in a way that communicates care and respect for patients, and that supports the social bounds necessary for the task. Such autonomous aspects have application to educational, companion and personal assistant human-robot interaction scenarios. Furthermore, many social signals should be embedded in the functional behaviors of robots, not added to the behavioral repertoire as specific gestures. Finally, the interpretation of social signals coming from humans should be integrated with the current robot behavior controller, and depending on the type of controller this is, thus, a different process. So far, robots work with what could be called “perceived” emotions and social abilities, i.e., additions to their instrumental abilities. This focus of this workshop is instead the following question: How can emotion and social interaction be grounded in the behavioral repertoire of the robotic system? This includes sub questions such as: Is the robot able to have intrinsic emotions? How could emotions, grounded in the embodiment of the robot, provide socially adaptive behavior to the robot? How can the communication of emotions between a robot and a human be grounded? The workshop welcomes conceptual papers and convincing applications, as well as concrete methods and algorithms relevant for the topic.

Speakers

Christian Balkenius (Lund University), Estela Bicho Erlhagen (Univ. of Minho), Lola Cañamero (Univ. of Hertfordshire), Stefan Wermter (Univ. of Hamburg)

Hands-on Tutorial on Robotics System Toolbox from MathWorks

http://www.mathworks.com/products/robotics/

Organizers

Yanliang Zhang,(Yanliang.Zhang@mathworks.com, MathWorks Inc.)

Abstract

MathWorks has announced the introduction of new Robotics System Toolbox™ into its MATLAB and Simulink product families. Available with the company's Release 2015a (R2015a), Robotics System Toolbox provides ready-to-use algorithms and hardware connectivity for developing autonomous mobile robotics applications. It provides an interface and complete integration between MATLAB and Simulink, and Robot Operating System (ROS) and enables engineers to design, test and deploy robotics algorithms on ROS-enabled robots and robot simulators such as Gazebo and V-REP. In this tutorial, MathWorks engineers demonstrate how to use Robotics System Toolbox for developing robotics applications with ROS-enabled robots and simulators.

Speakers

Yanliang Zhang, Carlos Santacruz-Rosero (MathWorks Inc.)

ECHORD++: Urban Robotic Applications

http://www.echord.eu/news-details/news/workshop-echord-urban-robotic-applications-friday-october-2nd-20/

Organizers

Alberto Sanfeliu, Antoni Grau and Ana Puig-Pey (Universitat Politécnica de Catalunya)

Abstract

Urban Robotics is a new challenging area of robotic applications, which will have impact in key urban areas: Collaborative Society, Mobility, ICT technology, Energy and Environment. Robots will impact among others, in transportation of people and goods, urban services (like maintenance or cleaning), environment monitoring, road repairing and urban surveillance.

The workshop will include a Key Note of the state of the art of Urban Robotics and presentations from selected invited speakers. There will be an Open Call for papers, which will follow a review process and some of them will be presented as oral presentations and the others, as posters. The papers will be compiled in workshop proceedings and distributed among the audience. We are preparing Special Issue on Urban Robotics in a JCR indexed journal.

Moreover we will present an overview of the ECHORD++ project and the current state of the Experiment and PDTI (Public end-user Driven Technological Innovation) Calls.

Micro-Nano Assembly Reality Check: Customer Needs vs. Research Activities

http://www.amir.uni-oldenburg.de/iros2015/

Organizers

Sergej Fatikow (Univ. Oldenburg), Michaël Gauthier (Femto-ST), Tobias Tiemerding (OFFIS)

Abstract

The objective of this workshop is to bring industry and research together for a discussion about current trends and challenges in industrial micro- and nano assembly. The half-day workshop will be organized in two phases. First, short talks on customer needs (15 minutes) are going to be presented by industry and research institutes. These will be followed by an evaluation of the current research topics regarding micro- and nano assembly in Horizon2020. The second step is a World-Café as a space for discussions, experience exchange and synthesis of key points in small groups. The conclusion of the workshop is the presentation of World-Café results in a panel discussion. This workshop is supported by IEEE RAS Technical Committee on Micro/Nano Robotics and Automation.

Speakers

Fumito Arai (Nagoya University), Toshio Fukuda (Nagoya University), Michaël Gauthier (Femto-ST), Olaf Mollenhauer (Tetra GmbH), David Heriban (Percipio Robotics S.A), Tobias Tiemerding (OFFIS), Quan Zhou (Aalto University), Ning Xi (Michigan State University)

Tutorial: How to Use ROS and Gazebo with the ROBOTIS OP2

http://en.robotis.com/BlueAD/board.php?bbs_id=news&mode=view&bbs_no=1140088&page=1&key=&keyword=

Organizers

K. Daun, J. Kim, R. Jung (ROBOTIS)

Abstract

Over the past few years the kid sized open humanoid-robot-platform DARwIn OP has been successfully used for research and education. So far, the computational power limited the range of applications. The newly released successor ROBOTIS OP2 is a new platform manufactured by ROBOTIS. With additional computational power it enables the robot to run more complex code on-board in real-time, for instance in the fields of computer vision or motion planning. To allow an easy exchange of software features and to encourage collaboration ROBOTIS is working on the support of the Robot Operating System (ROS), which provides an integration of several popular libraries as MoveIt, OpenCV or the physics simulator Gazebo. Currently, an interface for the kid size humanoid ROBOTIS OP2 and the full size humanoid THOR-MANG are under development. The interface for THOR-MANG will be used by Team ROBOTIS at the DARPA Robotics Challenge Finals. In the first half of the tutorial, we give an overview on the current ROBOTIS ROS environment for the OP2. First, we describe the hardware of the OP2 and give a short introduction to ROS. Afterwards, we explain the usage of ROS and the simulator Gazebo with the OP2. In the second half participants will have the opportunity to apply the new knowledge and work on a small ROS-based project with the ROBOTIS OP2.

Speakers

K. Daun, R. Jung (ROBOTIS)

2nd Workshop on Robotics & Automation in Nuclear Facilities

https://ra4nuclearfacilities.wordpress.com/wokshops/

Organizers

William R. Hamel (Univ. of Tennessee, Knoxville), Yoshi Nakamura (Univ. of Tokyo), Raja Chatila (ISIR UPMC), Hajime Asama (Univ. of Tokyo)

Abstract

The general objective of this workshop is to provide a forum for exchange between researchers and users of robotics and automation technologies in nuclear facilities. The workshop will include presentations and discussions about the challenges of normal operations, plant decommissioning, and unexpected scenarios like the recent Fukushima Daiichi accident and recovery activities.

This full-day workshop will provide the opportunity for researchers and users to meet and discuss the recent results and emerging technology requirements. Specific objectives are to provide workshop participants with:

1. Updates on key R&A technologies applicable to Nuclear Facilities from both academia and industry.
2. Presentations and discussions regarding recent nuclear power plant decommissioning uses of, and results with, R&A from around the world.
3. Presentations and discussions regarding the problems of long-term nuclear fuel storage and the roles of R&A technologies.
4. Overview of the International Research Institute for Nuclear Decommissioning and other new R&D facilities in Japan.
5. Updates on the utilization of R&A technologies at the Fukushima Daiichi site.

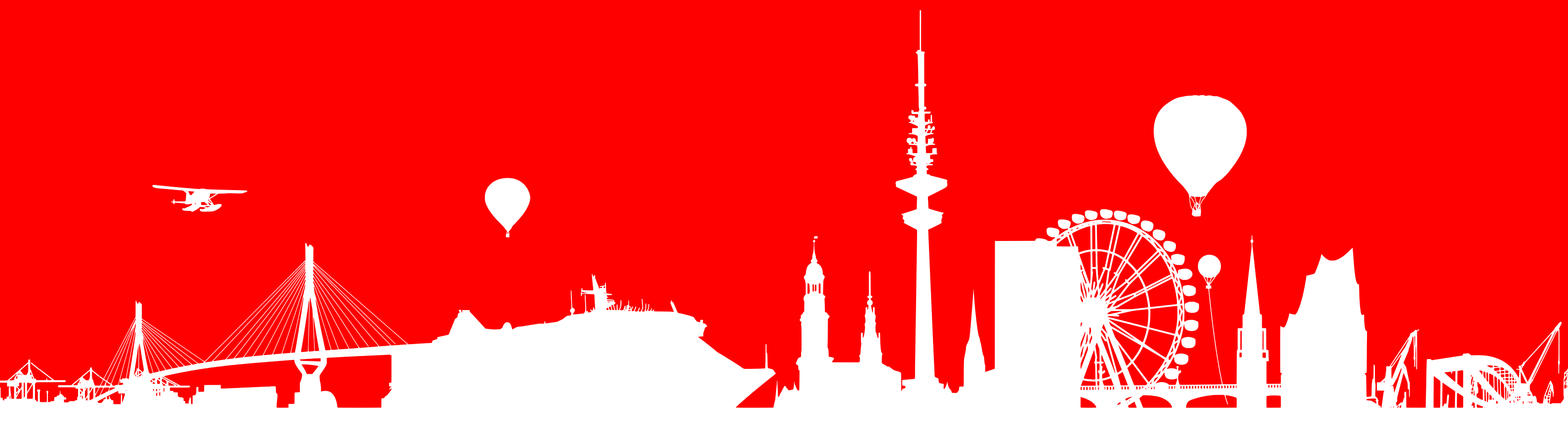
Speakers

Philipe Garrec (CEA), Shinji Kawatsuma (Japan Atomic Energy Agency), Rustan Stolkin, (Univ. of Birmingham) Claudio Semini (IIT), Tetsuo Kotoku (International Research Institute for Nuclear Decommissioning and AIST)

Technical Sessions

Tuesday

September 29, 2015



Physical Human-Robot Interaction 1

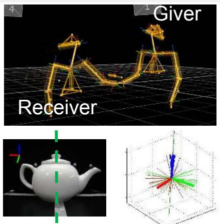
Chair *Yasuhisa Hasegawa, Nagoya University*
Co-Chair *Freek Stulp, École Nationale Supérieure de Techniques Avancées*

11:20–11:35	TuCT1.1

Characterization of Handover Orientations for Efficient Robot to Human Handovers

Wesley P. Chan[1], Matthew K.X.J. Pan[2],
Elizabeth A. Croft[2] and Masayuki Inaba[1]
[1]Univ. of Tokyo, Japan [2]Univ. of British Columbia, Canada

- Surveyed handover orientations of 20 common objects used by people.
- Identified patterns in handover orientation using novel notion of *affordance axes.*
- Computed mean handover orientations using a distance minimization approach.
- Results will be used towards enabling robots to learn handover orientations from observing natural handovers.



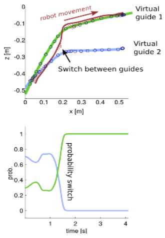
Affordance axis   Handover orientations

11:35–11:50	TuCT1.2

Co-manipulation with Multiple Probabilistic Virtual Guides

Gennaro Raiola[1,2], Xavier Lamy[3], Freek Stulp[1,2]
[1]Ensta-ParisTech, France [2]INRIA-Flowers, France [3]CEA, France

- **Virtual guides**: Constrain movement of robot along task-relevant trajectories.
- **Previous work:** Limited to single guides.
- **Our contributions:** Generate virtual guides through kinesthetic teaching; Use a probabilistic framework to select and switch between multiple different guides.
- **Pilot studies** show that probabilistic guides improve safety and efficiency of task completion.

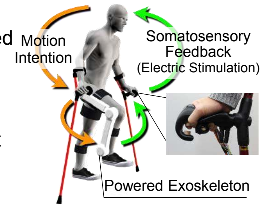


11:50–12:05	TuCT1.3

Electric Stimulation Feedback for Gait Control of Walking Robot

Yasuhisa Hasegawa[1], Keisuke Nakayama[2],
Kohei Ozawa[2] and Mengze Li[1]
[1]Nagoya University, Japan, [2]University of Tsukuba, Japan

- A finger-mounted walk controller for paraplegic patient wearing a powered exoskeleton is proposed.
- The user voluntarily controls his hip joint angle through force sensors of the controller and perceives hip joint angle through an electric stimulation device of the controller.
- A walking robot is introduced to simulate the patient body for preliminary experiment.



Powered exoskeleton with finger-mounted walk controller

12:05–12:20	TuCT1.4

Adaptive Optimal Control for Coordination in Physical Human-Robot Interaction

Yanan Li, Keng Peng Tee, Rui Yan, Wei Liang Chan, Yan Wu and Dilip Kumar Limbu
Institute for Infocomm Research (I2R), Singapore

- Game theory and policy iteration are employed to analyze the interactive behaviors of the human and the robot in physical interactions.
- The human's control objective is estimated and it is used to adapt the robot's own objective, such that human-robot coordination can be achieved.
- An optimal control is developed to achieve the robot's control objective.

12:20–12:35	TuCT1.5

Pre-Collision Control Strategy for Human-Robot Interaction Based on Dissipated Energy in Potential Inelastic Impacts

Roberto Rossi, Matteo Parigi Polverini,
Andrea Maria Zanchettin and Paolo Rocco
Politecnico di Milano, Italy

- A novel model-based injury index based on dissipated energy in potential inelastic impacts
- Reactive pre-collision control (hQP) to constrain the introduced index while reducing robot reflected mass
- Experimental validation on ABB Frida for inelastic and elastic blunt impacts

Unmanned Aerial Systems 1

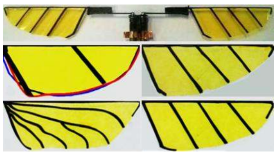
Chair *Metin Sitti, Max-Planck Institute for Intelligent Systems*
Co-Chair *Alberto Ortiz, University of the Balearic Islands*

11:20–11:35	TuCT2.1

Compliant Wing Design for a Flapping Wing Micro Air Vehicle

D. Colmenares[1], R. Kania[1], W. Zhang[1], M. Sitti[1,2]
[1]Carnegie Mellon University
[2]Max Planck Institute for Intelligent Systems

- Prior work used rigid wings for simple modeling and fabrication
- Three novel flexible designs were tested
- A twisted design improved efficiency by 73.6% and lift production by 53.2% compared to the original rigid



11:35–11:50	TuCT2.2

Fault Tolerant Control for Multiple Successive Failures in an Octorotor: Architecture and Experiments

M. Saied[1,2], B. Lussier[1], I. Fantoni[1],
C. Francis[2] and H. Shraim[2]
[1]Heudiasyc, UTC, France [2]CRSI, UL, Liban

- Complete architecture for a fault tolerant coaxial octorotor that
  - tolerates four motors failures
  - provides onboard error detection, fault diagnosis and system recovery
- Experimental validation through fault injection in real flights

Coaxial Octorotor of the Heudiasyc Laboratory

11:50–12:05	TuCT2.3

A Micro-Aerial Platform for Vessel Visual Inspection based on Supervised Autonomy

Francisco Bonnin-Pascual, Alberto Ortiz,
Emilio Garcia-Fidalgo and Joan P. Company
University of the Balearic Islands, Spain

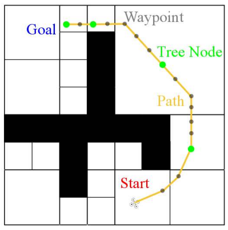
- Micro-Aerial Vehicle for vessel visual inspection
- Easy to use thanks to supervised autonomy and extensive use of behaviour-based high-level control
- Navigation managed by speed controllers fed by two optical-flow sensors
- Experimental results prove its operability and suitability

12:05–12:20	TuCT2.4

Real-Time 3D Navigation for Autonomous Vision-Guided MAVs

Shengdong Xu[1], Dominik Honegger[1],
Marc Pollefeys[1] and Lionel Heng[2]
[1]ETH Zürich, Switzerland
[2]DSO National Laboratories, Singapore

- Octree-based state lattice for optimal trajectory searches
- Encoding large swathes of free space into few symbolic octants
- Cost-optimal trajectory in real-time
- Minimized memory consumption

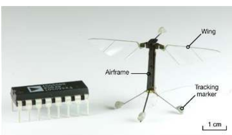


12:20–12:35	TuCT2.5

Wind Disturbance Rejection for an Insect-Scale Flapping-Wing Robot

Pakpong Chirarattananon[1], Kevin Y. Ma[2],
Richard Cheng[3], and Robert J. Wood[2]
[1]City University of Hong Kong, Hong Kong
[2]Harvard University, USA [3]Princeton University, USA

- The robotic insect has achieved unconstrained stable flight.
- Towards the goal of autonomous flight in outdoor settings, we investigate the effects of wind gusts on the flight dynamics.
- Two proposed disturbance rejection schemes reduced the position error by more then 50% when the robot was subject to 60 cm.s^{-1} horizontal wind.

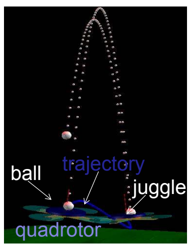


12:35–12:50	TuCT2.6

Ball Juggling with an Under-Actuated Flying Robot

Wei Dong[1], Guo-Ying Gu[1], Ye Ding[1], Xiangyang Zhu[1],
and Han Ding[1]
[1]Shanghai Jiao Tong University, Shanghai, China

- **A trajectory tracking approach for the under-actuated quadrotor robots**
- ***Applied for real-time ball juggling:***
  - more than ten hits per rally in the best cases
  - averagely 3-4 hits per rally
  - in most of the tests, ensure ≥ 2 hits per rally
- ***Also applied for cooperative juggling:***
  - verified through real-time experiments
  - *More detailed results will be presented with videos*



Robot Vision 1

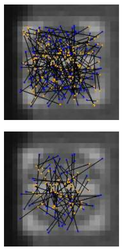
Chair *Markus Vincze, Vienna University of Technology*
Co-Chair

11:20–11:35	TuCT3.1

TailoredBRIEF: Online Per-Feature Descriptor Customization

Andrew Richardson[1], Edwin Olson[1]
[1]Ford Motor Company, USA [2]University of Michigan, USA

- Online learning to customize intensity-test image feature descriptors
- Specific intensity tests may be sensitive to changes in viewpoint or other effects
- Simulate viewpoint change in situ to determine individual test reliability
- Suppress unreliable test outcomes efficiently with little impact on run time in a keyframe-based system

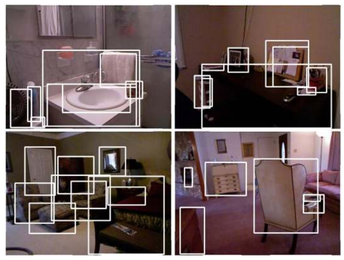


11:35–11:50	TuCT3.2

3D Selective Search for Obtaining Object Candidates

Asako Kanezaki[1] and Tatsuya Harada[1]
[1]The University of Tokyo, Japan

- New combination of Selective Search and supervoxel segmentation.
- Works on RGB-D frames.
- Produces good object candidates for the top 100 windows per frame.

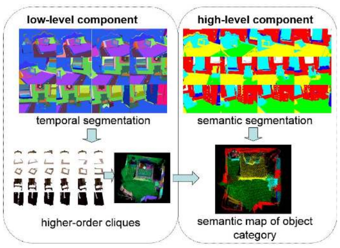


11:50–12:05	TuCT3.3

Building Temporal Consistent Semantic Maps for Indoor Scenes

Zhe Zhao and Xiaoping Chen
University of Science and Technology of China, China

- Incrementally find the temporal information and correspondence of objects
- A higher-order Dense CRF is used to enforce temporal information
- Object category and structural class are jointly inferred

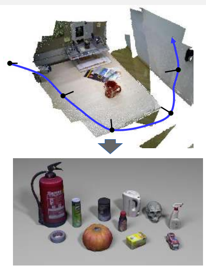


12:05–12:20	TuCT3.4

RGB-D Object Modelling for Object Recognition and Tracking

Johann Prankl, Aitor Aldoma,
Alexander Svejda and Markus Vincze
Vienna University of Technology, Austria

- Object models for recognition, tracking and visualization
- No assumption (textured/ non-textured)
- Full 3D by merging partial models
- Metrically accurate and visually appealing models
- Easy to use



12:20–12:35	TuCT3.5

A Mosaicing Approach for Vessel Visual Inspection using a Micro-Aerial Vehicle

Emilio Garcia-Fidalgo, Alberto Ortiz,
Francisco Bonnin-Pascual and Joan P. Company
University of the Balearic Islands, Spain

- A novel mosaicing approach to create mosaics using images taken from a MAV for vessel inspection
- Overlapping images are found using a BoW scheme based on a binary visual dictionary which is built online
- The approach uses a graph-registration method to find the correct topology
- Results in different environments are presented

12:35–12:50	TuCT3.6

Countering Drift in Visual Odometry for Planetary Rovers by Registering Boulders in Ground and Orbital Images

Emmanouil Hourdakis and Manolis Lourakis,
Foundation for Research and Technology-Hellas, Greece

- Visual Odometry (VO) is essential for planetary exploration rovers to operate autonomously
- However, VO's incremental mode of operation results in accumulated drift over long trajectories
- We propose a global localization method that corrects drift by matching boulders extracted from orthorectified orbital and ground images and using them periodically to re-localize the rover and refine the VO estimate

SLAM 1

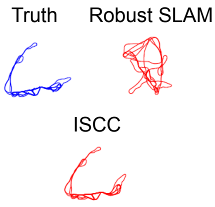
Chair *Luca Carlone, Georgia Institute of Technology*
Co-Chair *Joerg Stueckler, Technical University Munich*

11:20–11:35	TuCT4.1

Robust Incremental SLAM with Consistency-Checking

Matthew Graham[1], Jonathan P. How[2], and Donald Gustafson[1]
[1]Charles Stark Draper Laboratory, USA [2]MIT, USA

- **Problem:** Current robust SLAM algorithms not robust to landmark measurement outliers
- Formulate robust SLAM problem as an optimization. Require solution to be statistically consistent
- **Contribution:** Novel incremental SLAM algorithm, *ISCC*, that is robust to **both** loop closure and landmark errors



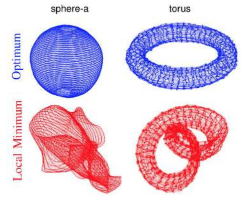
11:35–11:50	TuCT4.2

Lagrangian Duality in 3D SLAM: Verification Techniques and Optimal Solutions

Luca Carlone[1], David Rosen[2], G. Calafiore[3], John Leonard[2] and Frank Dellaert[1]
[1] Georgia Tech, USA [2] MIT, USA [3] Politecnico di Torino, Italy

- Existing SLAM back-ends do not **guarantee convergence** to the max. likelihood estimate (bad convergence = bad map)
- We use **duality theory** to derive:

1. **Verification techniques** that tell you if your optimizer (g2o, gtsam, …) converged to the right solution
2. **Optimal solutions** (when the duality gap is zero) that compute globally optimal estimates via convex programming



Our techniques can automatically evaluate the quality of a SLAM estimate, avoiding the need for visual inspection

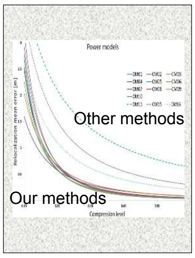
11:50–12:05	TuCT4.3

Trajectory-driven point cloud compression techniques for visual SLAM

Luis Contreras[1], Walterio Mayol-Cuevas[1],
[1]University of Bristol, United Kingdom

We develop and evaluate methods based on a novel data compression strategy for visual SLAM that uses traveled trajectory analysis.

The results show that compressing maps to levels of 25% or even less of the original data is possible, while preserving good 6D visual relocalisation performance.

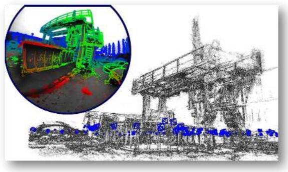


12:05–12:20	TuCT4.4

Large-Scale Direct SLAM for Omnidirectionnal Camera

David Caruso[1], Jakob Engel[1] and Daniel Cremers[2]
[1]Ecole Polytechnique,France
[2]Technische Universität München, Germany

Real-time fully direct SLAM for central omnidirectional camera. Built upon LSD-SLAM pipeline.



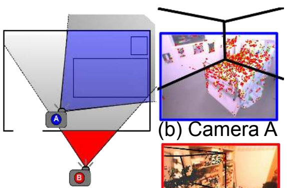
Video and dataset: https://vision.in.tum.de/omni-lsdslam

12:20–12:35	TuCT4.5

Layout Aware Visual Tracking and Mapping

Marta Salas*, Wajahat Hussain*, Alejo Concha, Luis Montano, Javier Civera, J.M.M Montiel
ROPERT, Universidad de Zaragoza, Spain

Camera view at location B shows severe occlusion of the map points inside the room. Due to our layout box reasoning, SLAM algorithm is able to reason about the occlusion and proceed with tracking the camera instead of considering itself lost as standard SLAM algorthims.



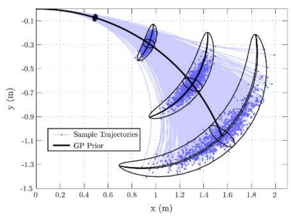
(a) Occlusion in Indoor Scene. (b) Camera A (c) Camera B

12:35–12:50	TuCT4.6

Full STEAM Ahead: Exactly Sparse Gaussian Process Regression for Batch Continuous-Time Trajectory Estimation on SE(3)

Sean Anderson and Timothy D. Barfoot
University of Toronto, Canada

- We perform batch continuous-time trajectory estimation in SE(3) using a very efficient form of Gaussian-process regression
- A physically motivated prior is proposed that results in a block-tridiagonal inverse kernel matrix
- (*right*) The mean and covariance of our *exactly* sparse GP prior match well to particles generated from an ideal nonlinear prior



Biological Applications of Micro Robots

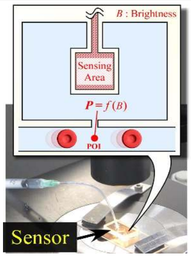
Chair *Kamilo Melo, EPFL*
Co-Chair *Barbara Mazzolai, Istituto Italiano di Tecnologia*

11:20–11:35	TuCT5.1

An On-Chip, Electricity-Free and Single-Layer Pressure Sensor for Microfluidic Applications

Chia-Hung Dylan Tsai, Toshiki Nakamura and Makoto Kaneko
Osaka University, Japan

- Pressure sensor for microfluidic applications, such as micro-robots.
- Pressure is determined based on the color intensity (brightness) in the sensing area.
- The absolute correlation between color intensity and reference pressure is 0.973.
- Pressure resolution is 3.04 kPa.
- Time constant for step response is 0.85 s.

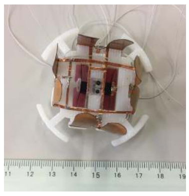


11:35–11:50	TuCT5.2

Characteristics Evaluation of a Biomimetic Microrobot for a Father-son Underwater Intervention Robotic System

Chunfeng Yue[1,3], Shuxiang Guo[1,2], Maoxun Li[1] and Yaxin Li[1]
[1]Kagawa University, Japan [2]Beijing Institute of Technology, China
[3]University of Electronic Science and Technology of China, China

- Designed a microrobot for underwater manipulation task which is inspired by an octopus.
- Realized buoyancy adjustment for the microrobot which can provide 11.8mN buoyancy force.
- Carried out a series of underwater experiments to verify the performance of the biomimetic microrobot.

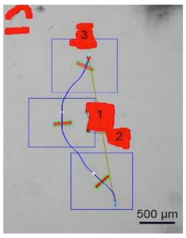


11:50–12:05	TuCT5.3

Navigation of a Rolling Microrobot in Cluttered Environments for Automated Crystal Harvesting

Samuel Charreyron[1], Roel S. Pieters[1], Hsi-Wen Tung, Maurice Gonzenbach, and Bradley J. Nelson[1]
[1] Multi Scale Robotics Lab, Zurich, Switzerland

- Automation of a rolling microrobot for protein crystal retrieval
- Real-time tracking of the microrobot and obstacles in its environment
- Obstacle free nonholonomic motion planning for basic motion
- Path following control using a moving virtual target

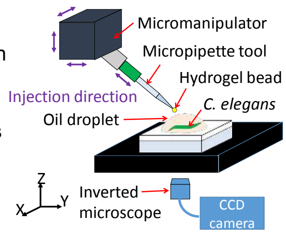


12:05–12:20	TuCT5.4

Survival Microinjection into C. elegans with In vivo Observation based on Micromanipulation

Masahiro Nakajima[1], Yuki Ayamura[1], Masaru Takeuchi[1], Naoki Hisamoto[1], Strahil Pastuhov[1], Yasuhisa Hasegawa[1], Toshio Fukuda[1,2,3], Qiang Huang[3]
[1]Nagoya University, Japan [2]Meijo University, Japan
[3]Beijing Institute of Technology, China

- Survival microinjection into *Caenorhabditis elegans* (*C. elegans*) with in vivo observation based on micromanipulation.
- Microinjections with micro-gel beads to encapsulate chemicals for injection
- Evaluation of different size of pipette tools for success and survival rates of microinjection

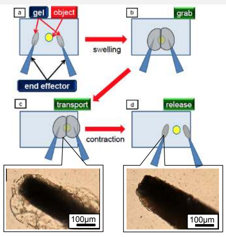


12:20–12:35	TuCT5.5

Development of thermos responsive gel coated end effector for micro manipulation

Hideaki Saijo[1], Masaru Kojima[1], Mitsuhiro Horade[1], Kazuto Kamiyama[1], Yasushi Mae[1], and Tatsuo Arai[1]
[1]Osaka University, Japan

- The pNIPAAm gel coated end effector with micro heater for micro manipulation was proposed
- We confirmed that the new gel end effector can be opened and closed by a slight change of wattage.
- The manipulation of objects using the new gel end effector was achieved



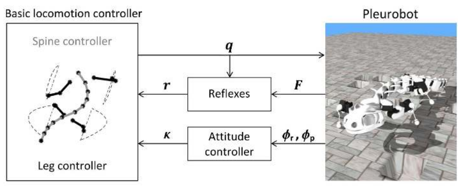
Manipulation by pNIPAAm

12:35–12:50	TuCT5.6

Inv. Kinematics and Reflex Based Controller for body-limb coordination of a Salamander-Like Robot walking on uneven terrain

T. Horvat[1], K. Karakasiliotis[1], K. Melo[1], L. Fleury[1], R. Thandiackal[1] and A. J. Ijspeert[1]
[1]Biorob, EPFL, Switzerland

- Stumble/extension reflexes + attitude controller implemented in a salamander robot
- Tested on tailed and tailless version in a simulation and on a real robot
- Improved performance on uneven terrain



Surgical Robotics 1

Chair *Paul Loschak, Harvard University*
Co-Chair *Jessica Burgner-Kahrs, Gottfried Wilhelm Leibniz Universität Hannover*

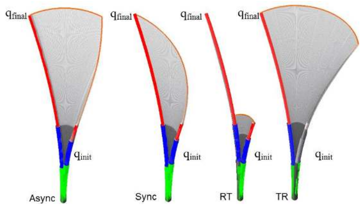
11:20–11:35 TuCT6.1

Implications of Trajectory Generation Strategies for Tubular Continuum Robots

Carolin Fellmann and Jessica Burgner-Kahrs

Center of Mechatronics, Leibniz Universität Hannover, Germany

- Concentric tube continuum robots
- 4 trajectory generation strategies
- Evaluation
- Implications for collision free path planning

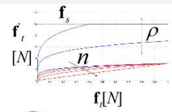
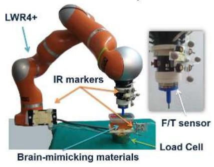


11:35–11:50 TuCT6.2

Force feedback enhancement for soft tissue interaction tasks in cooperative robotic surgery

Elisa Beretta[1,2], Federico Nessi[2], Giancarlo Ferrigno[2] and Elena De Momi[2]
[1]KUKA Roboter GmbH, Germany [2]Politecnico di Milano, Italy

- **Prevent force-induced damage to soft tissues** during hands-on robotic surgery
- Torque-based Impedance control with **non-linear force feedback** augmentation
- Performance evaluation on brain-mimicking gelatin phantoms
- **Hand-tremor rejection** and **>50% reduction of the tissue indentation depth** allows increased interaction safety

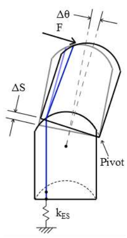



11:50–12:05 TuCT6.3

A Robotic System for Actively Stiffening Flexible Manipulators

Paul M. Loschak, S. F. Burke, E. Zumbro, A. R. Forelli, and Robert D. Howe
Harvard University, USA

- A stiffness-changing flexible manipulator is useful for improving accuracy, safety, and workflow in minimally invasive procedures
- Analytical modeling is used to relate system parameters with overall device stiffness
- Experiments validated the model
- The resulting system can automatically adjust the stiffness as desired by clinicians

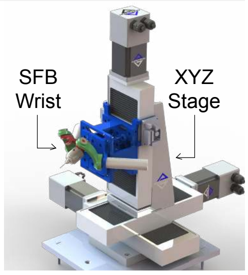


12:05–12:20 TuCT6.4

Design and Control of a Parallel Linkage Wrist for Robotic Microsurgery

Alperen Degirmenci[1], F.L. Hammond III[2], J.B. Gafford[1], C.J. Walsh[1], R.J. Wood, and R.D. Howe[1]
[1] Harvard University, USA, [2] MIT, USA

- 6-DoF teleoperated robotic system for micromanipulation and microsurgery.
- Spherical five-bar mechanism enables tool orientation.
- Design is optimized to maximize manipulability and workspace.
- “Pop-up MEMS” technology-enabled surgical gripper allows the measurement of grasping forces.

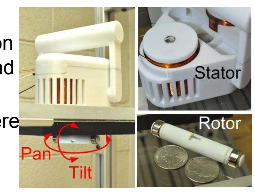


12:20–12:35 TuCT6.5

Design and Analysis of A Magnetic Actuated Capsule Camera Robot for Single Incision Laparoscopic Surgery

Xiaolong Liu[1], Gregory Mancini[1], Jindong Tan[1]
[1]University of Tennessee, Knoxville, USA

- This paper proposes a magnetic actuated camera robot for SILS.
- The design features a unified actuation for the camera fixation, translation, and rotation.
- The camera’s tilt motion dynamics were developed to achieve fine motion control.
- The camera system was theoretically analyzed and experimental validated.

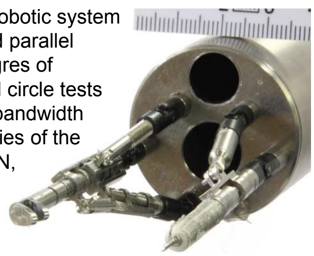


12:35–12:50 TuCT6.6

A new Single-Port Robotic System based on a Parallel Kinematic Structure

Sebastian Matich[1], Carsten Neupert[1], Andreas Kirschniak[2], Helmut F. Schlaak[1] and Peter Pott[1]
[1]Technische Universität Darmstadt, Germany
[2]University Hospital Tübingen, Germany

We present a new single port robotic system that uses a unique miniaturized parallel kinematic structure with 5 deegres of freedom. The results of several circle tests confirm the impressive speed bandwidth and the robust control capabilities of the manipulators. TCP forces of 4 N, speeds of 327 mm/s and accelerations exceeding 1 G can be achieved.



Manipulation Planning and Control 1

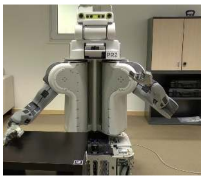
Chair *Umar Asif, UWA*
Co-Chair *Leslie Kaelbling, MIT*

11:20–11:35 TuCT7.1

POMDP Manipulation via Trajectory Optimization

Vien Ngo[1], Marc Toussaint[1]
[1]University of Stuttgart, Germany

- A framework for object manipulation based on **tactile feedback**.
- Integration of **hierarchical POMDP** and **trajectory optimization** frameworks.
- The solver is **sampling-based** and using **QMDP approximation**.
- Experiments on a simulated 7-DoF KUKA arm and the physical Willow Garage PR2 platform.

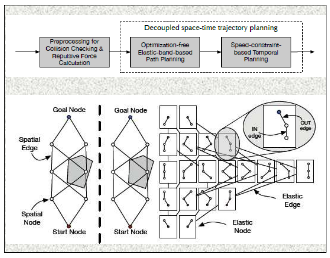


11:35–11:50 TuCT7.2

Tunable and Stable Real-Time Trajectory Planning for Urban Autonomous Driving

Tianyu Gu[1], Jason Atwood[1],
Chiyu Dong[1], John Dolan[1,2] and Jin-Woo Lee[3]
[1]ECE, CMU, USA [2]RI, CMU, USA [3]GM R&D, USA

- Real-time on-road trajectory planning for autonomous passenger vehicles.
- Computationally efficient decoupled space-time planning formulation.
- Emphasizes on the tunability and stability of the planned trajectory.
- Deliberative reference planning (DRP) with novel optimization-free elastic-band method.
- Reactive local planning (RLP) with focused trajectory sampling and search pattern.

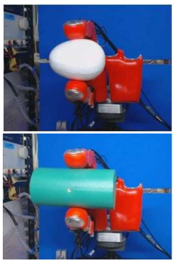


11:50–12:05 TuCT7.3

Robust In-Hand Manipulation of Variously Sized and Shaped Objects

Satoshi FUNABASHI, Alexander SCHMITZ,
Takashi SATO, Sophon SOMLOR and Shigeki SUGANO
Waseda University, Japan

- TWENDY-ONE's hand: 13 motors, springs, 6-axis F/T in fingertips, soft and sensitive skin
- Learning from demonstration
- Untrained/unknown object shape and posture
- Object size from initial grasping posture
- More stable with sensors
- More robust than interpolation control
- With deep learning less supervised learning necessary



12:05–12:20 TuCT7.4

Hierarchical planning for multi-contact non-prehensile manipulation

Gilwoo Lee [1], Tomás Lozano-Pérez [1],
and Leslie Pack Kaelbling[1]
[1]Massachusetts Institute of Technology, USA

- Hierarchical approach to planning sequences of non-prehensile and prehensile actions.
- Subdivide the planning problem into three stages (object contacts, object poses and robot contacts)
- Significant reduction in search space

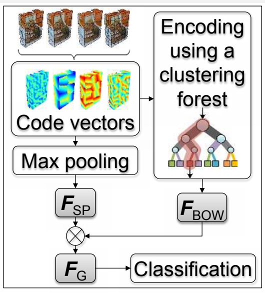
LIS LEARNING & INTELLIGENT SYSTEMS

12:20–12:35 TuCT7.5

Discriminative Feature Learning for Efficient RGB-D Object Recognition

U. Asif, M. Bennamoun,and F. Sohel
The University of Western Australia, Australia

- Feature code vectors are extracted from several segmentations of an RGB-D object.
- Code vectors are max-pooled into a vector F_{SP} and encoded into a Bag-of-Words based vector F_{BOW} using a random clustering forest.
- The vectors F_{SP} and F_{BOW} are concatenated into a feature representation F_G for object-class prediction.



Sensor Fusion 1

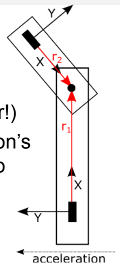
Chair *Jaime Valls Miro, University of Technology Sydney*
Co-Chair *Marko Munih, University of Ljubljana*

11:20–11:35	TuCT8.1

Posture from Motion

Felix Wenk[1], Udo Frese[1,2],
[1]DFKI Bremen, Germany [2]University of Bremen, Germany

- **Skeleton**: Network of bodies
- **Posture**: Relative orientations of bodies
- **Hardware**: One IMU per body (no magnetometer!)
- **Idea:** Use (changing) accelerations of the skeleton's **motion** measured by IMUs on adjacent bodies to determine their posture.

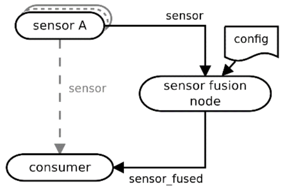


11:35–11:50	TuCT8.2

Generic Sensor Fusion Package for ROS

Denise Ratasich[1], Bernhard Frömel[1],
Oliver Höftberger[1] and Radu Grosu[1]
[1]Vienna University of Technology, Austria

- sensor- and application-independent
- configurable sensor fusion node
- handling asynchronous multi-rate measurements
- simple integration
- into applications running on top of the Robot Operating System

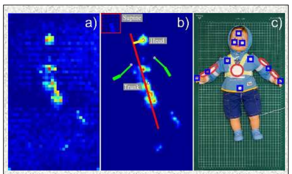


11:50–12:05	TuCT8.3

Using sensory data fusion methods for infant body posture assessment

A. Rihar[1], M. Mihelj[1], J. Pašič[1], J. Kolar[1], and M. Munih[1]
[1]University of Ljubljana, Slovenia

- Infant motor ability assessment
- Pressure distribution mattress
- Wireless inertial and magnetic measurement units on infant's trunk and arms
- Sensor data processing and fusion
- Validation with referential measurement system
- EU FP7 project CareToy



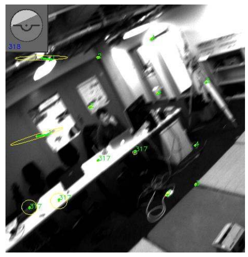
Raw (a) and processed (b) pressure image. c) Baby doll with measurement sensors

12:05–12:20	TuCT8.4

Robust Visual Inertial Odometry Using a Direct EKF-Based Approach

Michael Bloesch, Sammy Omari,
Marco Hutter and Roland Siegwart
ETH Zürich, Switzerland

- Fully robocentric filter state with camera extrinsics and IMU biases
- Minimal bearing vector and distance parametrization for features
- Direct tracking of multilevel patch features within the EKF
- Intensity errors as innovation term in the EKF update

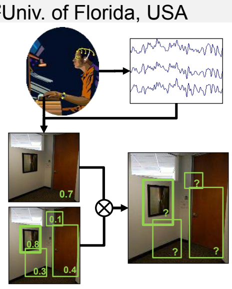


12:20–12:35	TuCT8.5

Human-Autonomy Sensor Fusion For Rapid Object Detection

Ryan Robinson[1], Hyungtae Lee[1], Michael McCourt[2]
Amar Marathe[1], Heesung Kwon[1], Chau Ton[2]
and William Nothwang[1]
[1]Army Research Lab, USA [2]Univ. of Florida, USA

- Augment computer-vision-based object detection with human neuro-physiological response (EEG + button) via late fusion
- Rapid serial visual presentation (RSVP) speeds human input for image triage applications
- 5% relative increase in mean average precision over computer-vision-only



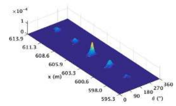
12:35–12:50	TuCT8.6

Kidnapped Laser-Scanner for Evaluation of RFEC Tool

Raphael Falque, Teresa Vidal-Calleja,
and Jaime Valls Miro
Centre for Autonomous System (CAS),
University of Technology Sydney, Australia

- Multimodal map matching for localisation in pipeline maps
- The approach models the correlation between modalities as a likelihood used to update a location prior
- The methodology accounts for the cylindrical geometry of the pipe using directional statistics

The pipe is scanned (top) and localised within the map (bottom)



Biologically-Inspired Robots 1

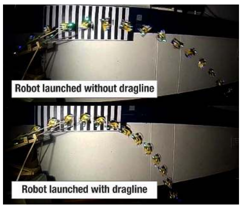
Chair *Mariapaola D'Imperio, Istituto Italiano di Tecnologia*
Co-Chair *Inaki Rano, Ulster University*

11:20–11:35	TuCT9.1

A Spider-Inspired Dragline Enables Aerial Pitch Righting in a Mobile Robot

Stacey Shield, Callen Fisher
and Amir Patel
University of Cape Town, South Africa

- Mechanism for achieving aerial pitch righting in mobile robots inspired by jumping spiders' draglines.
- Tested using mathematical model of spider and small robotic platform.
- Dragline can also potentially function as an aerial brake.
- It may have size and weight advantages over established righting methods.

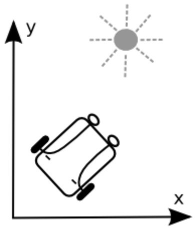


11:35–11:50	TuCT9.2

Noise, Morphology and Control. The Stochastic behaviour of Braitenberg vehicles.

Inaki Rano[1]
[1]Ulster University, UK

- Braitenberg vehicles (BV): bio-inspired non-linear controllers for wheeled robots.
- Existing models assume noise-free sensors.
- We present the first analysis with Gaussian sensor noise
- Trajectory PDF depends on: Noise levels, robot morphology, and BV parameters.
- We obtained: features of the best BV parameters, and PDF uncertainty bound.

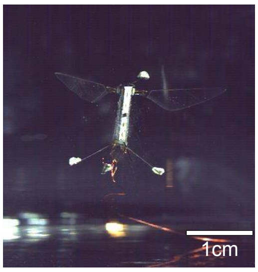


11:50–12:05	TuCT9.3

Hybrid aerial and aquatic locomotion in an at-scale robotic insect

Yufeng Chen, E. Farrell Helbling,
Nick Gravish, Kevin Ma, and Robert J. Wood
John A. Paulson School of Engineering and Applied Sciences, Harvard University, USA

- Identify a multi-modal flapping strategy that enables locomotion in both air and water in a single device
- Develop a computational fluid dynamics simulation to model fluid-wing interaction in air and water
- Demonstrate a flying and swimming capable flapping-wing insect-like robot

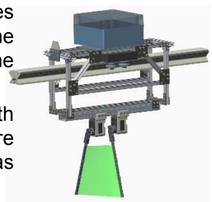


12:05–12:20	TuCT9.4

Dynamic Modeling and Experimental Analysis of a Two-Ray Undulatory Fin Robot

Michael Sfakiotakis[1], John Fasoulas[1], and Roza Gliva[1]
[1]Technological Educational Institute of Crete, Greece

- We present a dynamic model for a two-ray undulatory fin system, which incorporates hydrodynamic contributions, as well as the effect of the elastic membrane deformation.
- The model's main aspects, particularly with regard to the hydrodynamic effects, are explored via simulation studies, as well as via experiments with a robotic prototype.
- The developed model can aid in optimizing the design, control, and propulsive efficacy

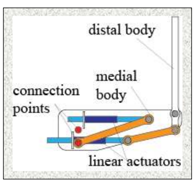


12:20–12:35	TuCT9.5

A Novel Parallely Actuated Bio-Inspired Modular Limb

Mariapaola D'Imperio, Luca Carbonari, Nahian Rahman, Carlo Canali and Ferdinando Cannella
Advanced Robotics Department of Istituto Italiano di Tecnologia, Genoa, Italy

- Novel bio-inspired general purpose limb
- Modularity and inertia reduction
- Direct and Inverse Kinematic analysis



12:35–12:50	TuCT9.6

Emotional modulation of PPS as a way to represent reachable and comfort areas

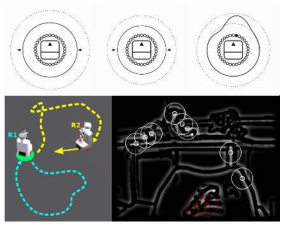
Marwen Belkaid, Nicolas Cuperlier and Philippe Gaussier
ETIS Lab, CNRS/ENSEA/Univ. Of Cergy-Pontoise

- **Proposed model:** Emotions modulate the perception of the peripersonal space (*PPS*)

→comfort zone + reachable space

- **Experiments:**

From 1-resource survival tasks towards vision-based object reaching



Humanoid and Bipedal Locomotion 1

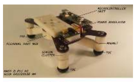
Chair *Sven Behnke, University of Bonn*
Co-Chair *David Orin, The Ohio State University*

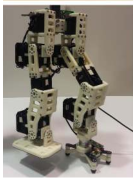
11:20–11:35 TuCT10.1

A Three-Toe Biped Foot with Hall-Effect Sensing

Sergio Castro Gomez[1], Marsette Vona[1], and Dimitrios Kanoulas[2]
[1]Northeastern University, USA
[2]Istituto Italiano di Technologia, Italy

- novel foot design for biped robots to sense the **Center of Pressure**
- new **reliable** and **low-cost** method to detect contact forces by the deflection of three flexural toes using **Hall-effect magnetic field** sensors
- calculate the CoP from force measurements comparing five **Neural Network** models
- same level of **accuracy** and **reliability** as with standard force sensing resistors



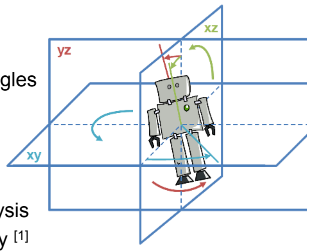


11:35–11:50 TuCT10.2

Fused Angles: A Representation of Body Orientation for Balance

Philipp Allgeuer, Sven Behnke
University of Bonn, Germany

- Novel representation of 3D orientations
- Properties superior to Euler angles
- Designed for applications that involve balance, e.g. walking robots
- Complete mathematical and geometric definitions and analysis
- Released Matlab/Octave library [1]



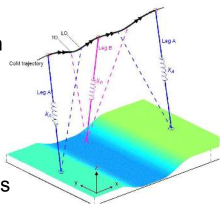
[1] Link: https://github.com/AIS-Bonn/matlab_octave_rotations_lib

11:50–12:05 TuCT10.3

Dynamic Walking in a Humanoid over Uneven Terrain Using a 3D-Actuated Dual-SLIP Model

Yiping Liu[1], Patrick M. Wensing[2], David E. Orin[1] and Yuan F. Zheng[1]
[1]The Ohio State University [2]Massachusetts Institute of Technology

- Scenario: **prepared** uneven terrain
- Template: 3D Dual-SLIP w/ leg actuation
- Nonlinear trajectory optimization based on a multiple-shooting formulation
- Address 1-step terrain height change up to 10% of leg length
- Resultant gaits show human-like features
- Applicability demonstrated to control Atlas walking over uneven terrain in simulation

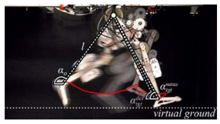


12:05–12:20 TuCT10.4

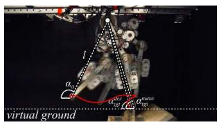
Evaluation of Decentralized Reactive Swing-Leg Control on a Powered Robotic Leg

Alexander Schepelmann[1], Jessica Austin[1], and Hartmut Geyer[1]
[1]Carnegie Mellon University, USA

- A decentralized reactive swing-leg controller for robust foot placement into desired ground targets is transferred to and evaluated on robotic hardware.



- The controller enables robust foot placements on hardware, both when swing-leg motion is undisturbed, as well as when obstacles are encountered in early, mid, and late swing.

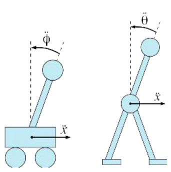


12:20–12:35 TuCT10.5

Gradient-Driven Online Learning of Bipedal Push Recovery

Marcell Missura, Sven Behnke,
Autonomous Intelligent Systems, University of Bonn, Germany

Using a pendulum-cart motivated gradient estimation and an online capable function approximator, a real robot learns strong push recovery skills form the experience of only a few steps.



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Autonomous Intelligent Systems

12:35–12:50 TuCT10.6

Experimental Validation of a Bio-Inspired Controller for Dynamic Walking with a Humanoid Robot

N. Van der Noot[1,2], L. Colasanto[2], A. Barrea[1], J. van den Kieboom[2], R. Ronsse[1] and A. J. Ijspeert[2]
[1]Université catholique de Louvain, Belgium
[2]École Polytechnique Fédérale de Lausanne, Switzerland

- Humanoid robot locomotion gaits are still far from the impressive human gaits.
- **Bio-inspired** walking controllers achieve more human-like gaits, mainly in simulation.
- Porting one of these bio-inspired controllers to a real robot, we perform a **50 steps walk** experiment.
- The resulting gait exhibits some **human-like features** like stretched stance leg.

Swarm Robotics

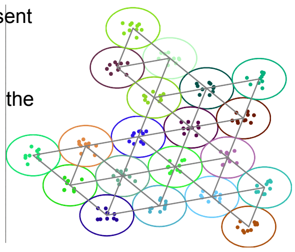
Chair *Joshua Peter Hecker, University of New Mexico*
Co-Chair *Shigang Yue, University of Lincoln*

11:20–11:35 TuCT11.1

Segregating Multiple Groups of Heterogeneous Units in Robot Swarms

Edson Filho[1], Luciano Pimenta[1]
[1]Universidade Federal de Minas Gerais, Brazil

- Create an **Abstraction** to represent each group;
- A **Potential Function** separates the groups;
- Group centers form a **Lattice**;
- **Guaranteed** convergence;

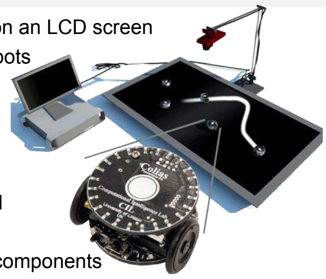


11:35–11:50 TuCT11.2

COSΦ: Artificial Pheromone System for Robotic Swarms Research

Farshad Arvin[1], Tomáš Krajník[1], Ali Emre Turgut[2] and Shigang Yue[1]
[1]University of Lincoln, UK [2]METU, Turkey

- Light-sensitive robots move on an LCD screen
- External camera localizes robots
- Artificial pheromones are released at robots' positions
- Pheromones are displayed on the LCD screen
- Robots sense, follow or avoid the displayed pheromones
- Open-source & off-the-shelf components

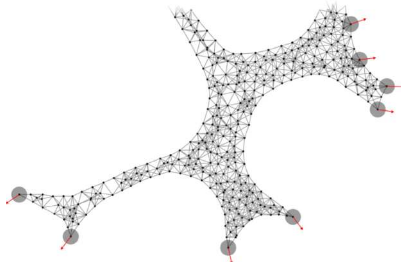


11:50–12:05 TuCT11.3

Distributed Cohesive Control for Robot Swarms: Maintaining Good Connectivity in the Presence of Exterior Forces

Dominik Krupke[1], Maximilian Ernestus[1], Michael Hemmer[1] and Sándor P. Fekete[1]
[1]TU Braunschweig, Germany

Leader robots form Steiner trees using **local heuristics** which yield **fault-tolerant** and **self-stabilizing** swarm behavior.

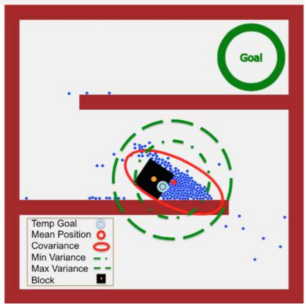


12:05–12:20 TuCT11.4

Stochastic Swarm Control with Global Inputs

Shiva Shahrokhi, Aaron T. Becker
University of Houston, TX, USA

- Push a block through a maze using a swarm of robots with *global inputs*—all robots get the same global input
- We present a hybrid, hysteresis, mean & variance controller
- We choose *local goals* to steer the swarm: collect swarm in corners, aggregate behind block to push

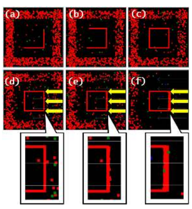


12:20–12:35 TuCT11.5

Collective Construction of Dynamic Structure Initiated by Semi-Active Blocks

Ken Sugawara[1], Yohei Doi[1],
[1]Tohoku Gakuin University, Japan

- We propose of collective construction method through interaction between simple robots and intelligent blocks.
- Constructed structure is under dynamic equilibrium.
- We also show the structure could reinforce its wall to adapt to external stress.

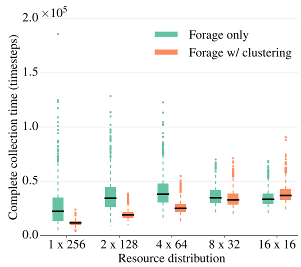


12:35–12:50 TuCT11.6

Exploiting Clusters for Complete Resource Collection in Bio-Inspired Robot Swarms

Joshua P. Hecker[1], Justin Craig Carmichael[1], and Melanie E. Moses[1,2]
[1]University of New Mexico, USA [2]Sante Fe Institute, USA

- **Robot swarms** search for and collect clustered resources
- Swarms use **EM** and **BIC** to find and exploit residual resources
- Information gathered when collecting **first 90%** of resources is vital to exploiting **last 10%**
- Biologically-inspired methods + Machine learning algorithms = **Robust**, **efficient search**



Learning from Demonstration

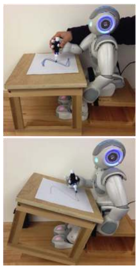
Chair *Rüdiger Dillmann, Karlsruhe Institute of Technology (KIT)*
Co-Chair *Sylvain Calinon, Idiap Research Institute*

11:20–11:35	TuCT12.1

Feature Space Decomposition for Effective Robot Adaptation

Chi Zhang[1], Hao Zhang[2], and Lynne E. Parker[1]
[1]University of Tennessee, USA [2]Colorado School of Mines, USA

- A novel Feature Space Decomposition approach is presented.
- Decompose high-dimensional original features extracted from demonstration data into principal and non-principal features.
- Non-principal features form a new low-dimensional search space for Reinforcement Learning to explore new environments.
- Robots adapt effectively, and find optimal solutions more quickly.

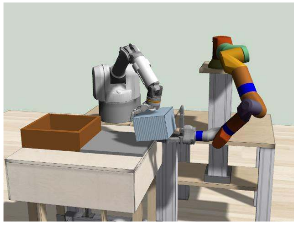


11:35–11:50	TuCT12.2

Probabilistic Progress Prediction and Sequencing of Concurrent Movement Primitives

Simon Manschitz[1,2], Jens Kober[3], Michael Gienger[2] and Jan Peters[1]
[1]TU Darmstadt [2]Honda RI-EU [3]TU Delft

- Approach for learning manipulation tasks that require concurrent motions
- Probabilistic prediction of progress for each MP
- Implicit synchronization of concurrent sequences
- Evaluated in bi-manual pick-and-place simulation study

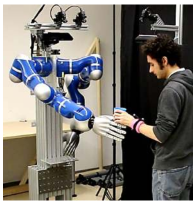


11:50–12:05	TuCT12.3

Learning Motor Skills from Partially Observed Movements Executed at Different Speeds

Marco Ewerton[1], Guilherme Maeda[1], Jan Peters[1,2] and Gerhard Neumann[1]
[1]TU Darmstadt, Germany [2]MPI, Germany

- This paper proposes an **Expectation-Maximization** algorithm to learn **Probabilistic Movement Primitives** from multiple demonstrations.
- The proposed algorithm allows for learning from trajectories with **missing data** and accounts for the **spatial-temporal variability** of the demonstrations.
- Some of the applications of this work lie in the field of Human-Robot Interaction.

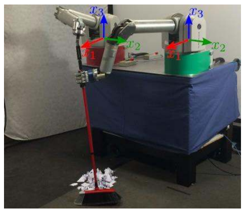


12:05–12:20	TuCT12.4

Learning bimanual end-effector poses from demonstrations using task-parameterized dynamical systems

João Silvério[1], Leonel Rozo[1], Sylvain Calinon[1,2] and Darwin G. Caldwell[1]
[1]Istituto Italiano di Tecnologia, Italy [2]Idiap Research Institute, Switzerland

- **Task-parameterized GMM** with quaternion-based representation of orientation to learn complete end-effector poses.
- **Quaternion-based dynamical systems** for computing virtual attractors in SO(3), encoding the desired task dynamics.
- Learning of **bimanual formation constraints** that can change during the task.



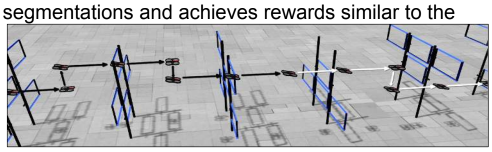
Sweeping as a bimanual coordination skill

12:20–12:35	TuCT12.5

Nonparametric Bayesian Reward Segmentation for Skill Discovery using IRL

Pravesh Ranchod[1], Benjamin Rosman[1,3], George Konidaris[2]
[1]University of the Witwatersrand, South Africa [2]Duke University, USA [3]CSIR, South Africa

- A method for segmenting unstructured expert trajectories based on the goals of the expert.
- Infers multiple reward functions, modelling skill switching behaviour within trajectories.
- Produces segmentations and achieves rewards similar to the expert.

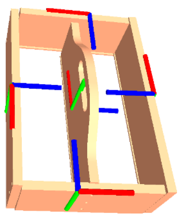


12:35–12:50	TuCT12.6

Temporal Segmentation of Interaction Phases in Sequential Manipulation Demonstrations

Andrea Baisero[1], Yoan Mollard[2], Manuel Lopes[2], Marc Toussaint[1] and Ingo Lütkebohle[1]
[1]University of Stuttgart, Germany [2]Inria, France
http://3rdhandrobot.eu/

- Being able to model the consequences of human actions in complex manipulation demonstrations is a key mile-stone for the successful development of autonomous robotic systems.
- In this work, we propose a CRF model to perform temporal segmentation on sequential assembly tasks, and to extract a transferrable representation for the final product of the assembly.



Grasping 1

Chair

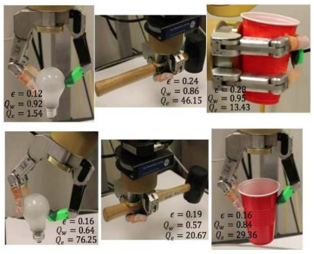
Co-Chair *Tetsuyou Watanabe, Kanazawa University*

11:20–11:35	TuCT13.1

Task-Based Grasp Quality Measures for Grasp Synthesis

Yun Lin and Yu Sun
University of South Florida

- Grasp should facilitate manipulation tasks
- Two task-based grasp quality measures
  - task wrench coverage measure
  - manipulator efficiency measure

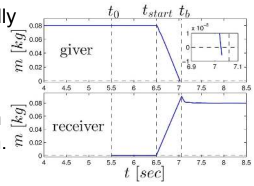


11:35–11:50	TuCT13.2

A human inspired stable object transfer for robots in hand-over tasks

Efi Psomopoulou and Zoe Doulgeri
Aristotle University of Thessaloniki, Greece

- An object load transfer strategy is proposed for a robotic assistant, which haptically ensures that the full load has been transferred to the receiver before releasing its grip.
- The strategy is based on a dynamically stable grasp controller with object weight estimation capabilities.
- It is theoretically proved that the system's stability is not dependent on the receiver's load acquisition pattern.



11:50–12:05	TuCT13.3

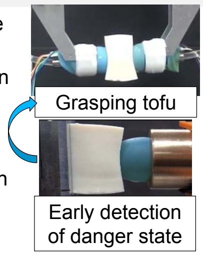
Identification of danger state for grasping delicate tofu with fingertips containing viscoelastic fluid

Ryota Adachi[1], Yoshinori Fujihira[1], Testuyou Watanabe[1]
[1]Kanazawa University, Japan

Final Goal: Grasp tofu without any advance knowledge about fracture.

Contribution: Identify danger state of tofu in early stage.

Method: Deformable fingertips filled with a viscoelastic fluid and MDL (minimum description length) principle based approach based on analysis of fluid pressure and contact force when pushing tofu.

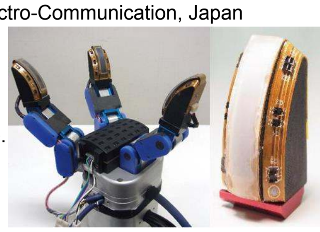


12:05–12:20	TuCT13.4

Grasping Control Based on Time-To-Contact Method for a Robot Hand Equipped with Proximity Sensors on Fingertips

Keisuke Koyama[1], Yosuke Suzuki[1], Aiguo Ming[1] and Makoto Shimojo[1]
[1]the University of Electro-Communication, Japan

- We demonstrate quick and soft-touch grasping using time-to-contact (TTC) converted from sensor value.
- TTC represents remaining time until collision.



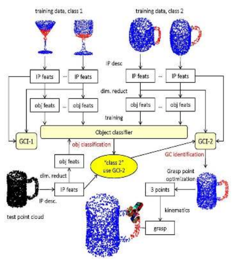
- Grasping test shows that the control reduces fingertip velocity at contact and adjusts fingertip to match the object shape.

12:20–12:35	TuCT13.5

Grasp Planning by Human Experience on a Variety of Objects with Complex Geometry

Chunfang Liu[1], Wenliang Li[1], Fuchun Sun[1] and Jianwei Zhang[2]
[1]Tsinghua University, China [2]Hamburg University, Germany

- Category object by a modified SHOT descriptor and MKNN method
- Learn the graspable component identifier based on human experience and ***geometrical categories*** of objects
- Analytical grasp planning on the graspable component
- Results resemble human grasps well on a variety of objects with complex geometry

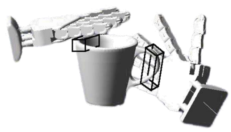


12:35–12:50	TuCT13.6

Grasp Planning with Soft Hands using Bounding Box Object Decomposition

Manuel Bonilla[1], Daniela Resasco[1], Marco Gabiccini[1] and Antonio Bicchi[1]
[1]Reseach Center "E. Piaggio", University of Pisa, Italy

- An algorithm to plan grasps for Soft Hands is presented. The method works as follows
  1. Decompose the object in Minimum Volume Bounding Boxes (MVBBs)
  2. Propose hand postures using the characteristics of MVBBs
  3. Evaluate if each hand posture leads to a successful grasp using a dynamic simulator.



- The probability of success of the hand poses generated with the proposed algorithm represents an evident improvement

Field Robots 1

Chair *Paulo Vinicius Koerich Borges, CSIRO*
Co-Chair *Koji Kawasaki, The University of Tokyo*

11:20–11:35	TuCT14.1

Dual Connected Bi-Copter with New Wall Trace Locomotion Feasibility That Can Fly at Arbitrary Tilt Angle

Koji Kawasaki, Yotaro Motegi, Moju Zhao, Kei Okada and Masayuki Inaba
Department of Mechano-Infomatics, The University of Tokyo, Japan

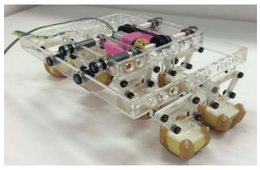
- We devised a mechanism that connected two bi-copter modules, each of which combines two of the four propellers into one set and named this mechanism the Bi²Copter.
- New action
  - Any tilt angle flying (5DOF)
  - Full spherical camera coverage
  - Wall trace locomotion
  - Passing overhanging wall
- Key point of the Bi²Copter
  - Rotate the tilt angle continuously
  - Thrust compensation for tilt angle

11:35–11:50	TuCT14.2

Compliant Wall-Climbing Robotic Platform for Various Curvatures

Yanheng Liu[1], Dong Gyu Lee[1], HyunGyu Kim[1] and TaeWon Seo[1]
[1]Creative Robot Design Lab., Yeungnam University, Korea

- Vertical wall-climbing robot on flat and curved surfaces
- Four-bar mechanism-based locomotion design and compliant adaptation on curved wall
- Flat dry adhesives are used for the attachment mechanism

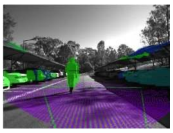


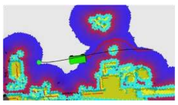
11:50–12:05	TuCT14.3

Discrete-Continuous Clustering for Obstacle Detection Using Stereo Vision

Robert Bichsel[1], Paulo V K Borges[2]
[1]ETH Zurich, Switzerland [2]CSIRO, Australia

- We create a 2D grid parallel to the ground while a continuous representation is used for the height.
- This representation allows for efficient clustering of objects.
- We present a novel clustering method combining the clusters into 'megaclusters'.
- Experimental results are shown on an autonomous vehicles.



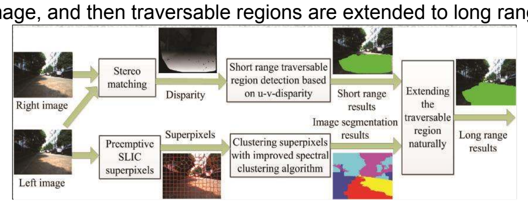


12:05–12:20	TuCT14.4

Long Range Traversable Region Detection Based on Superpixels Clustering for Mobile Robots

Huimin Lu[1,2], Lixing Jiang[2], and Andreas Zell[2]
[1]National University of Defense Technology, China
[2]University of Tuebingen, Germany

- A novel method was proposed to detect long range traversable regions without using any supervised or self-supervised learning
- Superpixels are clustered by spectral clustering to segment the image, and then traversable regions are extended to long range



12:20–12:35	TuCT14.5

Locust-Inspired Miniature Jumping Robot

Valentin Zaitsev[1,2], Omer Gvirsman[2], Uri Ben Hanan[1], Avi Weiss[1], Amir Ayali[2] and Gabor Kosa[2]
[1]Braude College, Israel
[2]Tel Aviv University, Israel

12:35–12:50	TuCT14.6

Design, Modeling and Control of A Novel Amphibious robot with Dual-swing-legs Propulsion Mechanism

Yang Yi[1], Zhou Geng[2], Zhang Jianqing[3] Cheng Siyuan[4] and Fu Mengyin[5]
Beijing Insititute of Technology

- We present a novel frog-inspired amphibious robot named FroBot.
- Compared with the other amphibious robots, FroBot has the same dual-swing-legs propulsion mechanism in the amphibious environment.
- FroBot's structure, dynamic model and some related experiments have been presented in this paper.

Haptics and Haptic Interfaces 1

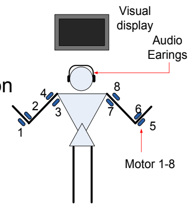
Chair *Domenico Prattichizzo, University of Siena*
Co-Chair *Jee-Hwan Ryu, Korea Univ. of Tech. and Education*

11:20–11:35	TuCT15.1

Effect of Vibrotactile Cues for Guiding Simultaneous Procedural Motion of Two Joints on Upper Limbs

Mu Xu[1], Dangxiao Wang[1],Yuru Zhang[1] and Dong Wu[2]
[1]Beihang University,China [2]Beijing Sport University, China

- Human's perception on identifying locations of two vibrotactile cues on two arms was studied
- Correct rate of using vibrotactile cues to command simultaneous procedural motion of two joints was measured
- The results may provide a foundation for utilizing vibrotactile cues to assist joint motion learning

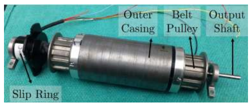


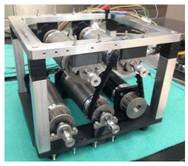
11:35–11:50	TuCT15.2

Performance Evaluation of Magneto-Rheological Based Actuation for Haptic Feedback in Medical Applications

Nima Najmaei[1,3], Ali Asadian[1,3]
Mehrdad R. Kermani[1], Rajni V. Patel[1,2,3]
[1] Dept. of Elect. & Comp. Engrg., [2] Dept. of Surgery, Western University, London ON, Canada; [3] CSTAR, London Health Science Center, London ON, Canada

- MR Fluid based actuators can be used to improve transparency and stability of haptic interfaces.
- A small-scale prototype armature-based MRF clutch is designed for haptic applications.
- A two-DOF prototype haptic interface is developed
- The performance of the MRF-based haptic interface in terms of stability and accuracy are studied and compared with those of commercial haptic devices.





11:50–12:05	TuCT15.3

Operability study on the Multisensory Illusion inducible in Microsurgical Robotic Systems

Jumpei Arata[1], Masashi Hattori[2], Masamichi Sakaguchi[2]
Ryu Nakadate[1] Susumu Oguri[1], Kazuo Kiguchi[1]
and Makoto Hashizume[1]
[1]Kyushu University, Japan [2]Nagoya Institute of Technology, Japan

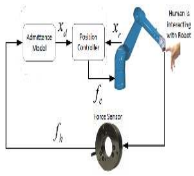
- Multisensory illusion was introduced into a microsurgical robotic system
- The experiments showed that the multisensory illusion is enhanced in multi-DOF movement compared with a single-DOF motion.
- Illusion and operability are significantly correlated in the MSS.
- Further design improvement and assessment is currently on-going.

12:05–12:20	TuCT15.4

Increasing the Impedance Range of Admittanc -Type Haptic Interfaces by Using Time Domain Passivity Approach

Muhammad Nabeel[1], JaeJun Lee[1], Usman Mehmood[1], Aghil Jafari[1], Jung-Hoon Hwang[2] and Jee-Hwan Ryu[1]
[1]KOREATECH, Rep. of Korea, [2]Korea Electronics Technology Institute, Rep. of Korea

- This paper proposes a method to increase the impedance range of admittance-type haptic interfaces
- This paper extends the Time Domain Passivity Approach (TDPA) to guarantee the stability of the system
- The admittance-type haptic interface is represented in electrical network domain to have clear causality



12:20–12:35	TuCT15.5

Haptic Rendering of Hyperelastic Models with Friction

Hadrien Courtecuisse[1], Yinoussa Adagolodjo[1], Hervé Delingette[3] and Christian Duriez[2]
[1]AVR Team-Project, CNRS Strasbourg and Strasbourg University
[2]Shacra Team-Project, INRIA Lille and Lille University
[3]Asclepios Team-Project, INRIA Sophia Antipolis

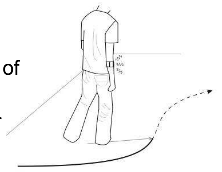
In this paper we propose a new solution to simulate a realistic haptic feedback of interactions with hyperelastic soft tissues.

12:35–12:50	TuCT15.6

Evaluation of a predictive approach in steering the human locomotion via haptic feedback

Marco Aggravi[1], Stefano Scheggi[1], and Domenico Prattichizzo[1,2]
[1] DIISM, University of Siena, Italy [2]Department of Advanced Robotics, Istituto Italiano di Tecnologia, Italy

- A haptic guidance policy to steer the user along paths and a predictive approach to compensate human haptic actuation delays is presented.
- An average distance error from the path of 0.24 m was achieved.
- The predictive approach brought a lower activation time of the haptic interfaces.



Surveillance Systems

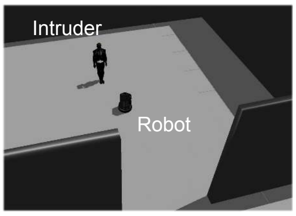
Chair *Satoshi Hoshino, Utsunomiya University*
Co-Chair *Sebastian Rockel, University of Hamburg*

14:00–14:15	TuDT1.1

Patrolling Robot based on Bayesian Learning for Multiple Intruders

Satoshi Hoshino, Shingo Ugajin, and Takahito Ishitawa
Utsunomiya University, Japan

- Single patrolling robot
- Unknown and multiple intruders
- Multi-armed bandit problem vs. patrolling problem
- Bayesian learning approach
- Stochastic patrolling strategies



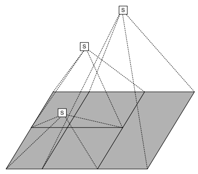
Intruder detection in a room

14:15–14:30	TuDT1.2

Deploying Teams of Heterogeneous UAVs in Cooperative Two-Level Surveillance Missions

Nicola Basilico[1], Stefano Carpin[2]
[1]Univ. of Milan [2]Univ. Of California, Merced

- Sentinel placement problem for surveillance tasks
- Heterogeneous UAVs with different performance
- Solution based on minimax formulation
- Simulations confirm theoretical predictions



14:30–14:45	TuDT1.3

Minimizing Communication Latency in Multirobot Situation-Aware Patrolling

Jacopo Banfi[1], Nicola Basilico[2], and Francesco Amigoni[1]
[1]Politecnico di Milano, Italy [2]Università degli Studi di Milano, Italy

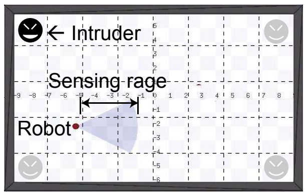
- A team of robots must patrol a set of predefined locations but only some regions provide communication links to a Mission Control Center
- Objective: minimize the inspection-communication delay under a mission time budget
- We propose an optimal MILP formulation and a more scalable heuristic algorithm

14:45–15:00	TuDT1.4

Probabilistic Surveillance by Mobile Robot for Unknown Intruders

Satoshi Hoshino and Takahito Ishitawa
Utsunomiya University, Japan

- Autonomous mobile robot for surveillance
- Unknown intruders
- Probabilistic surveillance approach
- Bayes' rule for estimating intrusion trends
- Adaptive surveillance behavior



Surveillance environment divided into cells

15:00–15:15	TuDT1.5

Detection of Continuous Barking Actions from Search and Rescue Dogs' Activities Data

Yuichi Komori[1], Kazunori Ohno[1],Takuaki Fujieda[1], Takahiro Suzuki[1] and Satoshi Tadokoro[1]
[1]Tohoku University, Japan

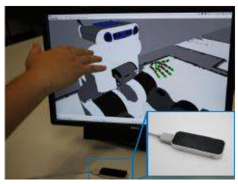
- Developed cyber-enhanced suits for search and rescue(SAR) dogs to visualize their investigations
- SAR dogs bark continuously when they find victims
- Continuous barking detections had been done by audio-based and motion-based method
- The F-scores of the audio and motion-based detection were 0.95 and 0.90

15:15–15:30	TuDT1.6

A Novel Optical Tracking based Tele-control System for Tabletop Object Manipulation Tasks

Haiyang Jin[1, 2], Liwei Zhang[3], Sebastian Rockel[1], Jun Zhang[2], Ying Hu[2] and Jianwei Zhang[1]
[1]University of Hamburg, Germany [2]Shenzhen Institutes of Advanced Technology, China [3]Fuzhou University, China

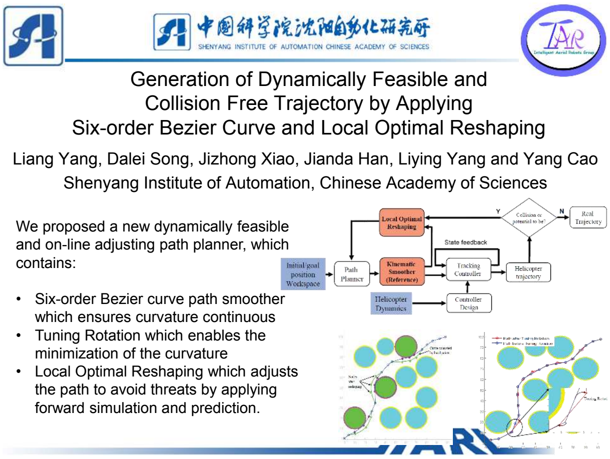
- A LeapMotion sensor is intergrated into the coordinate system of a PR2 robot to perform tele-control.
- An algorithm is developed to recognize the typical gestures for tabletop object manipulation.
- Three tele-control modes are developed, and the performance of different modes are evaluated by comprehensive assessment index.



Unmanned Aerial Systems 2

Chair *Jizhong Xiao, The City College of New York*
Co-Chair

14:00–14:15	TuDT2.1



14:15–14:30	TuDT2.2

Towards Table Tennis with a Quadrotor Autonomous Robot and Onboard Vision

Rui Silva[1], Francisco Saraiva Melo[1],
Manuela Veloso[2]
[1]IST, Portugal [2]CMU, USA

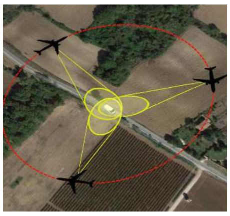
- Table tennis ball interception, using a commercial quadrotor with onboard vision.
- Framework for learning complex tasks, combining imitation learning and reinforcement learning.
- Dynamical system Motor Primitives for flexible representation of trajectories.
- Increase in the hitting rate as the robot learns.

14:30–14:45	TuDT2.3

Coordinated Vision-Based Tracking for Multiple UAVs

Venanzio Cichella[1], Isaac Kaminer[2],
Vladimir Dobrokhodov[2] and Naira Hovakimyan[1]
[1]University of Illinois at Urbana-Champaign, Urbana, Illinois, USA
[2]Naval Postgraduate School, Monterey, California, USA

- Multiple UAVs rotate around a static or moving target using UAV-target relative line-of-sight angle only as feedback
- Reduce computational load required to acquire more complex information (e.g. target's position, velocity)
- The UAVs coordinate with each other to maintain a predefined phase separation

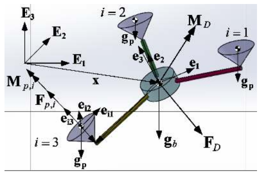


14:45–15:00	TuDT2.4

On Modeling and Control of a Holonomic Vectoring Tricopter

Michalis Ramp[1], Evangelos Papadopoulos[2]
[1,2]Department of Mechanical Engineering,
National Technical University of Athens, Greece

- The concept of a vectoring tricopter with **independent axes control** is presented using geometric methods.
- A globally defined dynamic model is produced followed by an allocation scheme and the development of an almost global vectoring controller.
- A stability proof and simulation results under disturbances and uncertainties validate the design.

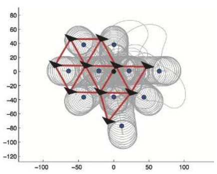


15:00–15:15	TuDT2.5

Distributed Formation Control of Fixed Wing Micro Aerial Vehicles for Area Coverage

Maja Varga[1], Meysam Basiri[1],
Gregoire Heitz[1] and Dario Floreano[1]
[1]EPFL, Switzerland

- Fixed wing MAVs – cannot hover or perform sharp turns
- We propose method for formation control based on flocking rules
- MAVs create equilateral triangular lattice formation using only local information
- In simulation and in field experiments we show effectiveness of our approach

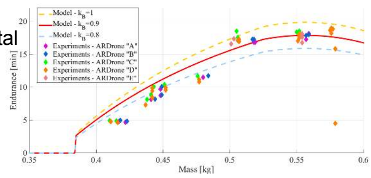


15:15–15:30	TuDT2.6

Power and Endurance Modelling of Battery-Powered Rotorcraft

Analiza Abdilla[1,2], Arthur Richards[1,2]
and Stephen Burrow[1]
[1]Department of Aerospace Engineering, University of Bristol, UK
[2]Bristol Robotics Laboratory, UK

- This paper characterizes the power consumption of electric rotorcraft and derives an endurance estimation model for such aircraft powered by LiPo batteries.
- Theoretical analysis is backed by experimental flight tests using a popular commercial quadrotor, namely the Parrot ARDrone2.0.



Robot Vision 2

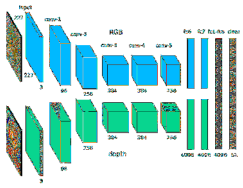
Chair *Wolfram Burgard, University of Freiburg*
Co-Chair *Dezhen Song, Texas A&M University*

14:00–14:15 TuDT3.1

Multimodal Deep Learning for Robust RGB-D Object Recognition

A. Eitel, J. T. Springenberg,
L. Spinello , M. Riedmiller and W. Burgard
University of Freiburg, Germany

- Object recognition tailored for robotics: more robust to real-world noise
- Two-stream CNN architecture for learning from both input modalities
- Special depth data augmentation and encoding for fine-tuning from pre-trained RGB networks
- State of the art performance on UW RGB-D Object Dataset

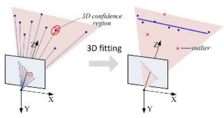


14:15–14:30 TuDT3.2

Robustness to Lighting Variations: An RGB-D Indoor Visual Odometry Using Line Segments

Yan Lu and Dezhen Song
Computer Science & Engineering, Texas A&M University, USA

- Utilize line segment features for RGB-D camera based visual odometry to improve its robustness to lighting variations.
- Detect line segments from color images and back-project them to 3D using a sampling approach.
- Analyze 3D line segment uncertainties and estimate camera motion by minimizing Mahalanobis distance.
- Experiments show superior performance under varying lighting on 6 out of 8 long image sequences.



Sampling-based line estimation. A 3D line segment is estimated from sample points using RANSAC and Mahalanobis distance.
Source code available at
http://telerobot.cs.tamu.edu/MFG/rgbd/livo

14:30–14:45 TuDT3.3

Ground Segmentation and Occupancy Grid Generation Using Probability Fields.

Ali Harakeh[1], Daniel Asmar[1], and Elie Shammas[1]
[1]American University of Beirut, Lebanon

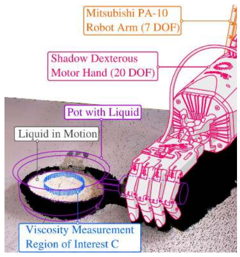
- Novel method for modeling the occupancy probability of pixels in a stereo image pair.
- The model is used for ground segmentation and occupancy grid generation.

14:45–15:00 TuDT3.4

Discriminating Liquids Using a Robotic Kitchen Assistant

Christof Elbrechter[1], Jonathan Maycock[1],
Robert Haschke[1] and Helge Ritter[1]
[1]Bielefeld University (Citec), Germany

- Kinect point-cloud input is processed in several steps leading to a scalar surface variance signal over time
- Liquid discrimination based on temporal sloshing behavior and decay
- Examination of robotic and manual excitation movements with different containers, liquids and fill-rates
- NN-Classification and polynomial regression of kinematic viscosity

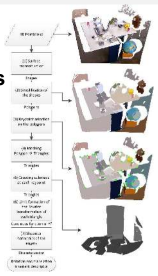


15:00–15:15 TuDT3.5

Rotation and Translation Invariant 3D Descriptor for Surfaces

Joshua Hampp[1], Richard Bormann[1],
[1]Fraunhofer Institute for Manufacturing
Engineering and Automation IPA, Germany

- **Fast** keypoint selection and **viewpoint invariant descriptor** for surface-based data
- Processing of **pointclouds and CAD models**
- Spherical harmonics on surfaces enable rotation invariance
- Evaluation and first experiments with a robot in indoor environments with RatSLAM
- **Code publicly available:**
  https://github.com/ipa-josh/cob_environment_perception



15:15–15:30 TuDT3.6

SRSL: Monocular Self-Referenced Line Structured Light

Alexander Duda[1], Jakob Schwendner[1],
Christopher Gaudig[1]
[1]German Research Center for Artificial Intelligence, DFKI Bremen

- Fusion of Structure from Motion with Structured-Light using a single off-the-shelf monocular camera.
- Visual Odometry is used to estimate the camera poses.
- Filtered Line Structured-Light measurements are integrated into a windowed bundle adjustment fixing the scale of the reconstruction.
- The approach allows for the capturing of dense 3D point clouds (colored) on moving systems in situations with low texture and minimal scene structure (see Fig.).
- Two different SRSL systems are evaluated in experiment scenarios ranging from underwater to office environments.

SLAM 2

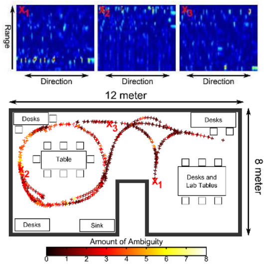
Chair *Kanji Tanaka, University of Fukui*
Co-Chair *Tiffany Huang, Carnegie Mellon University*

14:00–14:15 TuDT4.1

Spatial sampling strategy for a 3D Sonar Sensor supporting BatSLAM

Steckel Jan[1,2], Peremans Herbert[1],
[1]FTEW-ENM, University of Antwerp, 2000 Antwerp, Belgium
[2]CZT, University of Antwerp, 2000 Antwerp, Belgium

- 3D Sonar Sensor used for a complete SLAM system:
  - Estimation of odometry using high-resolution 2D data
  - Pose-Based SLAM using 3D sensor data
- The resulting system is capable of mapping office-like environments

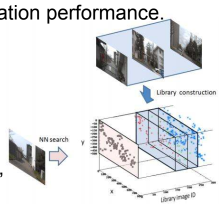


14:15–14:30 TuDT4.2

Cross-season Place Recognition using NBNN Scene Descriptor

Kanji Tanaka[1]
[1]Univ. of FUKUI, JAPAN

- Proposal: a compact discriminative scene descriptor
- Key idea: visual experience as a library of raw image data
- In contrast to BoW methods, the proposed approach achieves good generalization and domain adaptation performance.
- In contrast to existing NBNN approaches, we cast place recognition as an image retrieval task
- A challenging cross-season place recognition dataset (http://rc.his.u-fukui.ac.jp/ projects.html, "Cross-Season Localization")



14:30–14:45 TuDT4.3

A Fast Histogram-Based Similarity Measure for Detecting Loop Closures in 3D LIDAR Data

Timo Röhling, Jennifer Mack and Dirk Schulz

Fraunhofer FKIE, Germany

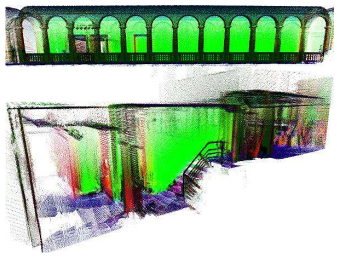
- Simple method to gauge similarity of LIDAR scan data
- Histograms encode statistics such as the distribution of measured ranges or distances to the ground plane
- Makes no assumptions about local features of the environment
- Up to 100 times faster than the NDT-based loop closure detection with similar classification performance

14:45–15:00 TuDT4.4

NICP: Dense Normal Based Point Cloud Registration

Jacopo Serafin[1], Giorgio Grisetti[1],
[1]Department of Computer, Control, and Management Engineering "Antonio Ruberti" at Sapienza University of Rome, Italy

- A novel registration algorithm that exploits the structure of 3D surfaces;
- Runs in real-time on CPU;
- Open-source standalone C++ library;
- Outperforms other state-of-the-art methods.



15:00–15:15 TuDT4.5

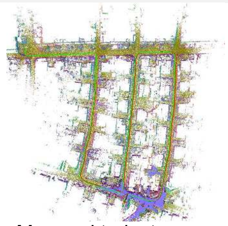
Pose Interpolation SLAM for large maps using moving 3D Sensors

Simone Ceriani[1], Carlos Sánchez[1],
Pierluigi Taddei[1], Erik Wolfart[1] , Vítor Sequeira[1]
[1]European Commission, Joint Research Centre, Italy

Warping effects on laser scans
- Compensated without external data

Large map management
- Efficient data structure
- Hybrid sparse voxel-based

SLAM framework
- Pose tracking
- Local Optimization
- Global Optimization (loop closure)



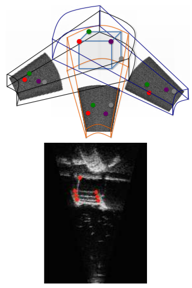
Map and trajectory involving a loop closure

15:15–15:30 TuDT4.6

Towards Acoustic Structure from Motion for Imaging Sonar

Tiffany A. Huang and Michael Kaess
Robotics Institute, Carnegie Mellon University, USA

- 3D structure from feature points in multiple 2D sonar images.
- Challenging because sonar does not provide elevation information.
- Unlike state-of-the-art, no planar assumptions needed.
- Simulation results for varied motions.
- Experimental results from imaging pier ladder.



Micro/Nano Robots 1

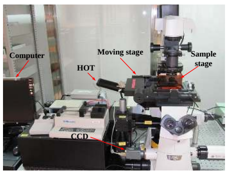
Chair *Tatsuo Arai, Osaka University*
Co-Chair *Dong Sun, City University of Hong Kong*

14:00–14:15	TuDT5.1

A Switch Controller for High Speed Cell Transfer with A Robot-aided Optical Tweezers Manipulation System

Xiangpeng Li[1], Hao Yang[2], Haibo Huang[1] and Dong Sun[2]
[1]Soochow University, Suzhou, China
[2]City University of Hong Kong, Hong Kong, China

- A geometrical model that formulates automatic cell trapping, high speed transfer, optical trap maintenance, and obstacle avoidance was developed.
- Based on the model, a switch controller for simultaneously solving the above four issues was proposed.

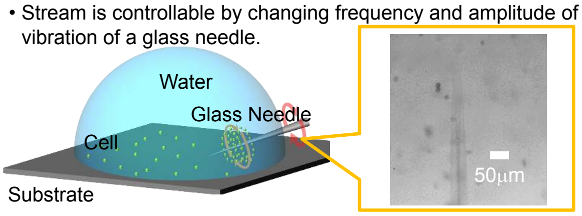


14:15–14:30	TuDT5.2

Generation of Swirl Flow by Needle Vibration for Micro Manipulation

Takayuki Hattori, Kazuto Kamiyama, Masaru Kojima
Mitsuhiro Horade, Yasushi Mae and Tatsuo Arai
Osaka University, Japan

- Non contact micro manipulation method using rotational stream by vibration of a glass needle is proposed.
- Stream is controllable by changing frequency and amplitude of vibration of a glass needle.

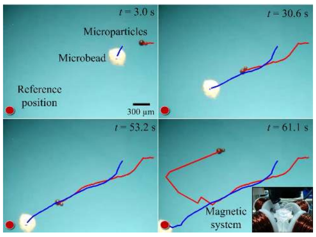


14:30–14:45	TuDT5.3

Non-Contact Manipulation of Microbeads via Pushing and Pulling using Magnetically Controlled Clusters of Paramagnetic Microparticles

Ahmed G. El-Gazzar[1], Louay E. Al-Khouly[1],
Anke Klingner[1], Sarthak Misra[2,3] and Islam S. M. Khalil[1]
[1]German University in Cairo, Egypt [2]University of Twente, The Netherlands
[3]University of Groningen, The Netherlands

- Non-contact pushing and pulling of non-magnetic microbeads using microparticles is achieved.
- Successful releases of microbeads are accomplished during micromanipulation and microassembly.
- A control strategy is presented to break free from the adhesive forces in micromanipulation and microassembly of microbeads.



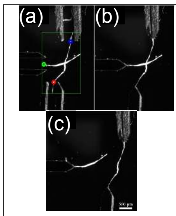
Non-contact pushing of a microbead.

14:45–15:00	TuDT5.4

Microrobotic Manipulation of Paper Fiber Bonds

Juha Hirvonen, Mathias von Essen, Pasi Kallio
Tampere University of Technology, Finland

- Conventional methods for testing paper fiber bonds are manual and slow
- Microrobotic testing increases speed and repeatability
- The algorithm for detecting suitable 3D grasp points from two microscope images is presented
- The algorithm is validated with bond breaking tests and the success rate is as high as 80 %



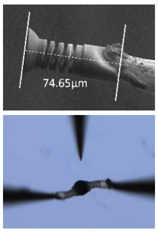
Grasp sequence

15:00–15:15	TuDT5.5

Direct Laser Written Passive Micromanipulator End-Effector for Compliant Object Manipulation

Maura Power[1], Guang-Zhong Yang[1],
[1]The Hamlyn Centre, Imperial College London, UK

- Novel compliant micromanipulator end-effector manufactured using direct laser writing.
- Closed loop control using visual servoing and haptic devices for manual or shared control.
- Increased workspace using 2 proposed compliant end-effectors when compared to typical rigid probe setup.
- Characterization of proposed passive spring end-effector with using force and displacement measurements.

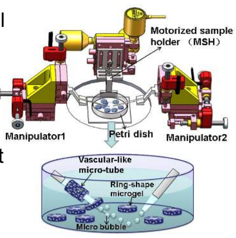


15:15–15:30	TuDT5.6

Automated Bubble-Based Assembly of Cell-Laden Microgels into Vascular-Like Microtubes

Xiaoming LIU[1], Qing SHI[1], Huaping WANG[1], Tao SUN[1], Ning YU[1], Qiang HUANG[1], and Toshio Fukuda[1]
[1]Beijing Institute of Technology, China

- Novel bubble-based micro-assembly method aiming at artificial micro-vessel
- **Full automation** realized by the multi-microrobotic system
- Key parameters are characterized to improve the assembly
- success rate: 100%; average time cost of assembling every microgel: 3.25s; assembled micro-tube: length of 1.2mm, outer diameter of 200μm



Surgical Robotics 2

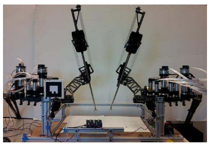
Chair *Gastone Ciuti, Scuola Superiore Sant'Anna*
Co-Chair *Arianna Menciassi, Scuola Superiore Sant'Anna - SSSA*

14:00–14:15	TuDT6.1

Measurement of the CablePulley Coulomb and Viscous Friction for a Cable Driven System

Muneaki Miyasaka[1], Joseph Matheson[1], Andrew Lewis[2] and Blake Hannaford[1]
[1]University of Washington, USA [2]Applied Dexterity Inc., USA

- Cable Driven systems encounter frictional force related to conditions of cable and guide pulley such as cable velocity, tension, type and number of pulley, and angle of cable wrapping around pulley.
- Using the RAVEN II surgical robotic research platform as the target system, the relation of the variables to friction was derived from experimental measurements.

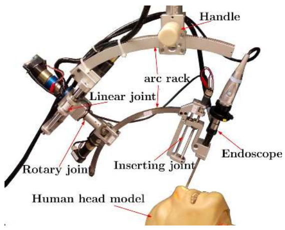


14:15–14:30	TuDT6.2

Modeling, Design and Control of an Endoscope Manipulator for FESS

Weiyang Lin, David Navarro-Alarcon, Peng Li, Zerui Wang, Hui Man Yip, Yunhui Liu, Michael Tong
The Chinese University of Hong Kong, HKSAR

- We present a robotic endoscope manipulator for sinus surgery
- The system has 5 passive DOF for manual set-up, and 4 active DOF for manipulation
- The robot is controlled by an IMU interface attached to the foot



14:30–14:45	TuDT6.3

A Hand-Held Flexible Mechatronic Device for Arthroscopy

Christopher J. Payne, Gauthier Gras, Michael Hughes, Dinesh Nathwani and Guang-Zhong Yang
Hamlyn Centre for Robotic Surgery, Imperial College London

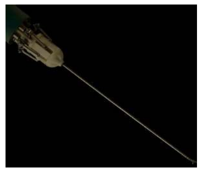
- Miniaturized flexible manipulator for arthroscopy with integrated imaging modalities in a hand-held design.
- Workspace analysis and force characterization of flexible manipulator performed.
- Pre-clinical cadaveric study demonstrates feasibility for accessing posterior regions of knee anatomy.

14:45–15:00	TuDT6.4

Rapid Manufacturing with Selective Laser Melting for Robotic Surgical Tools: Design and Process Considerations

Carlo A. Seneci[1], Jianzhong Shang[1], Ara Darzi[1], and Guang-Zhong Yang[1], *Fellow, IEEE*
[1]Imperial College London, UK

- SLM: melting metal powder to make solid (complex) structures
- Rapid manufacturing can be used for production of small batches of products
- Highly configurable production process
- Many variables govern this process
- Variables optimization and material properties tuning
- -> Patient-Specific surgical tools

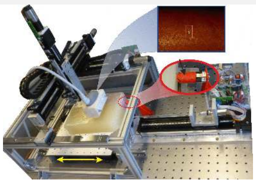


15:00–15:15	TuDT6.5

Towards physiological motion compensation for flexible needle interventions

Pedro Moreira, Momen Abayazid and Sarthak Misra
University of Twente, The Netherlands

- This work proposes a flexible needle steering algorithm to handle physiological motion disturbances.
- The system estimates the disturbance using a force sensor placed in contact with the soft-tissue.
- The system is evaluated through experiments steering a flexible needle into a moving soft-tissue phantom with an average targeting error of 1.05mm.

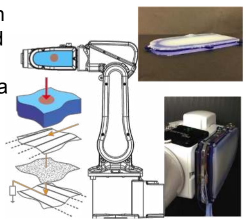


15:15–15:30	TuDT6.6

Smart sensorized polymeric skin for safe robot collision and environmental interaction

Tommaso Mazzocchi[1], Alessandro Diodato[1], Gastone Ciuti[1], Denis Mattia De Micheli[2] and Arianna Menciassi[1]
[1]Scuola Superiore Sant'Anna, Italy - [2]Scienzia Machinale, Italy

- Design, development and integration of a multi-touch piezoresistive-based polymeric tactile skin
- Integration of the tactile matrix onto a robotic manipulator and overall assessment
- Intended applications in robotic-assisted scenarios (*i.e.* robotic surgery) for safe interaction



Manipulation Planning and Control 2

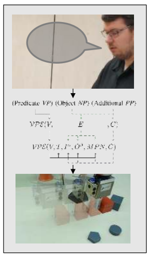
Chair *Kevin Lynch, Northwestern University*
Co-Chair *Michael Spangenberg, Universität Bayreuth*

14:00–14:15	TuDT7.1

Grounding of actions based on verbalized physical effects and manipulation primitives

Michael Spangenberg and Dominik Henrich
Chair for Applied Computer Science III
University of Bayreuth, Germany

- Describe natural language verbs in terms of sensor based motions
- Define physical effects to transform humans symbolic representation into robots subsymbolic representation
- Illustrate relations between natural language instructions, verbalized physical effects, and sensor based motions

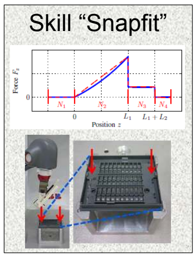


14:15–14:30	TuDT7.2

Combined Pose-Wrench and State Machine Representation for Modeling Robotic Assembly Skills

Arne Wahrburg[1], Stefan Zeiß[2], Björn Matthias[1]
Jan Peters[2] and Hao Ding[1]
[1]ABB Corporate Research Germany [2]TU Darmstadt, Germany

- A skill-based framework proposed for robot programming with reusable templates of robotic assembly skills
- With the approach, teaching time reduced, robot programming simplified, and robustness in robotic assembly improved
- The framework successfully implemented to perform a full PLC I/O module assembly using an ABB YuMi® robot.

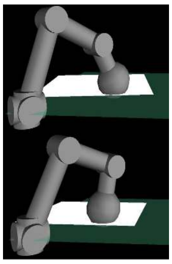


14:30–14:45	TuDT7.3

Force/Position/Rolling Control For Spherical Tip Robotic Fingers

Leonidas Droukas[1], Yiannis Karayiannidis[2], and Zoe Doulgeri[1]
[1]Aristotle University of Thessaloniki, Greece
[2]Chalmers University of Technology, Sweden

- A control law is proposed, achieving rolling of a soft robotic fingertip on a planar surface.
- An appropriate task Jacobian is defined, that allows linearization and decoupling of the system with respect to force/position and sliding dynamics, enabling the design of simple linear controllers fulfilling the control objectives.
- Furthermore, fine manipulation of a flat object by the rolling fingertip is achieved via tangential force control and demonstrated by simulations.

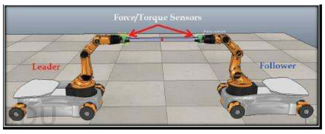


14:45–15:00	TuDT7.4

Cooperative Manipulation Exploiting only Implicit Communication

Anastasios Tsiamis[1], Christos K. Verginis[1], Charalampos P. Bechlioulis[1], and Kostas J. Kyriakopoulos[1]
[1]National Technical University of Athens

- No explicit communication
- Only position, velocity and force/torque sensing
- Leader designs trajectory



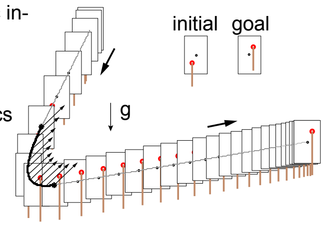
- Follower robustly estimates the desired trajectory via a novel prescribed performance estimation scheme
- Impedance control and load sharing
- Ultimate boundedness of the estimation and tracking error

15:00–15:15	TuDT7.5

Dynamic In-hand Sliding Manipulation

Jian Shi, J. Zachary Woodruff, Kevin M. Lynch
Northwestern University, USA

- Developed a framework for iterative planning of dynamic in-hand sliding for *n*-fingered planar regrasps.
- Provided solutions to the forward and inverse dynamics problems using soft-finger contact models.
- Validated the approach with simulations and preliminary experiments.

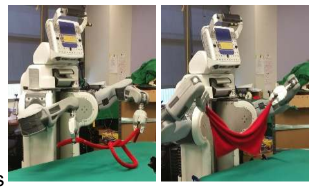


15:15–15:30	TuDT7.6

Leveraging Appearance Priors in Non-Rigid Registration, with Application to Manipulation of Deformable Objects

Sandy H. Huang[1], Jia Pan[2], George Mulcaire[1] and Pieter Abbeel[1]
[1]UC Berkeley, USA [2]University of Hong Kong, Hong Kong

- In *trajectory transfer*, a non-rigid registration from demonstration scene to test scene is extrapolated to transfer the demonstrated gripper motion to the test scene
- Our approach uses deep learning to capture appearance information using this to improve the registration
- The improved registration significantly improves capability of learning to manipulate deformable objects



Sensor Fusion 2

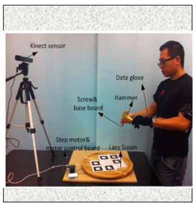
Chair *Weihua Sheng, Oklahoma State University*
Co-Chair *Alexandre Vicente, Imperial College London*

14:00–14:15	TuDT8.1

Fine Manipulative Action Recognition through Sensor Fusion

Ye Gu[1], Weihua Sheng[1]
Meiqin Liu[2] and Yongsheng Ou[3]
[1]Oklahoma State University, USA [2]Zhejiang University, China
[3]Shenzhen Institute of Advanced Technologies, China

- A multi-sensor fusion approach to recognizing fine manipulative actions.
- Feature selection allows better recognition performance.
- Object/action dependency is utilized to further improve the recognition accuracy.
- The algorithms are validated on our Portable Assembly Demonstration System.

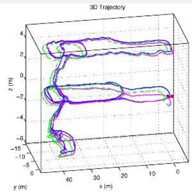


14:15–14:30	TuDT8.2

Vision-Aided Inertial Navigation with Line Features and a Rolling-Shutter Camera

Hongsheng Yu and Anastasios I. Mourikis
Dept. of Electrical and Computer Engineering, UC Riverside, US

- Key contributions:
  - A minimal parameterization for 3D lines, with improved linearity characteristics
  - A novel formulation for using line observations in images, suitable for rolling-shutter cameras
- Results: improved precision in point-feature-poor environments



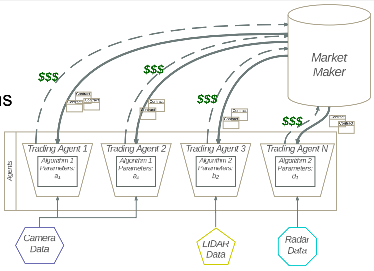
Experimental results: 0.37% final position error in 400-m trajectory

14:30–14:45	TuDT8.3

Financialized methods for market-based multi-sensor fusion

Jacob Abernethy[1], Matthew Johnson-Roberson[1]
[1]University of Michigan, USA

- Novel market-based approach to sensor fusion
- Agents bet on detections from multiple sensor modalities
- Demonstrated on real pedestrian data from camera and LIDAR in KITTI benchmark

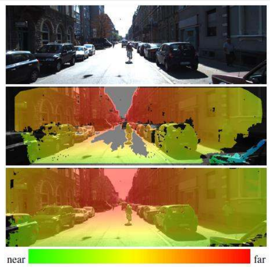


14:45–15:00	TuDT8.4

Incremental Dense Multi-modal 3D Scene Reconstruction

Ondrej Miksik[1], Yousef Amar[1], Vibhav Vineet[2],
Patrick Perez[3] and Philip H.S. Torr[1]
[1]University of Oxford, UK [2]Stanford, US [3]Technicolor R&I, FR

- Reliable depth maps are essential prerequisite for dense 3D reconstruction
- Cameras have limited dynamic range -> specular highlights, reflections, overexposure, …
- Combine camera and lidar to exploit complementarity of different sensing modalities

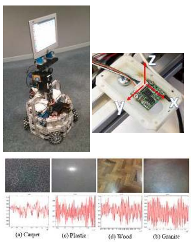


15:00–15:15	TuDT8.5

Surface Classification Based on Vibration on Omni-wheel Mobile Base

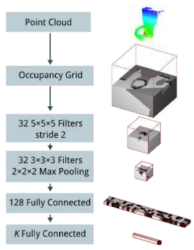
Alexandre Vicente, Jindong Liu, Guang-Zhong Yang
Imperial College London, UK

- This work proposes a comparison between different classifiers of identifying surfaces by using a 3-axis accelerometer sensor on a holonomic robot. Four typical hospital floors were tested using different motions. Final results show that a mixture of statistical and spectrum density based features are sufficient to identify surfaces with more than 85% overall accuracy



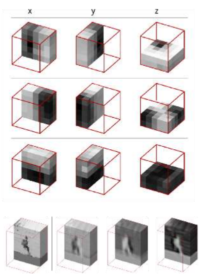
15:15–15:30	TuDT8.6

VoxNet: A Convolutional Neural Network for Real-Time 3D Object Recognition



VoxNet is a fast and accurate 3D Convolutional Neural Network Architecture for recognition in volumetric data.

We show state of the art results in data from three domains: LiDAR point clouds, RGBD point clouds and CAD models.



Biologically-Inspired Robots 2

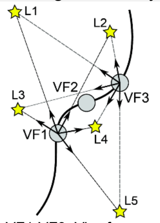
Chair *Kazuhiko Terashima, Toyohashi University of Technology*
Co-Chair *Fabian Reyes, Ritsumeikan University*

14:00–14:15	TuDT9.1

Trail-Map-Based Homing Under the Presence of Sensor Noise

Annett Stelzer[1], Michael Suppa[1] and Wolfram Burgard[2]
[1]Institute of Robotics and Mechatronics, DLR, Germany
[2]Dept. of Computer Science, University of Freiburg, Germany

- Trail-Map is a scalable landmark data structure for biologically inspired homing
- Simulations show that homing is robust against translational odometry errors, landmark occlusions and image noise
- Homing is sensitive to rotational errors and landmark outliers
- Trail-Map can be pruned by 50% without significant loss of homing accuracy



VF1-VF3: Viewframes
L1-L5: Landmarks

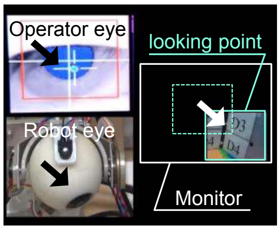
14:15–14:30	TuDT9.2

High Response Master-Slave system Using Gaze Tracking Data

Ayato kanada[1], Tomoaki Mashimo[1], Tetsuto Minami[1] and Kazuhiko Terashima[1]
[1]Tyohashi University of Technology, Japan

We propose an eye robot system with master-slave control using operator gaze tracking data.

If the operator directs his line-of-sight to the corner of a monitor, robot camera information is projected to the point where operator looking.

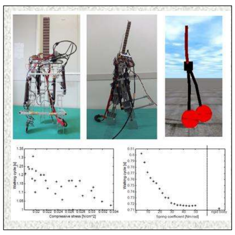


14:30–14:45	TuDT9.3

Passive Trunk Mechanism for Controlling Walking Behavior of Semi-passive Walker

H. Oku[1], N. Asagi[2], T. Takuma[1], and T. Masuda[1]
[1]Osaka Institute of Technology, Japan [2]Matsusada Precision

- Semi-passive walker
  - Energy efficient, but…
  - Uncontrollable behavior such as walking cycle and velocity
- Equipping novel trunk design referring human spine structure
  - Redundant joints with tunable viscoelasticity
  - Tune the viscoelasticity → Change dynamics of the walker → Control the behavior? → YES!

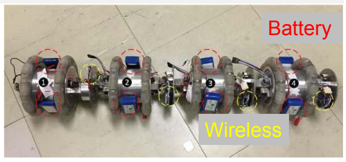


14:45–15:00	TuDT9.4

Study on Rectilinear Locomotion Based on a Snake Robot with Passive Anchor

Wenbin Tang[1], Fabian Reyes[1], and Shugen Ma[1,2]
[1]Ritsumeikan University, Japan , [2]Tianjin University, China

- A novel snake robot was fabricated.
- The special one-direction wheels services the role of passive anchors providing sufficient friction force.



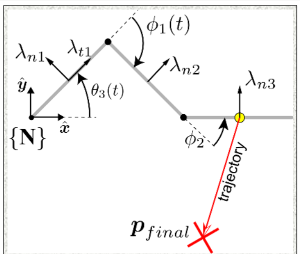
- The kinematics of rectilinear locomotion with two friction constraints hypothesis were proposed.
- Finally, the calculation of average velocities of different motion patterns were experimental confirmed.

15:00–15:15	TuDT9.5

Using a Planar Snake Robot as a Robotic Arm Taking into Account the Lack of a Fixed Base

Fabian Reyes[1], Wenbin Tang[1], Shugen Ma[1,2]
[1]Ritsumeikan University, Japan [2]Tianjin University, China

- A snake robot can be used to approach and, eventually, try to grasp and manipulate an object.
- Without a fixed-base, the snake robot has only friction as means of propulsion and fixation.
- By exploiting the friction between the ground and the snake's *tail*, the snake robot can be thought of as a robot arm.



Snake robot exploiting friction to follow a trajectory

15:15–15:30	TuDT9.6

Kinematics, Stiffness and Natural Frequency of a Redundantly Actuated Masticatory Robot Constrained by Two Point-Contact Higher Kinematic Pairs

Chen Cheng[1,2], Weiliang Xu[1], and Jianzhong Shang[2]
[1]University of Auckland, New Zealand
[2]National University of Defense Technology, China

Humanoid and Bipedal Locomotion 2

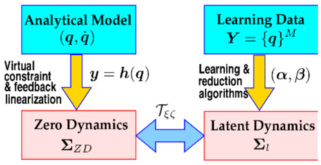
Chair *Darwin G. Caldwell, Istituto Italiano di Tecnologia*
Co-Chair *Christian Ott, German Aerospace Center (DLR)*

14:00–14:15	TuDT10.1

On the Relationship between Manifold Learning Latent Dynamics and Zero Dynamics for Human Bipedal Walking

Kuo Chen and Jingang Yi
Rutgers University, Piscataway, New Jersey, USA

- We built analytical relationships between machine-learning-based model and physical-principle-based dynamic model for bipedal walking



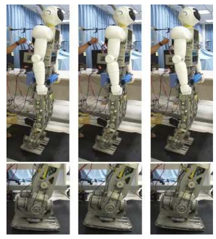
- The revealed, experimentally validated cross-model relationships help bridge two different modeling approaches and take advantages of their complementary properties

14:15–14:30	TuDT10.2

Active Control of Under-actuated Foot Tilting for Humanoid Push Recovery

Zhibin Li[1], Chengxu Zhou[1], Qiuguo Zhu[2], Rong Xiong[2], Nikos Tsagarakis[1], and Darwin Caldwell[1]
[1]Department of Advanced Robotics, Italian Institute of Technology
[2]State Key Laboratory of Industrial Control Technology, Zhejiang University

- We present a novel control framework to demonstrate a unique foot tilting maneuver based on ankle torque.
- A proof of concept is shown here that as long as the mechanical energy is bounded the humanoid can have feasible under-actuation and actively tilt the feet.
- The torque control capability is a key enabling technology for controlling the COM and adapting to terrain irregularity.



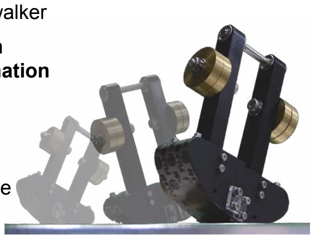
Balance recovery with active foot tilting

14:30–14:45	TuDT10.3

Thermobot: A Bipedal Walker Driven by Constant Heating

Takeru Nemoto[1] and Akio Yamamoto[1]
[1]Department of Precision Engineering, The University of Tokyo, Japan

- Based on passive dynamic walker
- **Powered by self-oscillation induced by thermal deformation of bimetal**
- Requires only hot surface (no battery)
- Walks on heated level surface

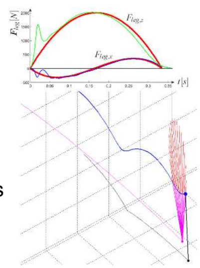


14:45–15:00	TuDT10.4

Biologically Inspired Dead-beat controller for bipedal running in 3D

Johannes Englsberger, Pawel Kozlowski, Christian Ott
German Aerospace Center (DLR), Germany

- Approximating GRF via polynomial splines
- Mainly analytical controller derivation
- Allows for running in 3D (flat floor)
- Controller is real-time capable, highly robust and very versatile
- Performance proven in multiple simulations
- BID controller can be embedded into whole-body control frameworks

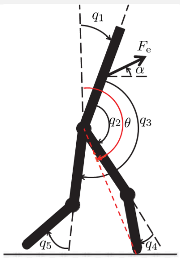


15:00–15:15	TuDT10.5

Adaptation of Dynamic Walking to Persistent External Forcing using HZD Control

Sushant Veer[1], Mohamad Shafiee Motahar[1] and Ioannis Poulakakis[1]
[1]University of Delaware, USA

- Dynamic bipedal walking under persistent excitation for application to cooperative object transportation
- Exogenous time-varying force used as an command signal rather than a disturbance
- Speed adaptation of the biped studied under the effect of the exogenous force

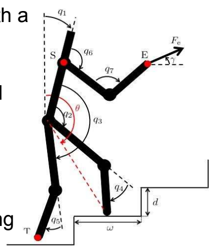


15:15–15:30	TuDT10.6

Integrating Dynamic Walking and Arm Impedance for Cooperative Transportation

Mohamad Shafiee Motahar[1], Sushant Veer[1], Jian Huang[1] and Ioannis Poulakakis[1]
[1]University of Delaware, USA

- Integration of arm impedance control with a dynamic walking biped
- Interaction force between the leader and the biped acts as a command for driving the biped
- Application to cooperative object transportation with proprioceptive sensing by the biped



Physical Human-Robot Interaction 2

Chair *Sylvain Calinon, Idiap Research Institute*
Co-Chair *Keehoon Kim, Korea Institute of Science and Technology*

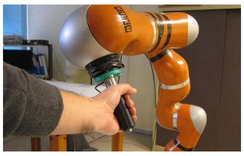
14:00–14:15	TuDT11.1

Reinforcement Learning of Variable Admittance Control for Human-Robot Co-manipulation

Fotios Dimeas, Nikos Aspragathos
University of Patras, Greece

- Reinforcement Learning (Fuzzy Q Learning) of variable damping for adaptation to the minimum jerk trajectory model
- A systematic approach to optimize admittance gains without prior knowledge of the movement to be conducted or user intervention
- Testing on a point-to-point translational movement

User experimental study:
✓ Reduced human effort after training
✓ Less time required to complete the task (target unknown to the robot)

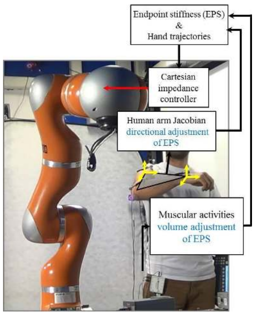


14:15–14:30	TuDT11.2

A Reduced-Complexity Description of Arm Endpoint Stiffness with Applications to Teleimpedance Control

Arash Ajoudani, Cheng Fang, Nikos Tsagarakis, and Antonio Bicchi
Department of Advanced Robotics, Italian Institute of Technology
Interdepartmental Research Centre "E. Piaggio", University of Pisa

- In this work, a novel and computationally efficient model of the arm endpoint stiffness behavior is proposed.
- Real-time tracking of the human arm kinematics is achieved using an arm triangle. In addition, a co-contraction index is defined using muscular activities of a dominant antagonistic muscle pair.
- Calibration and identification of the model parameters are carried out experimentally, using perturbation-based arm endpoint stiffness measurements in different arm configurations and co-contraction levels of the chosen muscles.
- Proposed model enables the master to naturally execute a remote task by modulating the direction of the major axes of the endpoint stiffness (EPS) and its volume using arm configuration and the co-activation of the involved muscles, respectively.

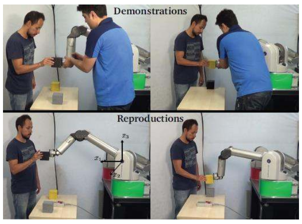


14:30–14:45	TuDT11.3

Learning Optimal Controllers in Human-Robot Cooperative Transportation Tasks with Position and Force Constraints

Leonel Rozo[1], Danilo Bruno[1],
Sylvain Calinon[1,2] and Darwin G. Caldwell[1]
[1]Istituto Italiano di Tecnologia, Italy [2]Idiap Research Institute, Switzerland

- Encoding of **collaborative behaviors** that vary according to task parameters.
- The desired position, velocity, and force are retrieved by **task-parametrized GMR**.
- An **optimal feedback** controller minimizes both the **robot effort** and **human intervention**.

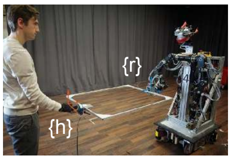


14:45–15:00	TuDT11.4

Grasp pose estimation in human-robot manipulation tasks using wearable sensors

Denis Ćehajić, Sebastian Erhart and Sandra Hirche[1]
[1]Technische Universität München, Germany

- Estimation strategy for identifying human grasp pose while minimizing the undesired interaction wrenches to the human
- Input motions satisfying the estimator convergence
- Experimental validation with a 7 DoF robot and a human partner equipped with an inertial sensor
- Global sensing system not needed

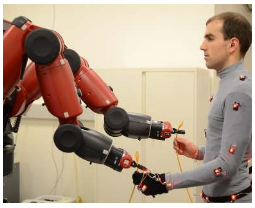


15:00–15:15	TuDT11.5

Personalized Kinematics for Human-Robot Collaborative Manipulation

Aaron M. Bestick, Samuel A. Burden, Giorgia Willits
Nikhil Naikal, S. Shankar Sastry, and Ruzena Bajcsy
University of California, Berkeley

- **Idea:** Generate personalized human kinematic models and use to identify ergonomically advantageous object handoff poses
- **Results:** Experiments show that handoffs planned using personalized models require significantly less compensatory torso motion than those planned using other schemes

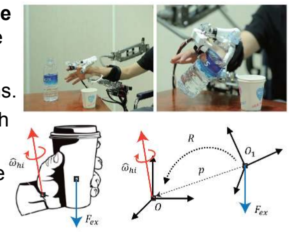


15:15–15:30	TuDT11.6

A Robust Control Method of Multi-DOF Power-Assistant Robots for Unknown External Perturbation using sEMG signals

Jaemin Lee[1], MinKyu Kim[1], and Keehoon Kim[1]
[1]Korea Institute of Science and Technology, Korea

- There are **human intention force** and **external disturbance** in use of power-assistant robot.
- **Wrist** has 3DOF complex motions.
- It is difficult to decompose wrench of human under perturbation.
- **sEMG** can accurately classify the human motion intention.
- **sEMG** is utilized to calibrate wrench of measured torque.



[Intention+External Perturbation]

Marine Robotics 1

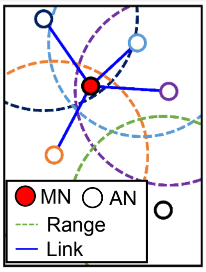
Chair *Jinhyun Kim, Seoul National University of Science and Technology*
Co-Chair *John M. Dolan, Carnegie Mellon University*

14:00–14:15 TuDT12.1

Underwater Sensor Network using Received Signal Strength of Electromagnetic Waves

Daegil Park[1], Kyungmin Kwak[2]
and Jinhyun Kim[2], Wan Kyun Chung[1]
[1]POSTECH, Republic of Korea [2]SeoulTECH, Republic of Korea

- EM wave based underwater localization scheme using received signal strength
- Short sensor range and signal identification problems solved using sensor network and channel allocation
- Experiment results show fast and reliable localization with high accuracy



14:15–14:30 TuDT12.2

Automatic Restoration of Underwater Monocular Sequences of Images

Paulo Drews-Jr[1,2], Erickson Nascimento[2],
Mario Campos[2] and Alberto Elfes[3]
[1]FURG, Brazil [2]UFMG, Brazil [3]CSIRO, Australia

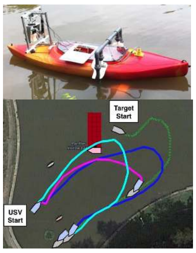
- A model-based methodology that uses the temporal relation, geometric and environmental information
- Uses a new statistical prior as initial guess
- Estimates depth using a combination of a new optical flow model and structure-from-motion techniques
- Experimental results on images acquired by a remotely operated vehicle (ROV) in naturally lit shallow seawater

14:30–14:45 TuDT12.3

COLREGS-Compliant Target Following for an Unmanned Surface Vehicle in Dynamic Environments

Pranay Agrawal[1], John M. Dolan[1],
[1]Carnegie Mellon University, USA

- Accurate and anthropomorphic motion estimation-based autonomous target-following by an USV while following the COLEGS rules in dynamic environment.
- Monte-Carlo sampling based motion prediction of dynamically feasible and collision- free paths with fuzzy weights.
- Continuously learning the target vessel's navigational behavior from its path history.



14:45–15:00 TuDT12.4

Robust Control Design for Positioning of an Unactuated Surface Vessel

Baris Bidikli[1], Enver Tatlicioglu[2],
Erkan Zergeroglu[3]
[1]Izmir Katip Celebi University, Turkey [2]Izmir Institute of Technology, Turkey [3]Gebze Technical University, Turkey

- In this paper, a robust controller is designed to achieve accurate positioning of an unactuated surface vessel by using multiple unidirectional tugboats.
- A specific location configuration for opposing tugboats and a matrix decomposition are utilized for this design.
- Detailed stability analysis ensured asymptotic tracking.
- Numerical simulation results demostrate the efficiency of the proposed controller.

15:00–15:15 TuDT12.5

Motion Safety for Vessels: An Approach Based on Inevitable Collision States

Michael Blaich[1], Simon Weber[1],
Johannes Reuter[1] and Axel Hahn[2]
[1]University of Applied Sciences Konstanz, Germany
[2]University of Oldenburg, Germany

- Motion safety for a vessel is more then a collision free trajectories - the vessel has to maintain a state for which an evasive trajectory is available all the time
- New method for non-stopping ICS
- Ensure that the vessel can reach a safe area e.g. a pier or anchoring place
- If it is not possible ensure that the distances to all other vessels is increasing

15:15–15:30 TuDT12.6

Atoms Based Control of Mobile Robots with Hardware-In-the-Loop validation

Adrien Lasbouygues[1], Benoit Ropars[12],
Robin Passama[1], David Andreu[1] and Lionel Lapierre[1]
[1]LIRMM, France [2]Ciscrea, France

- Need : gain efficiency in control design : reusability, evolutivity and integrate knowledge from environment specialists
- Solution based on a formal description of control as a modular Composition of basic entities called Atoms
- Associated with a methodology to that goes from control design to its implementation
- Use of Constraints to map control needs (stability) and implementation target abilities
- Illustrated through Hardware-In-the-Loop simulation

Soft-bodied Robots 1

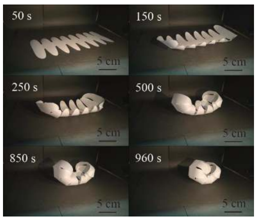
Chair *Dario Floreano, Ecole Polytechnique Federal, Lausanne*
Co-Chair *Jamie Paik, Ecole Polytechnique Federale de Lausanne*

14:00–14:15	TuDT13.1

Kirigami Robot : Making Paper Robot Using Deskop Cutting Plotter and Inkjet Printer

Hiroki Shigemune[1], Shingo Maeda[2], Yusuke Hara[3] , Uori Koike[1] and Shuji Hashimoto[1]
[1]Waseda University, Japan [2]Shibaura Intitute of Technology, Japan
[3] National Institute of Advanced Industrial Science and Technology, Japan

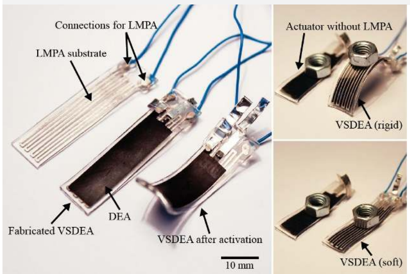
- Fabrication of **self-folding paper robot** with a desktop cutting plotter and inkjet printer
- Self-folded structures with automatically cut paper
- Printed electrothermal actuator with inkjet silver ink
- Gripper and conveyer robots were fabricated with printed structure, actuator and wiring



14:15–14:30	TuDT13.2

Variable Stiffness Actuator for Soft Robotics Using Dielectric Elastomer and Low-Melting-Point Alloys

Jun Shintake, Bryan Schubert, Samuel Rosset, Herbert Shea and Dario Floreano
École polytechnique fédérale de Lausanne, Switzerland



- We present a novel bending actuator that can change stiffness (~90 x). The actuator enables functional soft robots with simplified structure.

14:30–14:45	TuDT13.3

SpineMan: Design of a Soft Robotic Spine-Like Manipulator for Safe Human-Robot Interaction

Gundula Runge[1], Tobias Preller[2], Sabrina Zellmer[2], Sebastian Blankemeyer[1], Marian Kreuz[1], Georg Garnweitner[2], Annika Raatz[1]
[1]Leibniz Universität Hannover, Germany
[2]Technische Universität Braunschweig, Germany

14:45–15:00	TuDT13.4

Model-free control framework for multi-limb soft robots

Vishesh Vikas[1], Piyush Grover[2] and Barry Trimmer[1]
[1]Tufts University, USA [2]Mitsubishi Electric Research Lab, USA

- Data-driven, adaptable, generic approach where control exists in robot's task space applicable to terrestrial locomotion robots.
- Approach summary – Discretize, Visualize, Learn and Optimize.
- **Discretize** factors dominating robot-environment interaction
- **Visualize** transitions using graph theory. Mathematical definition of periodic gait, locomotion sequence.
- **Learn** surface dependent state transitions (weighted graph arcs)
- **Optimize** to find control sequences. Integer Linear Programming problem can quickly solved using standard solvers
- Fault tolerance e.g. loss of limb scenario involves manipulation of graph but no re-learning of state transitions

15:00–15:15	TuDT13.5

Soft Pneumatic Actuator with Adjustable Stiffness Layers for Multi-DoF Actuation

Amir Firouzeh[1], Marco Salerno[1], Jamie Paik[1]
[1]EPFL, Switzerland

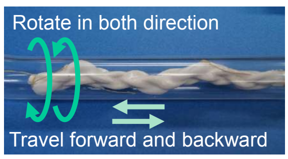
- Adjusting the stiffness of the chamber walls in a soft pneumatic actuator for activating it in different modes:
  1) Bending in two directions
  2) Elongation
  3) Combination of (1) and (2)
- Stiffness of each wall is controlled through temperature modulation of an embedded shape memory polymer layer

15:15–15:30	TuDT13.6

Six-Braided Tube In-pipe Locomotive Device

Hirozumi Takeshima[1], Toshio Takayama[1],
[1]Tokyo Institute of Technology, Japan

This novel device consists of six braided, inflatable tubes.
Features:
•Large elasticity due to pneumatic drive and soft and simple structure
•Simple control
•Ability to move in various pipes
•Separate control of the axial and rotational position



Field Robots 2

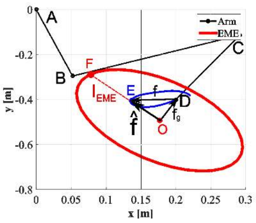
Chair *Hyouk Ryeol Choi, Sungkyunkwan University*
Co-Chair *Arash Ushani, University of Michigan*

14:00–14:15	TuDT14.1

Generalized Force-Energy Manipulability for Design & Redundant Robotic Arm

Daiki Mori[1], Genya ishigami[1],
[1]Keio University, Japan

- FEMI(Force-Energy Manipulabilty index) is proposed to evaluate an arm configuration for low energy consumption in a soil sampling mission on Mars.
- FEMI is calculated by the combination of energy manipulabiity and external force to evaluate the robotic arm for specific missions.

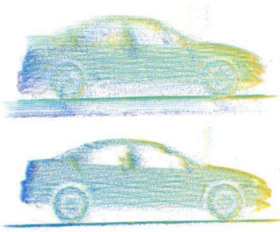


14:15–14:30	TuDT14.2

Continuous-Time Estimation for Dynamic Obstacle Tracking

A. K. Ushani[1], N. Carlevaris-Bianco[1],
A. G. Cunningham[1], E. Galceran[1], and R. M. Eustice[1]
[1]University of Michigan, USA

- We consider dynamic obstacle tracking for autonomous vehicles
- We model and solve this problem using continuous-time estimation and a formulation similar to SLAM
- We see improved performance relative to a baseline tracker

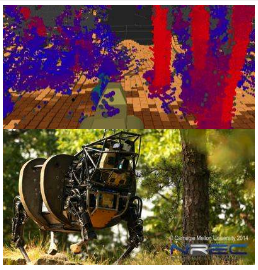


14:30–14:45	TuDT14.3

Scene Understanding for a High-mobility Walking Robot

David M. Bradley, Jonathan K. Chang,
Herman Herman, Peter Rander, and Anthony Stentz
NREC, CMU, USA

- **Terrain Classification** and **Ground Surface Modeling** from LIDAR and Images for autonomous navigation through complex off-road environments
- Part of a real-time perception system for a high-mobility quadruped walking robot.
- Extensive field testing and quantitative evaluation on manually labeled datasets across **various seasons, biomes, and lighting conditions**



14:45–15:00	TuDT14.4

2-2D Differential Gear Mechanism for Robot Moving Inside Pipelines

Ho Moon Kim[1], Yun Seok Choi[1],
Hyeong Min Mun[1] , Seung Ung Yang[1] , Chan Min Park[1]
and Hyouk Ryeol Choi[1]
[1] Sungkyunkwan University, KOREA

- MRINSPECT VI ++
  - 2-2D differential gear mechanism
  - Advanced adhesion mechanism
  - Rescue mechanism
- Experiment
  - Experiment for driving in pipeline
  - Experiment for driving in slip conditions

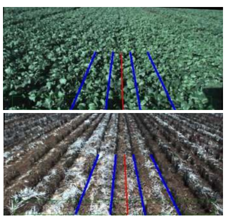
<MRINSPECT VI++>

15:00–15:15	TuDT14.5

Learning Crop Models for Vision-Based Guidance of Agricultural Robots

Andrew English, Patrick Ross,
David Ball, Ben Upcroft and Peter Corke
Queensland University of Technology

- Segmentation-free crop row tracking method.
- Offset of crop rows is learned online using SVM regression with colour, texture and stereo 3D structure descriptors.
- Works in a wide variety of fields without parameter adjustment.



15:15–15:30	TuDT14.6

Autonomous Golf Cars for Public Trial of Mobility-on-Demand Service

S Pendleton[1],T Utaicharoenpong[2],ZJ Chong[2],GMJ Fu[2],
B Qin[2],W Liu[1],X Shen[1],Z Weng[2],C Kamin[2],MA Ang[2],et.al.
[1]National University of Singapore, Singapore
[2]Singapore-MIT Alliance for Research and Technology, Singapore

- Systems design of 2 autonomous golf cars (GCs) for public trial - both and software design covered
- On-demand mobile booking
- Trial performed over 6 days, 352 km, 220 trips, 223 surveys
- No failure instances occurred, localization performance and survey results reflect good performance.

Haptics and Haptic Interfaces 2

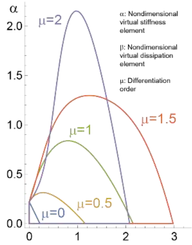
Chair *Angelika Peer, University of the West of England, Bristol*
Co-Chair *Patrick van der Smagt, TUM*

14:00–14:15	TuDT15.1

Stability of Haptic Systems with Fractional Order Controllers

Ozan Tokatli[1] and Volkan Patoglu[1]
[1]Sabanci University, Turkey

- We propose the use of fractional order controllers in haptic systems.
- We investigate the effect of the fractional differentiation order on the stability robustness of the overall sampled-data system theoretically and experimentally.
- We show that the fractional order calculus approach provides an extra degree of freedom, the order of differentiation, that can be tuned to improve the desired behavior of the system.

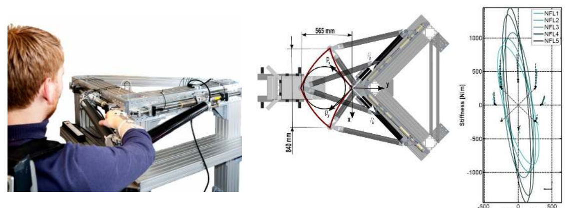


Stability regions of sampled-data system under various differointegration order

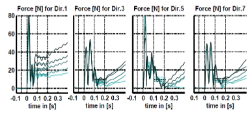
14:15–14:30	TuDT15.2

Two-dimensional orthoglide mechanism for revealing areflexive human arm mechanical properties

Hannes Höppner[1], Markus Grebenstein[1], and Patrick van der Smagt[2,3]
[1] Institute of Robotics and Mechatronics, German Aerospace Center (DLR), [2] Department for Informatics, Technische Universität München, Germany [3] fortiss, Associate Institute of the Technische Universität München, Germany



- stiff and light weight orthoglide robot buillt for revealing insights into purely mechanical human arm properties
- force task with 5 subjects --- clean data with always positive definite Cartesian stiffness matrices



14:30–14:45	TuDT15.3

Design and realization of the CUFF - Clenching Upper-limb Force Feedback wearable device for distributed mechano-tactile stimulation of normal and tangential skin forces.

Simona Casini[1], Matteo Morvidoni[1], Matteo Bianchi[2], Manuel Catalano[2], Giorgio Grioli[2], & Antonio Bicchi[1,2]
[1]Centro "E. Piaggio" - Univ. di Pisa, Italy [2]ADVR, IIT, Italy

- A simple **wearable device** for distributed mechano-tactile stimulation of arm skin
- Simultaneous rendering of **pressure** and **stretch cues** with normal and tangential forces
- Description of working principle, mechanical design and control method
- Preliminary results show the device can deliver reliable grasping force information.

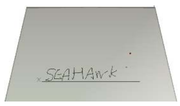
The prototype

14:45–15:00	TuDT15.4

Haptic Password

Junjie Yan[1], Kevin Huang[1], Tamara Bonaci[1] and Howard Chizeck[1]
[1]University of Washington, USA

- Haptic password is a novel password system based on haptic interaction
- It combines a discrete wavelet transform and artificial neural network, in order to use haptic information as a biometric feature for identification and authentication.
- Haptic password system is forgery resistant as well as user friendly. It is easy to memorize and update the password and the authentication process is fast.

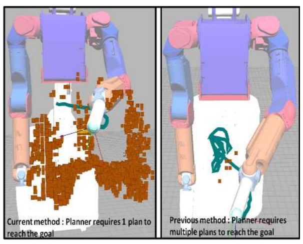


15:00–15:15	TuDT15.5

Combining Tactile Sensing and Vision for Rapid Haptic Mapping

Tapomayukh Bhattacharjee, Ashwin A. Shenoi, Daehyung Park, James M. Rehg, and Charles C. Kemp,
Georgia Institute of Technology, USA

- **Objective :** Enable a robot to efficiently obtain a dense haptic map of its visible surroundings.
- **Key Idea :** Visually similar objects probably feel the same.
- **Main Result :** Using dense haptic map, a robot successfully reached target locations with just one plan.

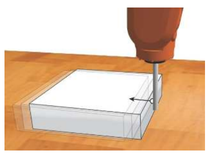


15:15–15:30	TuDT15.6

Shape and Pose Recovery from Planar Pushing

Kuan-Ting Yu[1], John Leonard[1,2], and Alberto Rodriguez[2]
[1]Computer Science and Artificial Intelligence Lab &
[2]Mechanical Engineering Department, MIT, USA

- Study the recovery of shape and pose of a planar movable object from observing a series of contacts.
- Tactile inference over contact points for object sliding on a frictional surface, using SLAM pose graph optimization.
- Experiments on simulated input data with artificial noises validate our approach.



Massachusetts Institute of Technology

MCube Lab

Human-Robot Interaction 1

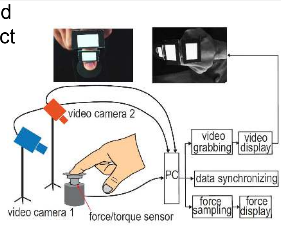
Chair *Yiannis Demiris, Imperial College London*
Co-Chair *Freek Stulp, École Nationale Supérieure de Techniques Avancées*

16:50–17:05 TuFT1.1

Measuring Fingertip Forces from Camera Images for Random Finger Poses

Nutan Chen[1], Sebastian Urban[1],
Justin Bayer[1] and Patrick van der Smagt[1]
[1]Technische Universität München, Germany

- This paper has presented a method that allows measuring finger contact force from the fingernail images at *various* finger joint angles.
- The effect of the finger joint on the force detection is analyzed using non-rigid image alignment and Gaussian process.
- This method is a significant step forward from a finger force estimator that requires tedious finger joint setting.

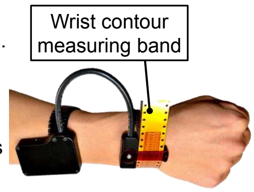


17:05–17:20 TuFT1.2

Hand Gesture Interface for Content Browse Using Wearable Wrist Contour Measuring Device

Rui Fukui[1], Naoki Hayakawa[1],Masahiko Watanabe[2] ,
Hitoshi Azumi[1] and Masayuki Nakao[1]
[1]The University of Tokyo, Japan [2]Panasonic Corporation, Japan

- Wearable wrist contour measuring device can recognize some classes of hand shapes and pronation angles.
- We develop real-time hand gesture interfaces for content browse of wearable or remote displays.
- Usability test reveals that pronation is to be assigned as a variable configurator and hand shape is to be assigned as an operation switcher.

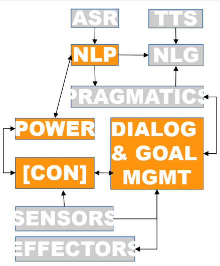


17:20–17:35 TuFT1.3

POWER: A Domain-Independent Algorithm for Probabilistic, Open-World Entity Resolution

Tom Williams, Matthias Scheutz,
Tufts University, USA

- We present an algorithm for resolving references (i.e., identifying entities referenced in natural language)
- The algorithm is domain independent, and handles both uncertain information and open worlds
- The algorithm's is evaluated through an empirical study and a proof-of-concept demonstration on a simulated robot, using the DIARC robotic architecture

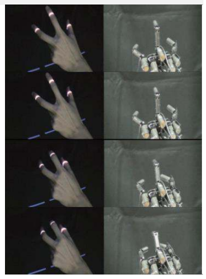


17:35–17:50 TuFT1.4

Development of Fast-Response Master-Slave System Using High-speed Non-contact 3D sensing and High-speed Robot Hand

Yugo Katsuki[1], Yuji Yamakawa[1],
Yoshihiro Watanabe[1] and Masatoshi Ishikawa[1]
[1]The University of Tokyo, Japan

- We developed a fast-response master–slave robot hand system using a high-speed vision system and a high-speed robot hand.
- The latency of the proposed system is so small that humans cannot recognize it.
- The motion of a human hand is obtained with high-speed non-contact 3D sensing, and this motion is mapped to a high-speed robot hand intuitively.

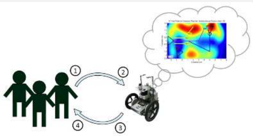


17:50–18:05 TuFT1.5

Human-Robot Information Sharing with Structured Language Generation from Probabilistic Beliefs

Rina Tse[1] and Mark Campbell[1]
[1]Cornell University, USA

- **Goal:** allow two-way belief communication and fusion between robots and humans, the former operating on pdfs, the latter on English sentences.



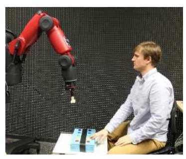
- Maximize semantic correctness and information preservation.
- Describe complex beliefs with a composition of multiple statements using a nonparametric Dirichlet Process Mixture of Statements (DP MoS) model.

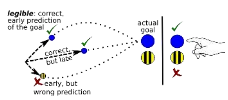
18:05–18:20 TuFT1.6

Facilitating Intention Prediction for Humans by Optimizing Robot Motions

Freek Stulp, Jonathan Grizou, Baptiste Busch, Manuel Lopes
FLOWERS: a joint INRIA / ENSTA-ParisTech team, France

- **Legibility**: Behavior that allows an observer to quickly derive intentions.
- **Main contribution:** Show that a robot can learn to generate legible behavior without a (user) model.
- **Method:** Direct policy search to optimize efficient and robust joint human-robot task completion.
- **Evaluation:** Two different tasks with a total of 20 subjects.





Unmanned Aerial Systems 3

Chair *Giuseppe Loianno, University of Pennsylvania*
Co-Chair *Maximilian Schulz, ETH Zurich*

16:50–17:05	TuFT2.1

Smartphones Power Flying Robots

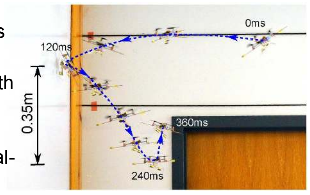
Giuseppe Loianno[1], Yash Mulgaonkar[1], Chris Brunner[2], Dheeraj Ahuja[2], Chris Brunner[2], Arvind Ramanandan[2], Murali Chari[2], Serafin Diaz[2], and Vijay Kumar[1]
[1]University of Pennsylvania, USA
[2]Qualcomm Technologies Inc., USA

- Autonomous smartphone flying robot using single camera and IMU
- The control, planning and estimation is running on a COTS smartphone at 200 Hz embedded in a single app
- Speeds up to 3 m/s with 3 cm average error
- The work allows any consumer with a smartphone to autonomously drive a quadrotor robot platform, even without GPS, by downloading an app, and concurrently build 3-D maps

17:05–17:20	TuFT2.2

Perching Failure Detection and Recovery with Onboard Sensing

Hao Jiang, Morgan Pope, Matthew Estrada, Bobby Edwards, Mark Cuson, Elliot Hawkes, Mark Cutkosky
Stanford University

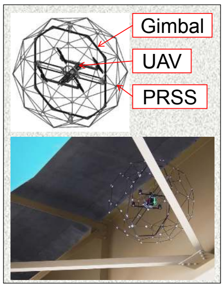


- Perching failure detection with only an onboard accelerometer
- Failure detection time as early as 40ms after the impact
- Over 90% detection accuracy with simple model and machine learning
- Correct identification of all 20 real-time perching experiments and successful recovery with the failed ones

17:20–17:35	TuFT2.3

Proposal and Experimental Validation of a Design Strategy for a UAV with a Passive Rotating Spherical Shell

S. Mizutani, Y. Okada, C. J. Salaan, T. Ishii
K. Ohno and S. Tadokoro
Tohoku University, Japan

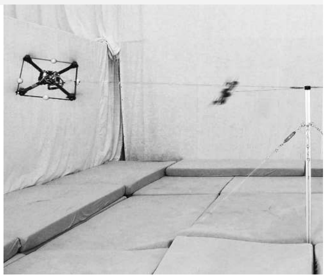


- A UAV with a passive rotating spherical shell (PRSS UAV) suitable for **flight in a confined space**
- Proposal of a design strategy with a consideration of **real-world mission requirements**
- Validation of the capability of the flight and inspection from **quantitative experiments** and **practical field tests**

17:35–17:50	TuFT2.4

High-speed, Steady Flight with a Quadrocopter Using a Tether

Maximilian Schulz, Federico Augugliaro, Robin Ritz and Raffaello D'Andrea
Institute for Dynamic Systems and Control, ETH Zurich

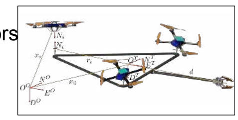


- Highspeed flights in confined spaces with quadrocopters
- Velocities of up to 15 m/s
- Centripetal accelerations of more than 13 g
- Analysis of aerodynamic effects at high speeds

17:50–18:05	TuFT2.5

Aerial Tool Operation System using Quadrotors as Rotating Thrust Generators

Hai-Nguyen Nguyen[1], Sangyul Park[1], Dongjun Lee[1]
[1]Seoul National University, Republic of Korea

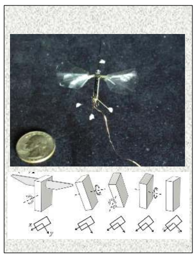


- Propose a **new aerial tool operation system** consisting of multiple quadrotors connected to a tool by spherical joints
- Utilize **quadrotors as thrusters** to control 6-DOF tool dynamics
- **Condition for fully-actuation** of tool dynamics depends on mechanical design of the system
- Allocate desired control of tool dynamics to each quadrotor while respecting spherical joint limits by solving a **second-order cone problem**

18:05–18:20	TuFT2.6

Rotating the heading angle of underactuated flapping-wing flyers by wriggle-steering

Sawyer B. Fuller[1], John P. Whitney[2] and Robert J. Wood[1]
[1]Harvard University, MA, USA [2]Disney Research, PA, USA



- The Harvard Robobee, an insect-scale aerial vehicle (and some other flapping-wing robots) are unable to steer
- Here, we show how nonlinearity in attitude dynamics can be used to perform rotation around this axis
- Motion consists of phased, cyclic oscillations about two other actuated axes, termed "wriggling"
- Demonstration of principle on Robobee

Robot Vision 3

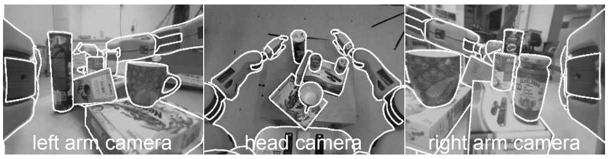
Chair *Justus Piater, University of Innsbruck*
Co-Chair *Peter Pinggera, Daimler*

16:50–17:05	TuFT3.1

SimTrack: A Simulation-based Framework for Scalable Real-time Object Pose Detection and Tracking

Karl Pauwels and Danica Kragic
KTH Royal Institute of Technology, Stockholm, Sweden

- Multi-camera object pose from depth and optical flow
- 6-DOF pose of 40 objects using 3 cameras at 30 Hz
- ROS package at *https://github.com/karlpauwels/simtrack*



17:05–17:20	TuFT3.2

High-Performance Long Range Obstacle Detection Using Stereo Vision

Peter Pinggera[1,2], Uwe Franke[1], Rudolf Mester[2,3]
[1]Daimler AG, Germany
[2]Goethe University, Germany [3]Linköping University, Sweden

- Fast-moving **autonomous vehicles** require early obstacle detection & localization

→ We propose a stereo vision approach for **highest detection performance & localization accuracy** at long range

- **Static** and **dynamic** objects
- **Non-flat** ground profiles
- **Real-time** execution

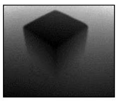
17:20–17:35	TuFT3.3

Fast 3D Edge Detection by Using Decision Tree from Depth Image

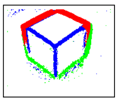
Masaya Kaneko[1], takahiro Hasegawa[1], Yuji Yamauchi[1] , Takayoshi Yamashita[1], Hironobu Fujiyoshi[1], and Hiroshi Murase[2]
[1]Chubu University, Japan [2]Nagoya University, Japan

- Proposed method
  - Generating depth image and training samples
  - Training decision tree
  - Raster-scan by decision tree
  - Non-maximal suppression

⇒ **25 times faster** classification than that of conventional method



Depth image



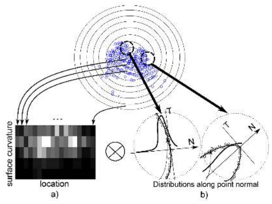
Proposed method

17:35–17:50	TuFT3.4

SCurV: A 3D descriptor for object classification

Antonio Rodríguez-Sánchez[1], Sandor Szedmak[1] and Justus Piater[1]
[1]Intelligent and Interactive Systems, Dept. of Computer Science, University of Innsbruck, Austria

- **SCurV is the result of computing the tensor product between:**
  - A global object-centered component based on surface curvature
  - A local viewpoint-centered representation providing degrees of convexity, concavity and flatness

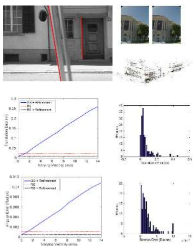


17:50–18:05	TuFT3.5

A Minimal Solution to the Rolling Shutter Pose Estimation Problem

Olivier Saurer[1], Marc Pollefeys[1], and Gim Hee Lee[2]
[1]ETH Zurich, Switzerland [2]MERL, USA

- Rolling Shutter artefacts degrade the accuracy of absolute pose estimation
- We approximate the camera motion with a linear translational motion model
- The minimal solution requires 5-point correspondences
- Besides localization the algorithm can be used for velocity estimation from a single rolling shutter image

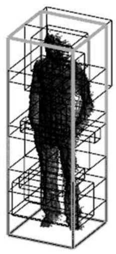


18:05–18:20	TuFT3.6

Real-Time Full-Body Human Attribute Classification in RGB-D Using a Tessellation Boosting Approach

Timm Linder, Kai O. Arras
Social Robotics Lab, University of Freiburg, Germany

- Detail knowledge about humans in the environment can be key information for social robots
- Extension of our tessellation boosting method that jointly learn best locations, scales and features
- **New geometric extent and color features**
- **5 different human attributes:** Gender, long trousers, long sleeves, long hair, has jacket
- Outperforms HOG + previous work without color features while achieving **up to 300 Hz** on CPU



SLAM 3

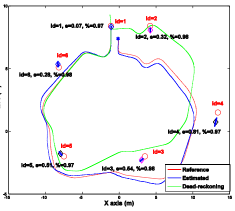
Chair *Tom Drummond, Monash University*
Co-Chair *Javier Civera, Universidad de Zaragoza*

16:50–17:05	TuFT4.1

A Composite Beacon Initialization for EKF Range-Only SLAM

Lionel Génevé[1], Olivier Kermorgant[1], Édouard Laroche[1]
[1] ICube Laboratory, University of Strasbourg-CNRS, Strasbourg, FRANCE

- New method to initialize the beacons in an EKF for the 2D RO-SLAM case
- Short delayed initialization with Cartesian representation of the beacon‘s position
- 2 range measurements used to create a Gaussian mixture with 2 hypotheses which are inserted in the filter‘s state

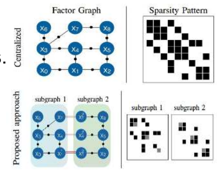


17:05–17:20	TuFT4.2

Exactly Sparse Memory Efficient SLAM Using the Multi-Block Alternating Direction Method of Multipliers

Siddharth Choudhary, Luca Carlone, Henrik I. Christensen and Frank Dellaert
Institute for Robotics and Intelligent Machines, Georgia Tech, USA

- ADMM approach to scalable SLAM that preserves the sparsity structure.
- Straight forward implementation and intutitve interpretation using factor graphs.
- Allows to easily trade off between computation time and accuracy (*just in time flavor*).
- Draws connection to recent literature on decentralized optimization.



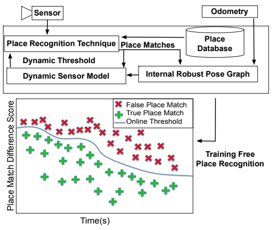
17:20–17:35	TuFT4.3

Online Place Recognition Calibration for Out-of-the-Box SLAM

Adam Jacobson, Zetao Chen and Michael Milford
Queensland University of Technology, Australia
Australian Centre for Robotic Vision

This paper presents:

- A novel technique for online place recognition calibration without prior environmental knowledge.
- A calibration method leveraging robot experience and an internal pose graph to tune parameters.
- Experiments in two diverse environments, including the New College dataset, with varying

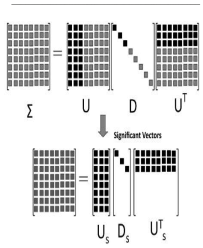


17:35–17:50	TuFT4.4

Reduced Dimensionality EKF for SLAM in a Relative Formulation

Dinesh Gamage[1], Tom Drummond[1],
[1]Monash University, Australia.

- The number of parameters could get quite large in a SLAM system.
- Optimizing such a large system will be impractical requiring alternative methods.
- In this work we identify the dominant dimensions of the problem and try to optimize only those enabling more information to be fused, but reducing the complexity.

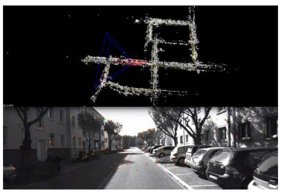


17:50–18:05	TuFT4.5

Stereo Parallel Tracking and Mapping for robot localization

T. Pire[1], T. Fischer[1], J. Civera[2], P. De Cristóforis[1] and J. Jacobo Berlles[1]
[1]University of Buenos Aires, Argentina
[2]University of Zaragoza, Spain

- Real-Time Stereo Visual SLAM system based on PTAM
- Exploites the parallel nature of SLAM problem
- Stereo constraints are enforced on pose and map refinements
- Sparse metric Map
- Binary features (KLT+BRIEF)
- Open source code build on ROS



Micro/Nano Robots 2

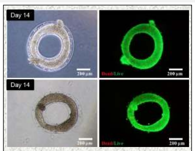
Chair *Yasuhisa Hasegawa, Nagoya University*
Co-Chair *Gilgueng Hwang, CNRS*

16:50–17:05	TuFT5.1

Electrodeposition of Cell-laden Alginate-PLL Hydrogel Structures for Spatially Selective Entrapment

Zeyang Liu[1], Masaru Takeuchi[1],
Masahiro Nakajima[1], Toshio Fukuda[2] and Qiang Huang[3]
[1]Nagoya Univ, Japan [2]Meijo Univ, Japan [3]Beijing Institute of Technology, China

- Fabricating cell-laden alginate-PLL hydrogel structures with predefined shapes
- The shape is maintained and cell leakage is avoided by coating PLL shell
- Rat liver cells (RLC-18) are successfully encapsulated within the alginate-PLL microcapsules to form donuts-like cellular aggregation after 2 weeks cultivation



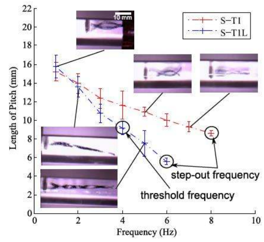
Cell viability of 14-day cultured 3D tissue

17:05–17:20	TuFT5.2

Morphologies and Swimming Characteristics of Rotating Magnetic Swimmers with Soft Tails at Low Reynolds Numbers

T. Xu[1,2], H. Yu[1], H. Zhang[1], C. Vong[1] and L. Zhang [1,2,3]
[1]The Chinese University of Hong Kong, Hong Kong SAR, China
[2]Shenzhen Research Institute, CUHK, Shenzhen, China
[3]Chow Yuk Ho Technology Centre for Innovative Medicine, Hong Kong SAR, China

- Dynamic morphologies: Helical shape & Twisted shape
- Swimming direction does not change with the rotating direction
- Pitch length decreases with the rotational frequency
- Threshold frequency & step-out frequency

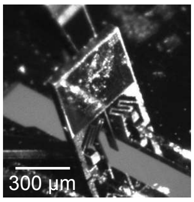


17:20–17:35	TuFT5.3

Stereovision-based Control for Automated MOEMS Assembly

Andrey V. Kudryavtsev, Guillaume J. Laurent,
Cédric Clévy, Brahim Tamadazte, Philippe Lutz
FEMTO-ST Institute, UBFC/UFC/ENSMM/UTBM,
Université de Franche-Comté, Besançon, France

- Single-view Model-based visual tracking analysis. Problem of depth coordinate estimation at the microscale
- Development of the algorithm allowing to estimate depth coordinate using stereo visual feedback
- Microassembly automation. Results and brief analysis

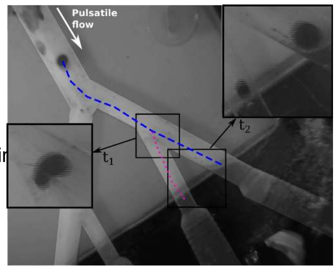


17:35–17:50	TuFT5.4

Magnetic Microbot Design Framework for Antiangiogenic Tumor Therapy

Lyès Mellal[1], D. Folio[1], K. Belharet[2] and A. Ferreira[1]
[1]PRISME Laboratory, INSA CVL, France
[2]PRISME Laboratory, HEI, France

- Tumor growth modeling
- Optimal therapeutic drug dose control
- Optimal magnetic microrobot design
- Experimental investigation in mm-sized fluidic artery phantoms

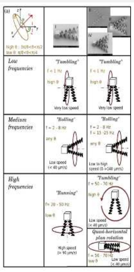


17:50–18:05	TuFT5.5

Multi-flagella Helical Microswimmers for Multiscale Cargo Transport and Reversible Targeted Binding

Nicolas Beyrand[1], Laurent Couraud[1], Antoine Barbot[1],
Dominique Decanini[1] and Gilgueng Hwang[1]
[1]LPN-CNRS, France

- Multi-flagella helical microswimmers can tumble, roll, run or hover
- Numerous propulsion modes enable the robots move rapidly with robustness
- Application to the precise and reversible targeted binding micromanipulation
- Application to the non-contact cargo transport of moving particles from 5 to 30 µm large

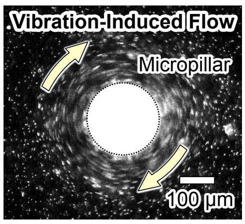


18:05–18:20	TuFT5.6

On-Chip Cell Transportation Based on Vibration-Induced Local Flow in Open Chip Environment

Takeshi Hayakawa, Shinya Sakuma and Fumihito Arai
Nagoya University, Japan

- Cell manipulation method based on vibration-induced flow.
- Local whirling flow can be induced around micropillars on a chip by applying circular vibration to the chip.
- Various manipulations, such as transportation, trapping and gathering are achieved by proposed method.



Surgical Robotics 3

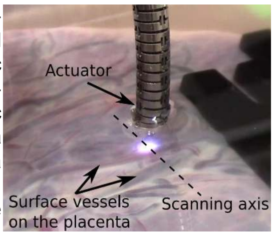
Chair *Robert James Webster III, Vanderbilt University*
Co-Chair *Paolo Fiorini, University of Verona*

16:50–17:05	TuFT6.1

Fluidic actuation for intra-operative *in situ* imaging

A. Devreker[1], B. Rosa[1], A. Desjardins[2], E.J. Alles[2], L.C. Garcia-Peraza[2], E. Maneas[2], et al.
[1]KU Leuven, Belgium [2]UCL, United Kingdom

Trends towards surgical invasiveness minimization requires surgical instrument innovation. A novel fluidic actuation system has been developed for *in situ* imaging of anatomic tissues. The actuator consists of a superelastic tool guide driven by a pair of pneumatic artificial muscles. Working channels allow interchange of instruments or sensors.

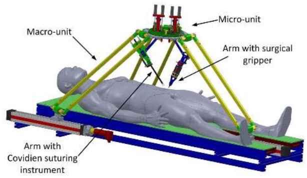


17:05–17:20	TuFT6.2

Motion Planning for a Multi-Arm Surgical Robot Using Both Sampling-based Algorithms and Motion Primitives

Nicola Preda[1], Auralius Manurung[2], Olivier Lambercy[2], Roger Gassert[2], Marcello Bonfè[1]
[1]University of Ferrara, Italy [2]ETH Zurich, Switzerlandountry

- Development of a motion planning and control architecture for a novel surgical robot, characterized by a hybrid serial/parallel kinematics
- To address a suturing task, the proposed motion planner embeds online generation of collision-free paths and the execution of predefined motion primitives

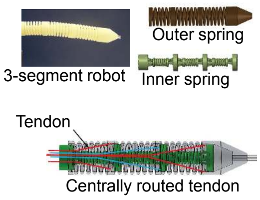


17:20–17:35	TuFT6.3

Design and Kinematic analysis of a Neurosurgical Spring-based Continuum Robot using SMA Spring Actuators

Yeongjin Kim and Jaydev P. Desai
University of Maryland, College Park, MD, USA

- MRI-compatible neurosurgical robot
- SMA spring-based actuation
- Parallel spring structure (outer spring and inner inter-connected spring backbone)
- Unique tendon routing configuration (centrally routed) for independent joint control



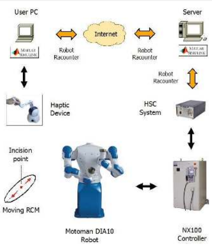
17:35–17:50	TuFT6.4

17:50–18:05	TuFT6.5

Analysis of a Moving Remote Center of Motion for Robotics-Assisted Minimally Invasive Surgery

C. D. Pham[1], F. Coutinho[2], A. C. Leite[2], F. Lizarralde[2], P. J. From[1], R. Johansson[3]
[1]NMBU, Norway [2]COPPE-UFRJ, Brazil [3]Lund University, Sweden

- Active control of the motion for the incision point and robot end effector;
- Kinematic modeling of the robotic system subject to velocity constraints;
- Kinematic singularities are tackled by using the Filtered Inverse approach;
- Experimental results for singularity avoidance and haptic control.

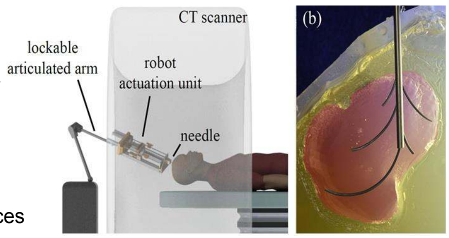


18:05–18:20	TuFT6.6

Robotic Intracerebral Hemorrhage Evacuation: An In-Scanner Approach with Concentric Tube Robots

Isuru Godage[1], Andria Ramirez[1], Raul Wirz[1], Kyle Weaver[1], Jessica Burgner-Kahrs[2], Robert Webster III[1],
[1]Vanderbilt University, USA [2]Leibniz Universitaet, Germany

- 1 in 50 lifetime incidence, 40% mortality
- First in-scanner experiments
- Hot-swappable tubes
- Intra-operative imaging enhances safety



Mobile Manipulation

Chair *Jeff Trinkle, Rensselaer Polytechnic Institute*
Co-Chair *Oliver Brock, Technische Universität Berlin*

16:50–17:05	TuFT7.1

Aerial manipulation for the workspace above the airframe

Syohei Shimahara, Robert Ladig, Leewiwatwong Suphachart, Shinichi Hirai, Kazuhiro Shimonomura
Ritsumeikan University, Japan

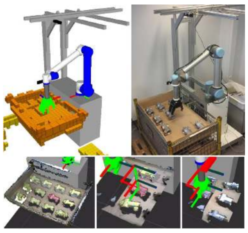
- A robotic hand mounted on top of the quadrotor
- The robotic hand module consists of the gripper and the slider part
- The robot smoothly achieved grasping of a bar object located over the airframe based on visual feedback control through the embedded vision system

17:05–17:20	TuFT7.2

Real-Time Object Detection, Localization and Verification for Fast Robotic Depalletizing

Dirk Holz[1], Angeliki Topalidou-Kyniazopoulou[1], Jörg Stückler[2] and Sven Behnke[1]
[1]University of Bonn, Germany
[2]Techniche Universität München, Germany

- Fast pipeline for detecting and grasping automotive parts on pallets.
- Initial detection of object candidates using real-time pallet segmentation.
- Surfel-based registration for accurate localization and verification of parts (e.g., detecting wrong objects).
- Using pre-computed trajectories for saving motion planning time.
- **Results:** Success rate ≈100%, cycle time ≈13s



17:20–17:35	TuFT7.3

In-situ Repetitive Calibration of Microscopic Probes Maneuvered by Holonomic Inchworm Robot for Flexible Microscopic Operations

O. Fuchiwaki[1], T. Yamagiwa[2], S. Ohmura[3] and Y. Hara[1]
[1]Yokohama National Univ., [2]ANA Co., Ltd, [3]DeNA Co., Ltd, Japan

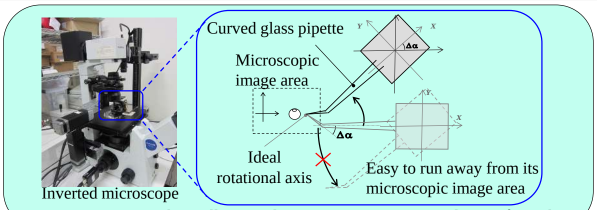


Fig. 2 Dexterous bio-cell manipulation using rotation around a tip of a probe

- Calibration for holonomic Inchworm robot by microscopic image.
- Motion errors in X, Y and θ axes are decreased down to their measuring resolutions in 6 calibrations under open loop control.

17:35–17:50	TuFT7.4

Constraint-Based Model Predictive Control for Holonomic Mobile Manipulators

Giovanni Buizza Avanzini[1], Andrea Maria Zanchettin[1] and Paolo Rocco[1]
[1]Politecnico di Milano, Italy

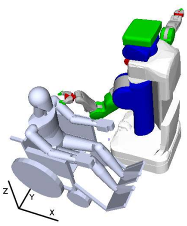
- A **Model Predictive Control** framework for tracking problems in **mobile manipulation** is presented
- **Constraints** are imposed to avoid collisions with obstacle and maintain the human in the robot's field of view
- **Experimental validation** shows the applicability of the approach in complex and dynamic scenarios

17:50–18:05	TuFT7.5

Task-Centric Selection of Robot and Environment Initial Configurations for Assistive Tasks

Ariel Kapusta[1], Daehyung Park[1], and Charles C. Kemp[1]
[1]Georgia Institute of Technology, USA

- Uses task-centric manipulability against state estimation error
- Considers various environmental DoF
- Finds a set of configurations from which a robot can perform a task
- Performs offline computation for fast solution at run time.
- Evaluated on 11 activities of daily living (e.g. shaving, feeding, bathing)
- Performs well against state estimation error

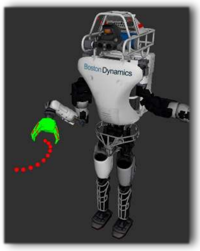


18:05–18:20	TuFT7.6

Orientation-based Reachability Map For Robot Base Placement

Jun Dong[1], Jeff Trinkle[2],
[1]Rensselaer Polytechnic Institute, United States
[2]National Science Foundation, United States

- Reachability database for base placement
- Data clustered regarding orientations
- Easy database inheritance for end effector frame extension
- Base placement with less constrained paths for extended end effector frame



Force and Tactile Sensing 1

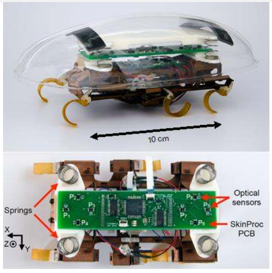
Chair *Joshua Goldberg, University of California, Berkeley*
Co-Chair *Robert Haschke, Bielefeld University*

16:50–17:05	TuFT8.1

Force Sensing Shell using a Planar Sensor for Miniature Legged Robots

Joshua Goldberg[1], Ronald Fearing[1],
[1]University of California, Berkeley, USA

- Low-cost, lightweight force-torque sensor using photointerrupters
- Force sensitivity 17 mN (1% of full scale)
- Torque sensitivity 0.72 mN-m (< 1% of full scale)
- Sensing shell can measure environment interaction forces including collision and drag

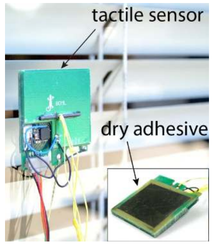


17:05–17:20	TuFT8.2

Tactile Sensing for Gecko-Inspired Adhesion

X. Alice Wu, S.A. Suresh, H. Jiang, J.V. Ulmen, E.W. Hawkes, D.L. Christensen, and Mark R. Cutkosky[1]
[1]Stanford University, USA

- Adhesion quality sensing is critical to a robot that utilizes gecko-inspired dry adhesives.
- We present a compact, robust, 3-axis capacitive tactile sensor that measures shear and distributed normal forces for adhesion.
- Results showcase the sensor's ability to detect unreliable contact and loading conditions before adhesion failure.

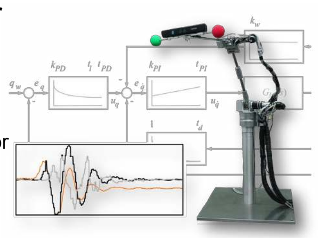


17:20–17:35	TuFT8.3

Link Elasticity Exploited for Payload Estimation and Force Control

Jörn Malzahn[1], Russell Schloss[2] and Torsten Bertram[2]
[1]Istituto Italiano di Tecnologia (ADVR), Italy
[2]TU Dortmund University (RST), Germany

- **Link elasticity as an enabler** for new sensing and control capabilities
- Estimate a priori unknown payload masses
- Sense and control end effector forces
- **Experimental results** with a multi-elastic link arm



17:35–17:50	TuFT8.4

Augmenting Curved Robot Surfaces with Soft Tactile Skin

Gereon Büscher, Martin Meier, Guillaume Walck, Robert Haschke and Helge J. Ritter
CITEC, Bielefeld University, Germany

- We present a technology to create **robust sensing units** that can be adapted to robot hands with narrwo spaces.
- Integrated piezroresistive fabric based tactile sensors cover extensive 3D faces
- Upholstery and patterned skin increase compliance and thus grasp stability
- Unit thickness starts at ~2.5 mm. Forces can be measured from ~3 to over 30 N at 1000Hz with 12bit resolution.

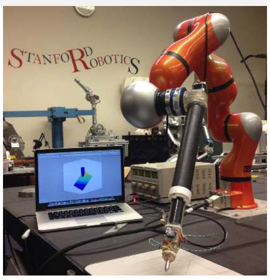

Shadow robot hand with 36 taxels on palm (+ 12 per tip)

17:50–18:05	TuFT8.5

SupraPeds: Smart Staff Design and Terrain Characterization

Shiquan Wang, Shuyun Chung, Oussama Khatib and Mark Cutkosky
Stanford University, USA

- We present a smart staff with variable length and tip sensing to enhance humanoid locomotion.
- A novel multiplexed extension mechanism and sensor design enable a lightweight staff.
- An active sensing method characterizes the terrain surface normal and coefficient of friction using simple motions.

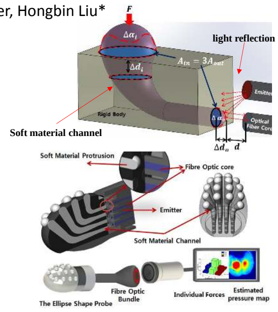


18:05–18:20	TuFT8.6

Feasibility Study- Novel Optical Soft Tactile Array Sensing for Minimally Invasive Surgery

Junghwan Back, Prokar Dasgupta, Lakmal Seneviratne, Kaspar Althoefer, Hongbin Liu*

- A novel design of optic soft tactile arrays has been created.
- The applied pressure is transmitted to the end of the channel, causing an axial protrusion of the soft material on the other end.
- A camera observes light intensity change, causing of the axial protrusion.
- It suitable for designing high density of tactile elements, easy to fabricate and miniaturize, to be designed in an arbitrary shape, and immune to electromagnetic interference.



The design concept of the soft tactile array sensor

Biologically-Inspired Robots 3

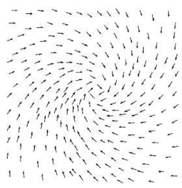
Chair *Koh Hosoda, Osaka University*
Co-Chair *Michael Sfakiotakis, Technological Educational Institute of Crete*

16:50–17:05	TuFT9.1

Low-rank forward models: a path to the self-organization visuo-motor systems

Ângelo Cardoso[1], Ricardo Ferreira[1], Ricardo Santos[1] and Alexandre Bernardino[1]
[1]Institute for Systems and Robotics – Univ. Lisboa, Portugal

- Forward models predict the effects of motor actions on sensors.
- Self-organization of sensorimotor systems which are adaptable to an environment is key for reliable forward models.
- The development of resource constrained sensorimotor systems is essential for low-cost energy efficient autonomous robots.

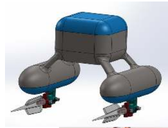


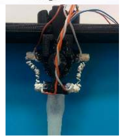
17:05–17:20	TuFT9.2

Multi-arm Robotic Swimmer Actuated by Antagonistic SMA Springs

M. Sfakiotakis, A. Kazakidi, T. Evdaimon, A. Chatzidaki, D.P. Tsakiris
Institute of Computer Science, FORTH, Greece

- Multi-arm underwater robot swimmers, actuated by **compliant** antagonistic pairs of **SMA springs**, were developed and tested.
- Their SMA-actuated joints are **controlled in closed-loop**, via a scheme based on the Prandtl-Ishlinskii model of the joints' response.
- This leads to significantly higher speed of operation and improved trajectory tracking accuracy of the SMA-actuated joints.
- Speeds of 0.5 body lengths / sec were achieved.



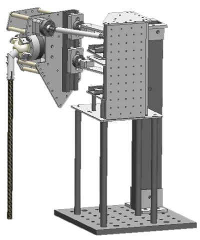


17:20–17:35	TuFT9.3

Surface EMG based Posture Control of Shoulder Complex Linkage Mechanism

Shuhei Ikemoto, Yuya Kimoto and Koh Hosoda
Osaka University, Japan

- The aim of this research is to develop a musculoskeletal robot arm which simplifies the sEMG based posture control.
- We develop a linkage mechanism, which can realize similar function to the shoulder complex, to achieve this purpose.
- The advantage has been successfully shown in an experiment.

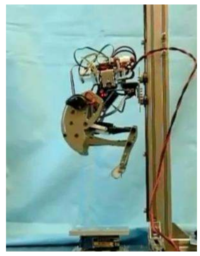


17:35–17:50	TuFT9.4

Development of Robot Legs Inspired by Bi-articular Muscle-tendon Complex of Cats

Ryuki Sato, Ichiro Miyamoto, Keigo Sato, Aiguo Ming and Makoto Shimojo
The University of Electro-Communications, Japan

- A new leg mechanism inspired by bi-articular muscle-tendon complex of cats is proposed for dynamic motions.
- The basic functions of the complex are realized by four-bar linkage mechanism with one elastic linkage.
- The feasibility of the mechanism is confirmed through jumping and landing experiments using developed prototype.

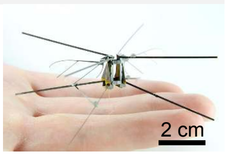


17:50–18:05	TuFT9.5

Design and fabrication of an insect-scale flying robot for control autonomy

Kevin Y. Ma[1], Pakpong Chirarattananon[2], and Robert J. Wood[1]
[1]Harvard University, USA [2]City University of Hong Kong, China

- A 5.5 cm wingspan, 380 mg flapping-wing, micro air vehicle is developed with a 115 mg payload capacity—sufficient to carry the requisite electronics for control autonomy. Controlled hovering flight is demonstrated.



- We demonstrate the feasibility of scaling up an established vehicle design to enable greater payloads, using current fabrication methods.

18:05–18:20	TuFT9.6

Sensing the Neighboring Robot by the Artificial Lateral Line of a Bio-inspired Robotic Fish

Wei Wang[1], Xingxing Zhang[2], Jianwei Zhao[3] and Guangming Xie[1]
[1]Peking University, China [2]East China Jiaotong University, China
[3]China University of Mining & Technology, China

- Fish can use the lateral line to sense states of its neighbors in schooling behaviors.
- We investigate how a focal robotic fish senses the states of its swimming neighbor by using its onboard artificial lateral line system for the first time.
- The results show that the robot's artificial lateral line can detect the beating frequency of its neighboring robot and the distance between the robots.
- Artificial lateral line sensing could become one popular close interaction method for underwater robot teams in the near future.

Humanoid and Bipedal Locomotion 3

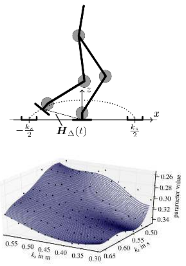
Chair *Tamim Asfour, Karlsruhe Institute of Technology (KIT)*
Co-Chair *Nikos Tsagarakis, Istituto Italiano di Tecnologia*

16:50–17:05 TuFT10.1

Generalization of Optimal Motion Trajectories for Bipedal Walking

Alexander Werner[1], Dietrich Trautmann[1], Dongheui Lee[2] and Roberto Lampariello[1]
[1]German Aerospace Center (DLR), Germany [2]Technical University of Munich, Germany

- Generate optimal cyclic step motions using optimization and a 2D complete model
- Construct a mapping from a 2D task space to optimal motions using machine learning
- Investigate performance of the machine learning in representing the mapping and its impact on feasibility of the trajectories
- Approach for use of optimal motions in combination with balancing and step adaptation

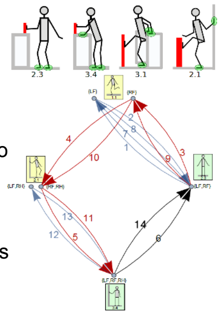


17:05–17:20 TuFT10.2

A Whole-Body Pose Taxonomy for Loco-Manipulation Tasks

Júlia Borràs[1] and Tamim Asfour[1]
[1]Karlsruhe Institute of Technology, Germany

- We analyze all the ways the body can be used to enhance balance, resulting in a taxonomy of whole-body poses using multi-contacts.
- This can have many applications: as a tool for autonomous decision making, to design complex motions, or simplify control, among others.
- We also present a method to analyze human motions detecting support poses and the transitions between them.

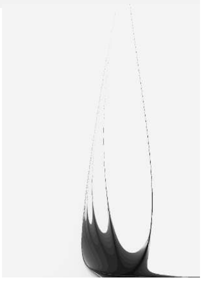


17:20–17:35 TuFT10.3

The Basin of Attraction for Running Robots: Fractals, Multistep Trajectories and Control

Tom Cnops[1], Zhenyu Gan[1,2] and C. David Remy[1,2]
[1]University of Michigan, USA [2]RAMlab, USA

- Even the basic SLIP-model has strong passive dynamics: in the figure all states are shown that come within one pixel of a limit cycle (greyscale: number of steps)
- If only limited control is available, multiple hops will be necessary to reach a desired state and the passive dynamics remain important
- We compare the performance of a greedy controller with an exhaustive search



17:35–17:50 TuFT10.4

Inversion-based gait generation for humanoid robots

Leonardo Lanari[1] and Seth Hutchinson[2],
[1]Sapienza, Italy [2]University of Illinois, USA

- Gait generation for bipedal robots
- CoM determination from desired ZMP as a stable inversion problem
- Resulting CoM reference trajectories bounded
- Allows design of simultaneous CoM/ZMP trajectories
- General unifying framework
- Conceptual extension of the Capture Point

17:50–18:05 TuFT10.5

Exploiting the Redundancy for Humanoid Robots to Dynamically Step Over a Large Obstacle

Chengxu Zhou, Xin Wang, Zhibin Li, Darwin Caldwell and Nikos Tsagarakis
Istituto Italiano di Tecnologia, Italy

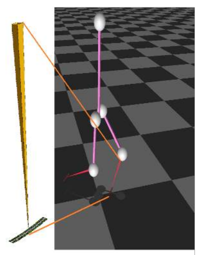
- A control framework is proposed to resolve the issue of stepping over a large obstacle by exploiting the redundancy of pelvis rotation and the versatility of foot trajectories for the humanoid robots.
- Its effectiveness is validated by that COMAN's capability of dynamically stepping over a large obstacle of 10cm height by 5cm width which is almost 20% of its leg length.

18:05–18:20 TuFT10.6

Passive Frontal Plane Coupling and Energetics in 3D Walking

Sebastian Sovero[1], Cenk Saglam[2],and Katie Byl[2]
[1]UCSB Mechanical Engineering, USA [2]UCSB Electrical Engineering, USA

-Investigates the coupling effects between Frontal and Sagittal plane in 3D walking
-Understanding the Frontal plane energy requirements as a function of stepping Time
-Simple passive design is sufficient for a variety of gaits, and a high degree of energy efficiency.



Compliance and Impedance Control 1

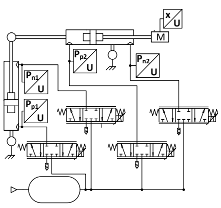
Chair *Salman Faraji, EPFL*
Co-Chair *Barkan Ugurlu, Ozyegin University / ATR*

16:50–17:05 TuFT11.1

Position and Closed Loop Stiffness Control for a Pneumatic Actuated Haptic Interface

Nicolas Herzig, Richard Moreau, Tanneguy Redarce, Frédéric Abry and Xavier Brun
Ampère Lab. UMR-CNRS-5005, Université de Lyon, France

- the BirthSIM is a pneumatic actuated haptic interface of a childbirth simulator
- The models to synthesize a position and closed loop stiffness non linear control law are presented.
- Pneumatic stiffness and closed loop stiffness are discussed
- The simulation results are presented to validate the control law behavior

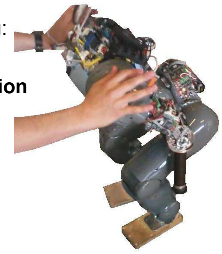


17:05–17:20 TuFT11.2

Practical considerations in using inverse dynamics on a humanoid robot: torque tracking, sensor fusion and Cartesian control laws

Salman Faraji, Luca Colasanto, Auke Jan Ijspeert
Biorobotics Laboratory, EPFL, Lausanne, Switzerland

- Proposing a Cartesian controller using:
  - Actuator model, friction estimation
  - Optimization based **state estimation**
  - Whole body **inverse dynamics**
- Performing various tasks in Cartesian space
- Taking different contact configurations
- Performing **agile** tasks while being **compliant**.

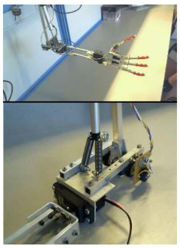


17:20–17:35 TuFT11.3

Lightweight Compliant Arm for Aerial Manipulation

Alejandro Suarez[1], Guillermo Heredia[1] and Anibal Ollero[1]
[1]Robotics, Vision and Control Group, University of Seville, Spain

- 3 DOFs arm: elbow pitch (linear actuator), wrist roll and pitch (standard servos)
- Compliance on elbow joint provided by extension springs connecting the linear actuator with the forearm (elastic tendons)
- Payload estimation from spring elongation, accuracy depending on elbow joint position
- Active and passive compliance for collision detection and reaction increasing safety



17:35–17:50 TuFT11.4

Torque and Variable Stiffness Control for Antagonistically Driven Pneumatic Muscle Actuators via a Stable Force Feedback Controller

Barkan Ugurlu, Paolo Forni, Corinne Doppmann, Jun Morimoto
Dept. of Brain Robot Interface, CNS-ATR, Kyoto, Japan

- A stable force feedback controller that can cope with inherent muscle nonlinearities was synthesized using the dissipativity theory.
- Torque and variable stiffness control was addressed by means of stable pneumatic muscle force feedback.
- The controller was validated via an extensive set of experiments.

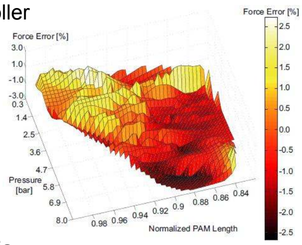


Fig: Pneumatic muscle modeling error.

17:50–18:05 TuFT11.5

Visual Shock Absorber Based on Maxwell Model for Anti-Rebound Control

Taku Senoo, Masanori Koike, Kenichi Murakami and Masatoshi Ishikawa
University of Tokyo, Japan

- A visually guided shock absorber without rebound is designed
- The architecture is based on the Maxwell model, which uses plastic deformation to suppress rebounding
- The system is constructed from a passive elastic body and a servo-controlled damper connected in series
- Successful catching of a rolling iron cylinder is demonstrated

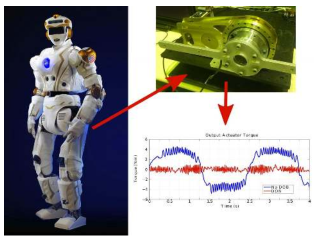
18:05–18:20 TuFT11.6

Leveraging Disturbance Observer Based Torque Control for Improved Impedance Rendering with Series Elastic Actuators

Joshua S. Mehling[1], James Holley[1], Marcia K. O'Malley[2]
[1]NASA/Johnson Space Center, USA [2]Rice University, USA

The Benefits:

- Improved Device Transparency
- Reduced Hysteresis
- More Accurate Rendering of Desired Dynamics



Marine Robotics 2

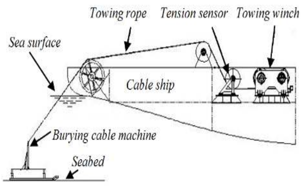
Chair *Wei Li, California State University, Bakersfield*
Co-Chair *Corina Barbalata, Heriot-Watt University*

16:50–17:05	TuFT12.1

Maintaining Constant Towing Tension between Cable Ship and Burying System under Sea Waves by Hybrid FUZZY P + ID Controller

Qi Chen, Wei Li, Xiaohui Wang, Yan Li, Shuo Li, Bin Xian
State Key Laboratory of Robotics, Shenyang Institute of Automation, China

We propose a hybrid FUZZY P + ID controller to stabilize the towing cable tension between a cable ship and a burying system. The real applications demonstrate that the FUZZY P + ID controller is much more robust than the conventional PID controller.



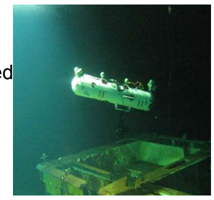
Sketch of a towing winch in the sea cable burying system

17:05–17:20	TuFT12.2

An Adaptive Controller for Autonomous Underwater Vehicles

Corina Barbalata[1], Valerio De Carolis[1], Matthew W. Dunnigan[1], Yvan Pétillot[1] and David Lane[1]
[1]Heriot-Watt University, United Kindom

- An auto-tuning method for the control of an AUV is proposed.
- The gains of the controller are determined online based on the adaptive interaction theory.
- Experimental results with the Nessie VII are presented.

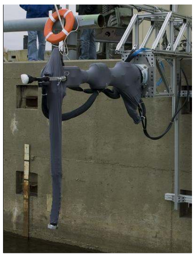


17:20–17:35	TuFT12.3

Autonomous Robotic Refueling of an USV in Varying Sea States

Gregory P. Scott[1], C. Glen Henshaw[1], Ian Walker[2] and Bryan Willimon[2]
[1]Naval Research Laboratory, USA
[2]Clemson University, USA

- Proof-of-concept development of a robotic manipulator to refuel USVs
- Concept derived from need to improve USV refueling process and sailor safety
- Demonstrated manual and autonomous refueling at varying sea states
- 81% success rate for autonomous contact
- 95% success rate for manual contact
- Patent pending: magnetic refueling puck

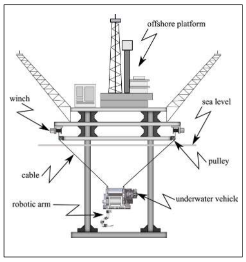


17:35–17:50	TuFT12.4

Hybrid Cable-Thruster Actuated Underwater Vehicle-Manipulator System (UVMS)

G. El-Ghazaly, M. Gouttefarde, V. Creuze
LIRMM, CNRS - Université de Montpellier, France

- In addition to vehicle thrusters, cables are used as an additional source of actuation to enhance UVMS work capabilities
- Kinematic and dynamic modeling of hybrid-cable actuated (HCT)-actuated UVMS
- Characterization of the (HCT)-actuated UVMS force capabilities



17:50–18:05	TuFT12.5

A centralized planner considering task spatial configuration for a group of marine vehicles

Igor Tuphanov[1], Alexander Scherbatyuk[1,2]
[1]Far Eastern Federal University, Russia,
[2]Institute for Marine Technology Problems, Russia

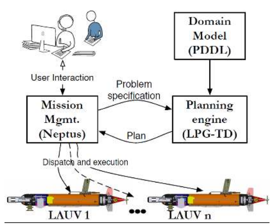
- Mission scheduling for multiple vehicles that considers segment following tasks.
- Field test results for a group of two vehicles: AUV and ASV.
- Various scenarios considered for group composition change.

18:05–18:20	TuFT12.6

On Mixed-Initiative Planning and Control for Autonomous Underwater Vehicles

Lukáš Chrpa[1], José Pinto[2], Manuel A. Ribeiro[2], Frédéric Py[2], Joao Sousa[2] and Kanna Rajan[2]
[1]University of Huddersfield, UK [2]University of Porto, Portugal

- combining “high-level” mission planning and “low-level” control of multiple heterogeneous AUVs
- “high level” mission planning decides which vehicle does which tasks and in which order
- “high-level” planning is enabled by specifying a **PDDL** domain model and the **LPG-TD** planner that can be easily embedded into the control software (**NEPTUS**)



Soft-bodied Robots 2

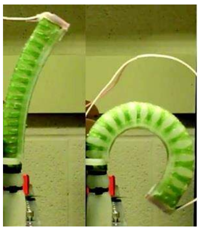
Chair *Cecilia Laschi, Scuola Superiore Sant'Anna*
Co-Chair *Eric D. Diller, University of Toronto*

16:50–17:05	TuFT13.1

Control of Soft Pneumatic Finger-like Actuators for Affective Motion Generation

Mohammadreza Memarian, Rob Gorbet, and Dana Kulić
University of Waterloo, Canada

- Improved the design of an existing soft pneumatic actuator for better robustness and increased controlled velocities
- Designed a low cost pneumatic filter for reducing noise during pulse width modulated pressure control
- Designed and implemented a position controller capable of following high velocity trajectories using gyroscopic feedback
- Validated performance using human affective motion data

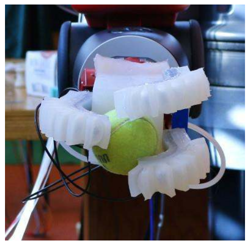


17:05–17:20	TuFT13.2

Haptic Identification of Objects using a Modular Soft Robotic Gripper

Bianca S Homberg[1], Robert K Katzschmann[1], Mehmet R Dogar[1] and Daniela Rus[1]
[1]Massachusetts Institute of Technology

- Compliant gripper robust to grasping uncertainty
- Internal sensing via resistive flex sensors report finger curvature
- Identification algorithm distinguishes between objects based on sensor data

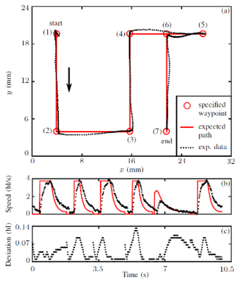


17:20–17:35	TuFT13.3

Millimeter-Scale Magnetic Swimmers Using Elastic Undulations

Jiachen Zhang and Eric Diller
University of Toronto, Canada

- Proposing a soft-body swimmer which uses undulations for propulsion
- The swimmer is actuated and steered by low-strength magnetic fields
- Mathematical model is proposed to describe the swimmer's deflection
- Waypoint following and independent control of two swimmers are demonstrated

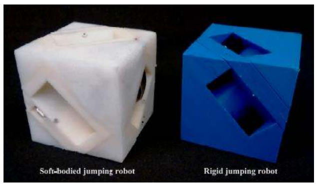


17:35–17:50	TuFT13.4

A soft cube capable of controllable continuous jumping

Shuguang Li, Robert Katzschmann,and Daniela Rus
Massachusetts Institute of Technology (MIT),USA

- A fully contained and autonomous jumping cube which has a soft body.
- It can be controlled to jump or toward a trajectory using jumping steps.
- The dynamic locomotion combines active jumping motions with passive bouncing motions.

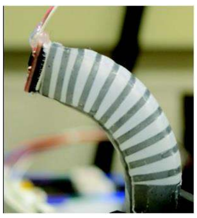


17:50–18:05	TuFT13.5

Modelling and Experimental analysis of a Novel Design for SPAMs

Mohammadreza Memarian, Rob Gorbet, and Dana Kulić
University of Waterloo, Canada

- Introduced a novel production method for soft pneumatic artificial muscles based on cut silk mesh wrapping that
  - Enables consistent and repeatable production of SPAMs
  - Simplifies the customization of their motion trajectory
- Proposed a model for the steady-state angular displacement of the actuator
- Verified the model experimentally

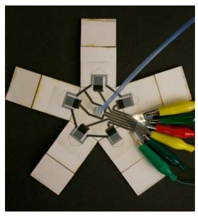


18:05–18:20	TuFT13.6

Printing Angle Sensors for Foldable Robots

Xu Sun[1], Samuel M. Felton[2], Robert J. Wood[2] and Sangbae Kim[1]
[1]MIT, USA [2]Harvard University, USA

We present inkjet printed angle sensors that can be fully integrated into fordable robots' laminate. It helps foldable robots to track the angle motion of robot hinges, and to better guide robot assembling by folding and to perform more complicated tasks that requires feedback control, making folded robots more capable in real world applications.



Printed Sensor Network on a Gripper

Joint/Mechanism Design

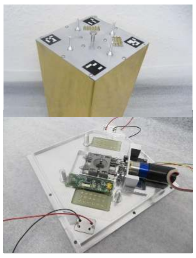
Chair *Claudio Melchiorri, University of Bologna*
Co-Chair *Gianluca Palli, University of Bologna*

16:50–17:05 TuFT14.1

A Robust Electro-Mechanical Interface for Cooperating Heterogeneous Multi-Robot Teams

Wiebke Wenzel[1], Florian Cordes[1] and Frank Kirchner[1,2]
[1]DFKI Robotics Innvoation Center, Germany [2]University of Bremen, Germany

- Docking device for multi-robot teams
- Capable of heavy loads of up to 1300 N
- Dust-resistant against extreme contamination with particles
- Docking in 90°-steps with tolerances of horizontal displacements up to 5 mm, rotation around vertical axis up to 7° and docking angle of up to 40°

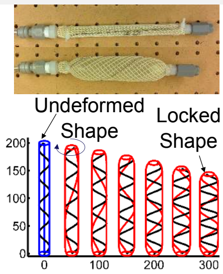


17:05–17:20 TuFT14.2

An Isoperimetric Formulation to predict Deformation Behavior of Pneumatic Fiber Reinforced Elastomeric Actuators

Gaurav Singh and Girish Krishnan,
University of Illinois Urbana-Champaign, USA

- **Locked shape** of actuator obtained by solving volume maximization problem subjected to fiber inextensibility constraint.
- **Intermediate deformed shapes** obtained by imposing an additional constraint on strain energy of the membrane.
- Analysis of novel actuators with fiber angles varying along the length.

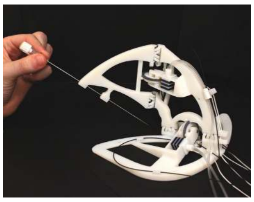


17:20–17:35 TuFT14.3

Toward Unibody Robotic Structures with Integrated Functions using Multimaterial Additive Manufacturing: Case Study of an MRI-compatible Interventional Device

Arnaud Bruyas[1], François Geiskopf[1] and Pierre Renaud[1]
[1]AVR - ICube, University of Strasbourg, CNRS, INSA Strasbourg

- New **multifunctional compliant joint** based on **multimaterial additive manufacturing**
- Application to the development of a **MR-compatible robotic device**
- Prototype obtained from **a single element**
- **Brakes** and **sensors embedded** in the structure

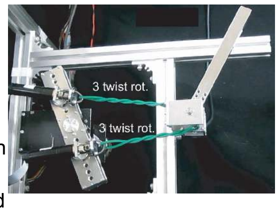


17:35–17:50 TuFT14.4

A Robotic Joint Design by Agonist and Antagonist Arrangement with Twisting Small-diameter Round-belts

Takahiro Inoue[1], Sizuka Yamamoto[1], Ryuichi Miyata[1] and Shinichi Hirai[2]
[1]Okayama Pref. Univ., Japan [2]Ritsumeikan Univ., Japan

- Hard polyurethane round-belts
- Antagonistic Arrangement
- Twisted by double DC motors
- Nonlinear contraction forces to twist rotations
- Speed reduction ratio:151 between joint angle and the twist rotation
- Stepper motor control is performed

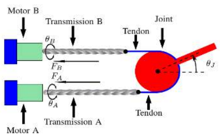


17:50–18:05 TuFT14.5

Modeling and Identification of a Variable Stiffness Joint Based on Twisted String Actuators

Gianluca Palli, Mohssen Hosseini
Lorenzo Moriello, Claudio Melchiorri
DEI – University of Bologna - Italy

- Dynamic modeling of a variable stiffness joint actuated by antagonistic twisted strings
- Position and stiffness control by static inversion is presented
- Identification of the joint stiffness is performed in dynamic conditions
- Control bandwidth is experimentally evaluated



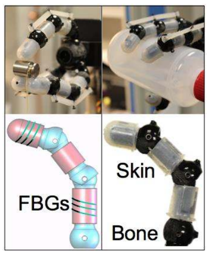
Scheme of the rotative joint with two antagonist twisted string transmission systems.

18:05–18:20 TuFT14.6

Fiber Optically Sensorized Multi-Fingered Robotic Hand

Leo Jiang[1], Kevin Low[1], Joannes Costa[2], Richard J. Black[2], and Yong-Lae Park[1]
[1]Robotics Institute, Carnegie Mellon University, USA
[2]Intelligent Fiber Optic Systems (IFOS), USA

- Three-fingered robotic gripper for precision and power grips.
- Fiber Bragg grating (FBG) sensors embedded in rigid bone and soft skin
- Force and tactile sensing
- Tendon-driven under-actuated system
- Active tendon for finger flexion motion
- Passive elastic back tendon for finger extension motion



Software and Architecture

Chair *Michael Beetz, University of Bremen*
Co-Chair *Lorenzo Natale, Istituto Italiano di Tecnologia*

16:50–17:05 TuFT15.1

Classifying Compliant Manipulation Tasks for Automated Planning in Robotics

Daniel Leidner[1], Christoph Borst[1], Alexander Dietrich[1], Michael Beetz[2], and Alin Albu-Schäffer[1,3]
[1]DLR, Germany [2]Uni Bremen, Germany [3]TU München, Germany

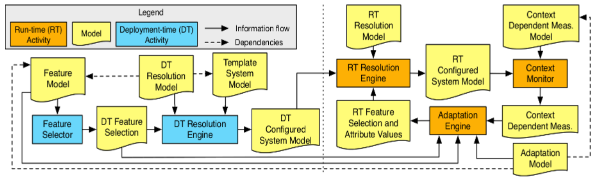
- Classify compliant manipulation tasks w.r.t. symbolic effects.
- Descriptive classification terms for the tool / target contact situation.
- Sub-categorize wiping tasks exploiting similar geometric structures.
- Exemplary process model abstraction for the task of sweeping shards.

17:05–17:20 TuFT15.2

RRA: Models and Tools for Robotics Run-Time Adaptation

Luca Gherardi[1] and Nico Hochgeschwender[2]
[1]ETH Zurich, Switzerland
[2]Bonn-Rhein-Sieg University, Germany

- We present models and tools which enables to *dynamically adapt robotic applications and address changes in the context*.

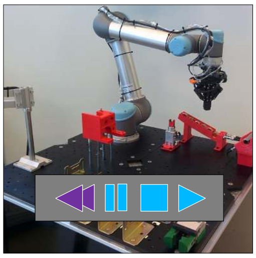


17:20–17:35 TuFT15.3

Automatic Error Recovery in Robot Assembly Operations Using Reverse Execution

Johan Sund Laursen[1], Ulrik Pagh Schultz[1], Lars-Peter Ellekilde[1]
[1]University of Southern Denmark, Denmark

- **Reverse execution** of assembly programs is used for error-handling.
- Programs created offline can be executed forwards and backwards
- **Instruction inversion** is used as the default reverse principle.
- **The default reverse** can be overwritten with other operations.
- Based on **Reversible computing** principles applied to robotics.

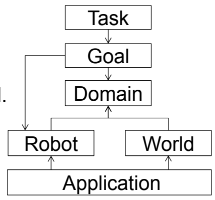


17:35–17:50 TuFT15.4

Modeling Robot and World Interfaces for Reusable Tasks

Robert Heim[1], Pedram Mir Seyed Nazari[1], Jan Oliver Ringert[2], Bernhard Rumpe[1], and Andreas Wortmann[1]
[1]RWTH Aachen, Germany [2]Tel Aviv University, Israel

- The RoboTask framework employs **multiple DSLs** to decompose robotics applications.
- Its DSLs model robot and world properties, tasks, goals, & domain model.
- Tasks and goals can be **reused with different robots**.
- This enables **separation of concerns** between domain experts & software engineering experts.

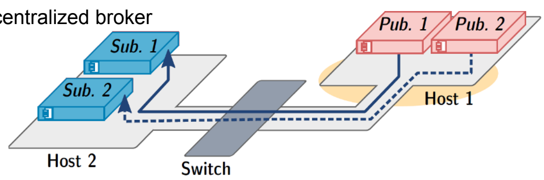


17:50–18:05 TuFT15.5

A Best-Effort Approach for Run-Time Channel Prioritization in Real-Time Robotic Application

Ali Paikan, Ugo Pattacini, Daniele Domenichelli, Marco Randazzo, Giorgio Metta and Lorenzo Natale
iCub Facility, Istituto Italiano di Tecnologia (IIT), Italy

- Prioritizing specific communication channels
- Remote and dynamic configuration
- Peer-to-peer and Publish-Subscribe architectures
- No centralized broker

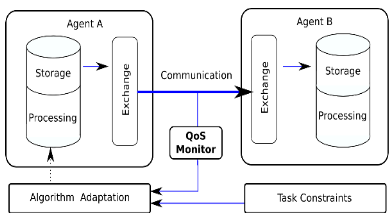


18:05–18:20 TuFT15.6

An Approach for a Distributed World Model with QoS-based Perception Algorithm Adaptation

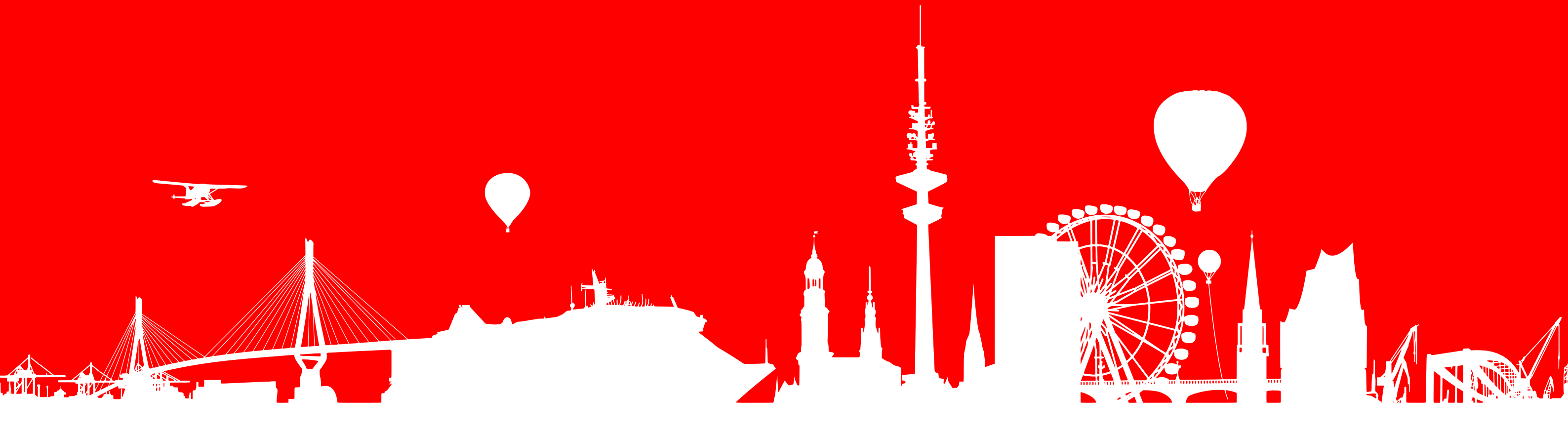
Sebastian Blumenthal[1], Nico Hochgeschwender[2], Erwin Prassler[2], Holger Voos[3], and Herman Bruyninckx[1]
[1]KU Leuven, Belgium [2]Bonn-Rhein-Sieg University, Germany
[3]University of Luxembourg, Luxembourg

- **mechanism for storage, exchange and processing of world model data**
- **feedback loop to adapt to QoS changes immediately**



Technical Sessions

Wednesday
September 30, 2015



Human-Robot Interaction 2

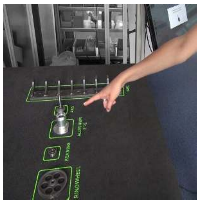
Chair *Paolo Rocco, Politecnico di Milano*
Co-Chair *Yiannis Demiris, Imperial College London*

08:30–08:45	WeAT1.1

Analysis and Semantic Modeling of Modality Preferences in Industrial Human-Robot Interaction

Stefan Profanter[1], Alexander Perzylo[1], Nikhil Somani[1], Markus Rickert[1] and Alois Knoll[2]
[1]fortiss, Germany [2]Technische Universität München, Germany

- Wizard-of-Oz study evaluating input modality preferences
- Statistically significant results: gesture > touch > 3D pen > speech
- Multimodal concept well received by participants (experts and non experts)
- Semantic modeling of modalities and preferences
- Additionally evaluated: cognitive load, gender differences



08:45–09:00	WeAT1.2

Human Intention Inference and Motion Modeling using Approximate E-M with Online Learning

Harish Ravichandar[1], Ashwin Dani[1],
[1]University of Connecticut, USA

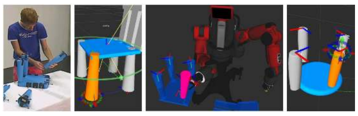
- A neural network (NN) is used to learn the dynamics of human arm motion from demonstrations
- We present an approximate E-M algorithm to infer the goal location (intention) of human reaching motion and an identifier-based learning algorithm to update the model online

09:00–09:15	WeAT1.3

Robot Programming from Demonstration, Feedback and Transfer

Yoan Mollard[1], Thibaut Munzer[1], Andrea Baisero[2]
Marc Toussaint[2] and Manuel Lopes[1]
[1]Inria, France [2]University of Stuttgart, Germany
http://3rdhandrobot.eu

1. Task Learning Process:
   - Observe demonstrations
   - Extract an assembly plan
2. Task Refining Process:
   - Show the user the learned knowledge and ask for corrections
   - Use object's degrees of freedom to simplify the assembly
   - Simulate the resulting assembly with a pick-and-place setup
   - Bootstrap a new task by transferring the knowledge from a previous assembly



09:15–09:30	WeAT1.4

Field Trial of an Information-Providing Robot in a Shopping Mall

Satoru Satake[1], Kotaro Hayashi[1],
Keita Nakatani[1] and Takayuki Kanda[1]
[1]ATR Intelligent Robotics and Communication Lab., Japan.

- Develop an information-providing robot
  - move around to **hand over flyers**
  - **Provide routes & recommendations** if visitors approached and requested
- Field trial on the shopping mall
  - It worked for **53.4h** (over 11 days)
- Analyze the Interviews from visitors
  - They found the information from the robot is useful, and want to use again

a)Handing over

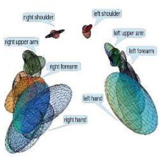
b)Provide routes

09:30–09:45	WeAT1.5

User Modelling for Personalised Dressing Assistance by Humanoid Robots

Yixing Gao, Hyung Jin Chang and Yiannis Demiris
Imperial College London, UK

- In this paper, we present an end-to-end approach for home-environment assistive humanoid robots to provide personalised assistance through a dressing application for users who have upper-body movement limitations.

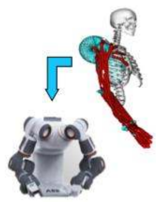


09:45–10:00	WeAT1.6

A redundancy resolution method for an anthropomorphic dual-arm manipulator based on a musculoskeletal criterion

Cecilia Lamperti[1], Andrea Maria Zanchettin[1],
Paolo Rocco[1]
[1]Politecnico di Milano, Italy

- Biomechanical criterion for the bimanual redundancy resolution
- Relationship between task and redundant variables
- Verification on a dual-arm anthropomorphic prototype robot



Unmanned Aerial Systems 4

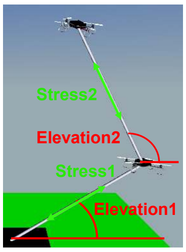
Chair *Antonio Franchi, LAAS-CNRS*
Co-Chair *Anibal Ollero, University of Seville*

08:30–08:45	WeAT2.1

Nonlinear Observer for the Control of Bi-Tethered Multi Aerial Robots

Marco **Tognon**[1,2], Antonio **Franchi**[1,2]
[1]CNRS, LAAS, [2]Univ de Toulouse, LAAS

- Two tethered aerial robots with any link possibility: **cable, strut, bar**
- Independent tracking of time-varying:
  - link **stresses** (tension / compression)
  - link **elevations**
- **Minimal** sensors: 2 accelerometers + **either** 2 encoders **or** 2 inclinometers
- Nonlinear **observability** analysis and nonlinear **observer** design
- **Asymptotic stability of the** closed loop



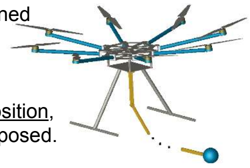
Extensive dynamical simulation campaign

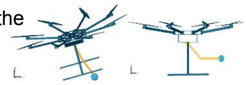
08:45–09:00	WeAT2.2

Adaptive Motion Control of Aerial Robotic Manipulators Based on Virtual Decomposition

Mohammad Jafarinasab, Shahin Sirouspour,
McMaster university, Canada

- The system composed of an Unmanned Aerial Vehicle and a serial robotic manipulator is underactuated.
- Using the method of virtual decomposition, adaptive motion control laws are proposed.
- System stability and convergence of the tracking errors are proven using a Lyapunov analysis.



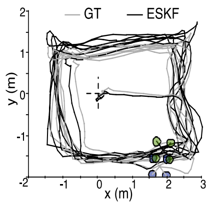


09:00–09:15	WeAT2.3

High-frequency MAV state estimation using low-cost inertial and optical flow measurement units

Angel Santamaria-Navarro[1], Joan Solà[1], and Juan Andrade-Cetto[1]
[1] Institut de Robòtica i Informàtica Industrial, CSIC-UPC, Spain

- MAV **odometry** at **high update rate**
- **IMU** and **Optical Flow smart camera** data fusion
- Benchmarking of a large amount of **Kalman filter variants**
- **Simulation** validation and **real robot experiments**



09:15–09:30	WeAT2.4

Real-Time Visual-Inertial Mapping, Re-localization and Planning Onboard MAVs in Unknown Environments

Michael Burri, Helen Oleynikova, Markus Achtelik and Roland Siegwart
Autonomous Systems Lab, ETH Zurich

- Visual-inertial based localization, map building and relocalization for meaningful global planning.
- Polynomial trajectory generation using nonlinear optimization to include motion constraints.
- Experiment (not in simulation) showing automated homing and reusing the map to plan a path to previously seen areas.

09:30–09:45	WeAT2.5

Aerial Manipulator for Structure Inspection by Contact from the Underside

Antonio E. Jimenez-Cano[1], Juan Braga[1], Guillermo Heredia[1] and Anibal Ollero[1]
[1]Robotics, Vision and Control Group, University of Seville, Spain

- Aerial manipulator for structure and bridge inspection.
- Dynamic modelling of the aerial manipulator including the multirotor and the arm, and the contact forces.
- Multirotor and manipulator controllers.
- Validation by simulation of solution control proposed.
- First experimental results with a prototype aerial manipulator inspecting a bridge.

09:45–10:00	WeAT2.6

Design and Implementation of an Unmanned Tail-sitter

Roman Bapst[1], Robin Ritz[2], Lorenz Meier[1] and Marc Pollefeys[1]
[1]CVG, ETH Zurich, Switzerland [2]IDSC, ETH Zurich, Switzerland

- Single controller for forward and hover flight
- Automatic transition based on forward velocity demand
- Closed loop position control results in simulation and outdoor experiments
- Controller published as open source

Robot Vision 4

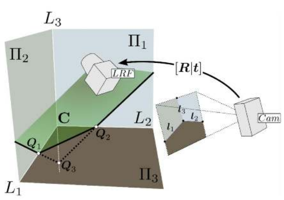
Chair *Julian Straub, Massachusetts Institute of Technology*
Co-Chair

08:30–08:45	WeAT3.1

A minimal solution for the Calibration of a 2D Laser-Rangefinder and a Camera based on Scene Corners

Jesus Briales, Javier Gonzalez-Jimenez
University of Malaga

- Extrinsic calibration of a camera and a LRF
- Minimal solution, with fewer observations
- No pattern, uses a scene corner
- Higher robustness and reliability than the state-of-the-art minimal solutions



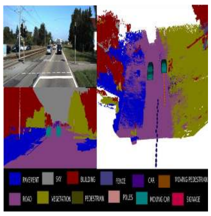
08:45–09:00	WeAT3.2

Dynamic Body VSLAM with Semantic Constraints

N Dinesh Reddy[1], Prateek Singhal[2], Visesh Chari[1,3] and K Madhava krishna[1]
[1]IIIT Hyderabad, India [2]GaTech,USA [3]INRIA,France

We use a new semantic motion segmentation algorithm using multi-layer dense CRF which provides state-of-the-art motion segmentation and object class labelling.

We incorporate semantic contextual information like support relations between the road surface and object motion, which helps better localize the moving object's pose vis-a-vis the world coordinate system, and also helps in reconstructing them.

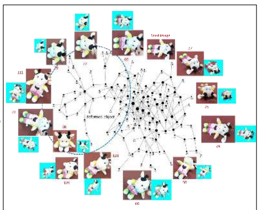


09:00–09:15	WeAT3.3

Incremental Learning from a Single Seed Image for Object Detection

Sehyung Lee, Jongwoo Lim, Il Hong Suh
Hanyang University, Korea

- From single seed images of the target objects, our algorithm detects these objects in the input sequence, and incrementally updates the databases with the detection results.
- Reasonably sized databases are maintained as graphs of the registered images, while new views of the objects are added as the detection proceeds.

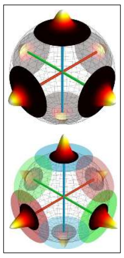

Constructed database and its representative images

09:15–09:30	WeAT3.4

Real-time Manhattan World Rotation Estimation in 3D

Julian Straub[1], Nishchal Bhandari[1], John J. Leonard[1] and John W. Fisher III[1]
[1]Massachusetts Institute of Technology

- The **Manhattan Frame (MF)** (see to the right) captures the Manhattan World (MW) structure of environments in the **space of surface normals**.
- We **derive real-time algorithms** for inference of the MF rotation and MW segmentation.
- Our evaluation demonstrates **robustness to dynamic camera motion** as well as **clutter.** The accuracy of the rotation estimate makes the algorithms **suitable for drift free rotation estimation** in MW environments.

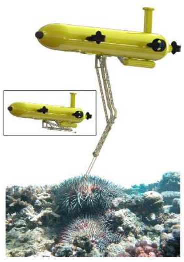


09:30–09:45	WeAT3.5

Robotic Detection and Tracking of Crown-of-Thorns Starfish

Feras Dayoub, Matthew Dunbabin and Peter Corke
Queensland University of Technology (QUT), Australia

- A novel vision-based underwater robotic system for the identification and control of Crown-Of-Thorns starfish (COTS) in coral reef environments.
- Detection and tracking system based on a Random Forest Classifier embedded within a particle filter tracker with sparse optical flow estimation for the filter prediction step.
- Experimental validation using underwater imagery and a robotic arm camera system.



09:45–10:00	WeAT3.6

B-SHOT: A Binary Feature Descriptor for Fast and Efficient Keypoint Matching on 3D Point Clouds

Sai Manoj Prakhya[1], Bingbing Liu[2], Weisi Lin[1]
[1]Nanyang Technological University [2]A*STAR

- We present the first 3D binary feature descriptor for efficient keypoint matching.
- Specifically, we propose a novel binarization technique and convert a state-of-the-art 3D feature descriptor, SHOT, to a binary feature descriptor, B-SHOT.
- Experiments show that B-SHOT offers competitive keypoint matching performance while being six times faster and having 32 fold less memory footprint.

SLAM 4

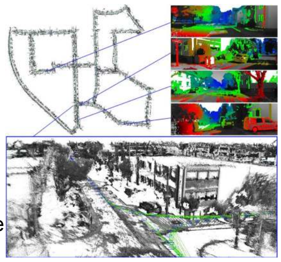
Chair *Joerg Stueckler, Technical University Munich*
Co-Chair *Adrian Brian Ratter, University of New South Wales*

08:30–08:45	WeAT4.1

Large-Scale Direct SLAM with Stereo Cameras

Jakob Engel, Jörg Stückler, Daniel Cremers
Computer Vision Group, Technical University Munich, Germany

- Fully direct Stereo-SLAM method (no keypoints), based on LSD-SLAM
- Novel affine lighting correction for direct image alignment.
- Evaluated on KITTI dataset and challenging sequences taken from a quadrocopter.
- State-of-the-art accuracy, real-time on CPU (single-threaded).
- Video: http://vision.in.tum.de/stereo-lsdslam

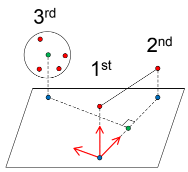


08:45–09:00	WeAT4.2

3-DOF Point Cloud Registration Using Congruent Triangles

Xiaolong Wang[1], Hong Zhang[2] and Guohua Peng[1]
[1]Northwestern Polytechnical University, China
[2]University of Alberta, Canada

- The 3-DOF assumption constrains the corresponding points to have similar elevations.
- A potential match is searched by first sampling two points and then using the third point as a verification.
- The projected coordinate system on the ground is adopted to locate the 3rd point.
- Both high accuracy and high speed are achieved on outdoor LiDAR datasets.



09:00–09:15	WeAT4.3

2D-SDF-SLAM: A Signed Distance Function based SLAM Frontend for Laser Scanners

Joscha-David Fossel[1], Karl Tuyls[1] and Jürgen Sturm[2]
[1]University of Liverpool, United Kingdom [2]Metaio, Germany

- We present a frontend for 2D laser scanner based SLAM.
- We combine map gradient based registration with a Signed Distance Function based map.
- We show empirically hat 2D-SDF-SLAM outperforms a similar occupancy grid map based SLAM frontend, both in simulation and on a physical platform. 2D-SDF-SLAM generates more accurate trajectories and smoother maps.

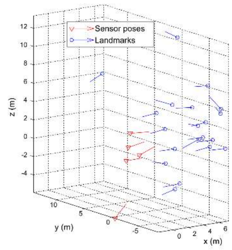
Fig. 1: QR code for video, article and source code.

09:15–09:30	WeAT4.4

Towards Intensity-Augmented SLAM with LiDAR and ToF Sensors

Robert A. Hewitt[1,2], Joshua A. Marshall[1]
[1]Queen's University, Canada [2]European Space Research and Technology Centre, The Netherlands

- Intensity measurements from active sensors largely ignored in literature.
- We model these measurements explicitly along with range and bearing in a sparse bundle adjustment estimation problem.
- Results show a solution exists and includes additional estimated parameters like reflectivity and surface normal.



09:30–09:45	WeAT4.5

Fused 2D/3D Position Tracking for Robust SLAM on Mobile Robots

Adrian Ratter and Claude Sammut
School of Computer Science and Engineering, The University of New South Wales, Australia

- Combines Laser Rangefinder based 2D-ICP with RGB-D based 3D-ICP to increase position tracking accuracy
- Uses regularization term in 3D-ICP to limit drift in directions where surface geometry is under-constrained
- Approximate TSDF structure to significantly increase efficiency
- Can generate large maps in real time on low powered computers

Map generated from a 225m trajectory of the MIT Stata Center

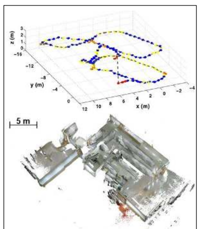
09:45–10:00	WeAT4.6

3D Pose Estimation with One Plane Correspondence using Kinect and IMU

HyunGi Cho, Suyong Yeon, Hyunga Choi, and Nakju Lett Doh
Korea University, Republic of Korea

A focus in terms of resolving degeneracy issues that can occur from a plane-based registration. For that purpose,

- **Rotation Compensation Method**: more accurate rotation estimation compared to IMU prediction under the degeneracy.
- **Degenerate Case Detector**: automatic detection of the effective rank.
- **Seamless Implementation**: a validation of feasibility using the proposed method.



Multi-floor Map

Micro/Nano Robots 3

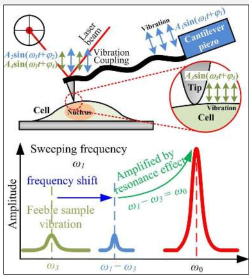
Chair *Yasushi Mae, Osaka University*
Co-Chair *Nicolas Andreff, Université de Franche Comté*

08:30–08:45 WeAT5.1

Real-time detecting and tracking nanoscale feeble vibrations based SF-AM AFM

Jialin Shi[1,2], Lianqing Liu[1],
[1]Chinese Academy of Sciences, China [2]University of the Chinese Academy of Sciences, China

- Represent a promising **mechanical biosensor** for detecting tiny vibrations of cell membrane based on AFM.
- Utilize micro-cantilever vibration coupling and resonance mechanism to **shift the frequency of cell to make it resonate** with the contact frequency.

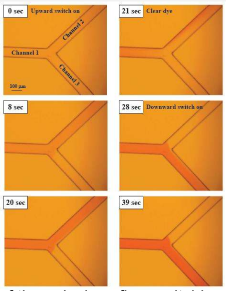


08:45–09:00 WeAT5.2

Robust Control for Valveless Flow Switching in Microfluidic Networks

Young Jin Heo[1], Junsu Kang[1], and Wan Kyun chung[1]
[1]POSTECH

- Development of the **robust controller** for precise regulation of flow rates**.**
- Precise flow regulation enables **valveless flow switching** in a microfluidic chip.
- **Robustness** and **optimality** of the closed-loop response are experimentally verified.



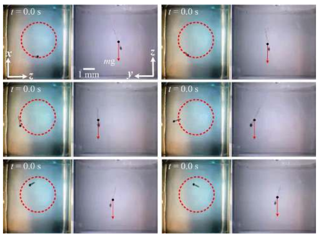
Experiment of the valveless flow switching

09:00–09:15 WeAT5.3

Propulsion and Steering of Helical Magnetic Microrobots using Two Synchronized Rotating Dipole Fields in Three-Dimensional Space

Abdelrahman Hosney[1], Anke Klingner[1], Sarthak Misra[2,3] and Islam S. M. Khalil[1]
[1]German University in Cairo, Egypt [2]University of Twente, The Netherlands
[3]University of Groningen, The Netherlands

- Motion control of helical microrobots is achieved in three-dimensional (3D) space using two synchronized rotating dipole fields.
- The synchronized rotating dipole fields compensate for the gradient forces and force due to gravity, and hence allow the helical microrobot to swim in 3D space without drift.



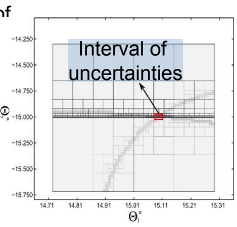
Helical microrobot swims in 3D space.

09:15–09:30 WeAT5.4

Precision Prediction Using Interval Exponential Mapping of a Parallel Kinematic Smart Composite Microstructure

Sergio Lescano, Micky Rakotondrabe, Nicolas Andreff
FEMTO-ST Institute, UBFC-ENSMM-UTBM-CNRS
Université de Franche-Comté, Besançon, France

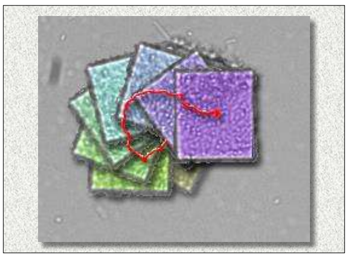
- A method to predict the precision of parallel microstructures is proposed
- We use the exponential representatio of transformation matrix with intervals
- The method has been demonstrate with a numerical example of paralle microrobot devoted to orient the lase spot towards vocal fold durin phonomicrosurgery



09:30–09:45 WeAT5.5

Dynamic Obstacle Avoidance for Bacteria-Powered Microrobots

Hoyeon Kim[1], U Kei Cheang[1],
A. Agung Julius[2] and Min Jun Kim[1]
[1]Drexel University, U.S.A. [2]Rensselaer Polytechnic Institute, U.S.A.

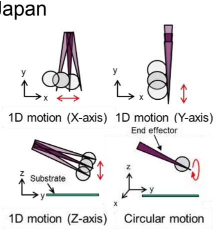


09:45–10:00 WeAT5.6

Releasing and Accurate Placing of Adhered Micro-Objects using High speed motion of End Effector

Eunhye Kim[1], Masaru Kojima[1], Kazuto Kamiyama[1],
Mitsuhiro Horade[1], Yasushi Mae[1], and Tatsuo Arai[1]
[1]Osaka University, Japan

- A release method using high speed motions to improve the placing accuracy is proposed.
- By analyzing dynamic model of releasing task, A circular motion is proposed.
- Five motions at high speed is used for verifying the efficiency of the circular motion by comparing placing position after release.



High speed motions of end effector

Surgical Robotics 4

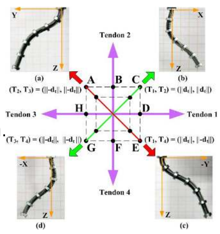
Chair *Kaspar Althoefer, King's College London*
Co-Chair *Ren Luo, National Taiwan University*

08:30–08:45	WeAT6.1

A Cross-helical Tendons Actuated Dexterous Continuum Manipulator

Anzhu Gao[1], Hao Liu[1], Yuanyuan Zhou[2] , Zhenda Yang[1], Zhidong Wang[1, 2] and Hongyi Li[1]
[1]Shenyang Institute of Automation, Chinese Academy of Science, China [2]Chiba Institute of Technology, Japan

- Four cross helical tendons are used for the actuations, each of which has a full revolution along the axis of manipulator.
- Two different types of S shapes are obtained when the adjacent two tendons are actuated with the same tendon length.
- Compared with the manipulator with four straight tendons, it has better tip orientation capability to the front plane.

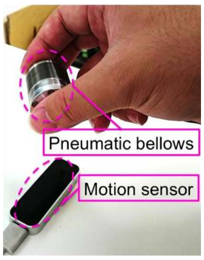


08:45–09:00	WeAT6.2

Compact Haptic Device Using a Pneumatic Bellows for Teleoperation of a Surgical Robot

Ryoken Miyazaki[1], Tomohisa Terata[2], Takahiro Kanno[1], Toshiaki Tsuji[2], Gen Endo[1] and Kenji Kawashima[1]
[1]Tokyo Medical and Dental Univ., Japan [2]Saitama Univ., Japan

- Lightweight master interface for a surgical robot system robotic forceps manipulator.
- Gripping control and gripping force display by the **Pneumatic Bellows**.
- Translational motion of forceps tip is operated by the **Hand Motion**.
- Construction of pneumatic driven master-slave system which capable of gripping force estimation.

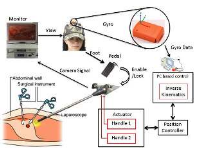


09:00–09:15	WeAT6.3

Robotic Flexible Laparoscope with Position Retrieving System for Assistive Minimally Invasive Surgery

Ren C. Luo, Jui Wang, Jung-Yu Tsai, Keng-Ming Lee and Yi-Wen Perng
National Taiwan University, Taiwan

- The ability of our system can at least save three anatomical positions, which could be retrieved by a single command with small errors.
- Protective algorithm is included in our system to make sure that over rotation of the gyro sensor, which is mounted the head, does not cause any damage.
- Design a new kind of laparoscope mechanism suited for our system.

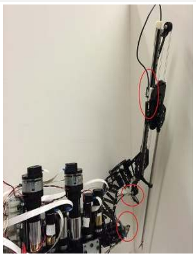


09:15–09:30	WeAT6.4

Improving Position Precision of a Servo-Controlled Elastic Cable Driven Surgical Robot using Unscented Kalman Filter

Mohammad Haghighipanah[1], Yangming Li[1], Muneaki Miyasaka[1] and Blake Hannaford
[1]University of Washington, USA

- In cable driven robots cable transmission introduces higher non-linearity and more uncertainties such as cable stretch and cable coupling.
- To improve the joint position estimation, the Unscented Kalman Filter (UKF) was adopted for state estimation.
- The experimental results showed that the proposed method improved joint position estimation on elastic links.

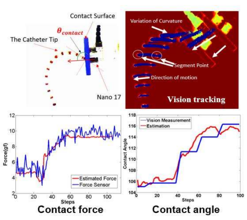


09:30–09:45	WeAT6.5

Catheter Contact Force Estimation from Shape Detection using a Real-Time Cosserat Rod Model

Junghwan Back, Thomas Manwell, Rashed Karim, Kawal Rhode, Kaspar Althoefer, Hongbin Liu*
[1]Department of Informatics, King's College London, UK
[2]Department Imaging and Biomedical Engineering, King's College London, UK

- Simplified Cosserat rod model to estimate contact information of ablation catheter tip.
- The frequency, and accuracies are 33.7Hz, 89.5%(force), and 88.13%(angle).
- It will become a satisfactory intrinsic force sensing solution for conventional ablation catheters after the required improvements.



09:45–10:00	WeAT6.6

A Retrofit Eye Gaze Tracker for the da Vinci and its Integration in Task Execution

Irene Tong[1], Omid Mohareri[1,2], Samuel Tatasurya[1], Craig Hennessey[3] and Septimiu Salcudean[1]
[1]University of British Columbia, Canada [2]Intuitive Surgical Inc., United States of America [3]Gazepoint, Canada

- An eye gaze tracker was developed to estimate the 3D gaze of surgical robot operators.
- A controller that applies forces to the master manipulators to guide the operator's hands was developed, implemented in the dVRK, and evaluated in a user study.

Motion and Path Planning 1

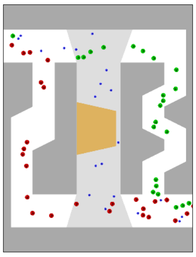
Chair *Luis Moreno, Carlos III University*
Co-Chair *Wouter van Toll, Utrecht University*

08:30–08:45 WeAT7.1

Dynamically Pruned A* for Re-planning in Navigation Meshes

Wouter van Toll[1] and Roland Geraerts[1]
[1]Utrecht University, The Netherlands

- Navigation meshes allow path planning in polygonal 2D/multi-layered environments.
- Agents must **re-plan** their paths when an obstacle is added or removed at runtime.
- DPA* prunes A* search based only on the old path. It is tailored for **real-time crowd simulation** with limited memory per agent.
- Very efficient in **complex** environments and for **visibility**-based re-planning.

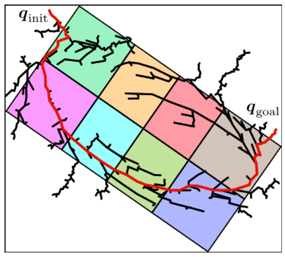


08:45–09:00 WeAT7.2

Motion planning using first-order synergies

Néstor García, Jan Rosell and Raúl Suárez
Institute of Industrial and Control Engineering
Universitat Politècnica de Catalunya (IOC-UPC)

- Extension of the concept of synergies to the velocity space.
- An automatic partition of the configuration space based on differences between synergies.
- FoS-RRT: a planner that grows a tree following the synergies.

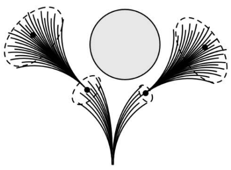


09:00–09:15 WeAT7.3

Sampling-based Planning for Maximum Margin Input Space Obstacle Avoidance

Junghee Park[1], Karl Iagnemma[1]
[1]Massachusetts institute of Technology, USA

- Safe navigation based on representative sample inputs with maximum distance from forbidden input sets.
- The inputs are 1) representatives of groups of nearby input sets resulting in similar maneuvers 2) the safest decisions with respect to various unmodeled sources of uncertainties
- This approach provides an obstacle avoidance strategy for the maximum control margins

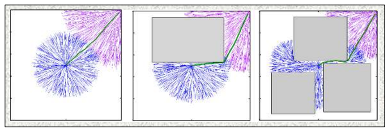


09:15–09:30 WeAT7.4

An Asymptotically-Optimal Sampling-Based Algorithm for Bi-Directional Motion Planning

Joseph A. Starek,[1] Javier V. Gomez,[2]
E. Schmerling,[1] L. Janson,[1] L. Moreno,[2] and M. Pavone[1]
[1]Stanford University, USA [2]Carlos III University of Madrid, Spain

- Introduces the Bi-directional Fast Marching Trees (BFMT*) path planning algorithm



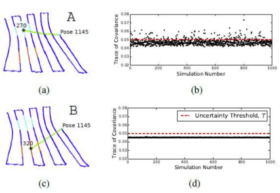
- First planner to simultaneously merge both bi-directional search and asymptotic optimality
- Upper-bounded on convergence rate to optimal solution
- Converges in simulation at least as fast as other optimal state-of-the-art planners (PRM*, RRT*, and FMT*), and sometimes faster

09:30–09:45 WeAT7.5

Risk Aversion in Belief-space Planning under Measurement Acquisition Uncertainty

Stephen M. Chaves, Jeffrey M. Walls,
Enric Galceran, and Ryan M. Eustice
University of Michigan, USA

- Gaussian belief-space planning framework with stochastic measurement acquisition
- Leverage randomness in the belief covariance to design risk-averse objective functions
- Leads to desirable decisions under uncertainty in applications like active SLAM

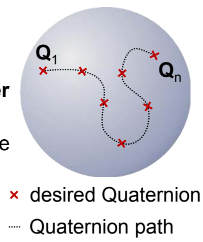


09:45–10:00 WeAT7.6

Smooth Orientation Path Planning with Quaternions Using B-Splines

Matthias Neubauer[1] and Andreas Müller[1]
[1]Johannes Kepler University Linz, Austria

- Path planning **for a set of unit quaternions Q_i** with i ∈ {1,…,n}
- Smooth path up to a desired order
- **Angular velocities** as well as **higher order derivatives** can be prescribed
- Path planning with **B-splines** describing the **local rotation vector** (similar to SLERP)
- Interpolation, approximation or combined approximation interpolation between desired quaternions is presented



Force and Tactile Sensing 2

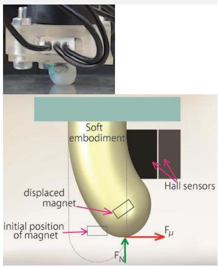
Chair *Gordon Cheng, Technical University Munich*
Co-Chair *Muye Pang, Wuhan University of Technology*

08:30–08:45	WeAT8.1

Robust Real time Material Classification Algorithm Using Soft Three Axis Tactile Sensor: Evaluation of the Algorithm

Damith S Chathuranga[1], Zhongkui Wang[1],
Yohan Noh[2] Thrishantha Nanayakkara[2] and Shinichi Hirai[1]
[1]Ritsumeikan University, Japan [2]King's College London, UK

- We introduces a texture classification algorithm that utilize SVM classifier.
- Novel three axis tactile sensor that use magnetic field measurements for transduction was utilized for sensing.
- Palpation velocity and small vertical load variances had minimum influence on the proposed algorithm.
- We compared this method with two other classification methods.



08:45–09:00	WeAT8.2

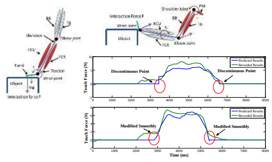
Prediction of Interaction Force using EMG for Characteristic Evaluation of Touch and Push Motions

Muye Pang [*1,2] Shuxiang Guo [*1,3] and Songyuan Zhang [*1]
[*1] Department of Intelligent Mechanical Systems Engineering Kagawa University, Japan
[*2] School of Automation Wuhan University of Technology, China
[*3] School of Life Science Beijing Institute of Technology China

Interaction force between operator and environment is estimated by EMG signals for the purpose of evaluation of touch and push motions by observer.

•A simplified muscle-skeleton model is built

•A Bayesian linear regression algorithm is used to predict interaction force.



09:00–09:15	WeAT8.3

Tactile sensing system for robotics dexterous manipulation

Andrés Ospina[1], Saifeddine Aloui[1],
C. Godin[1], M. Grossard[2] and A. Micaelli[2]
[1]CEA-leti [2]CEA-list

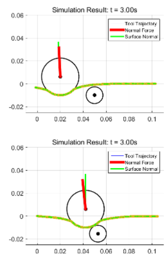
- Tactile sensing system capable of measuring three force components, and the position of the centroid of the forces applied to its sensitive surface

09:15–09:30	WeAT8.4

Feasibility of a Novel Indicator for Lump Detection Using Contact Pressure Distribution

Hyoungkyun Kim[1], Seungmoon Choi[1]
and Wan Kyun Chung[1]
[1]POSTECH, Korea, Republic of

- A novel indicator for lump detection
- Directional errors between the surface normal and normal force detects the lump in the soft tissue
- The proposed indicator uses contact pressure distribution only
- Simulation and experiment showed promising results



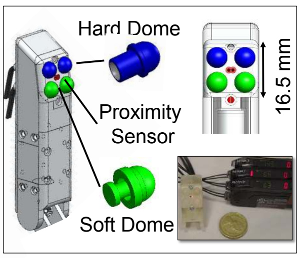
09:30–09:45	WeAT8.5

Force and Proximity Fingertip Sensor to Enhance Grasping Perception

Jelizaveta Konstantinova[1], Agostino Stilli[1],
and Kaspar Althoefer[1]
[1]King's College London, United Kingdom

The proposed integrated fingertip sensor combines:

- Two hard optical sensors to detect forces from the contact;
- Two soft optical force sensors to perceive forces from the contact and to enable grasp stability;
- Optical proximity sensor to measure the distance to nearby objects.

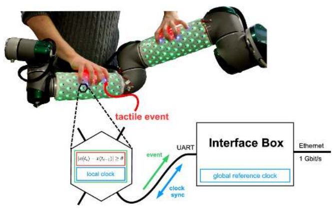


09:45–10:00	WeAT8.6

Event-Based Signaling for Data Reduction in Large-Scale Artificial Robotic Skin

Florian Bergner[1], Philipp Mittendorfer[1],
Emmanuel Dean-Leon[1] and Gordon Cheng[1]
[1]Technical University of Munich, Germany

- data rate reduction with respect to the non-event based system to 16% for unstimulated and to 48% for heavily stimulated skin
- comprehensive analysis for different test applications with 260 CellulARSkin cells on a UR-5 arm



Session WeAT9 Saal C4 Wednesday, September 30, 2015, 08:30–10:00

Biologically-Inspired Robots 4

Chair *Jessica Burgner-Kahrs, Gottfried Wilhelm Leibniz Universität Hannover*
Co-Chair *Joonbum Bae, UNIST*

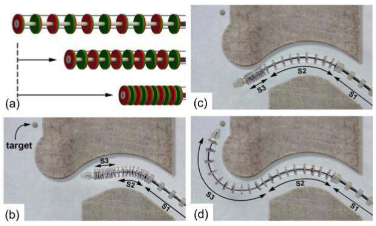
08:30–08:45	WeAT9.1

A Tendon-Driven Continuum Robot with Extensible Sections

Thien-Dang Nguyen and Jessica Burgner-Kahrs

Center of Mechatronics, Leibniz Universität Hannover, Germany

- Tendon Actuation
- Telescoping backbone
- Extensible sections
- Magnetic spacer disks
- Larger range of bending radii per section

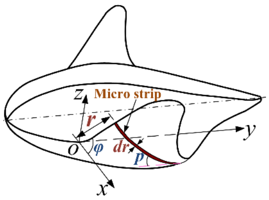


08:45–09:00	WeAT9.2

The Effect of Spanwise Flexibility on the Propulsion Performance of an Oscillating Pectoral Fin

Hongwei Ma, Yueri Cai, Shusheng Bi
Guanghua Zong and Zhao Gong
Beihang University, China

- The kinematic model of oscillating pectoral fin was established.
- The dynamic model of oscillating pectoral fin was developed based on the blade element theory.
- The influence of spanwise flexibility was analyzed theoretically.
- The experiments were carried out to study the propulsion performance of the bionic pectoral fin.



09:00–09:15	WeAT9.3

Thorax Unit Driven by Unidirectional USM for Under 10-Gram Flapping MAV Platform

Masaki Hamamoto[1], Hideki Etoh[1]
and Tomoyuki Miyake[1]
[1]SHARP Corporation, Japan

- A unidirectional ultrasonic motor (USM) is applied to the thorax unit of a flapping micro aerial vehicle (MAV) with the aim to develop an MAV in the 10-gram-range.
- Owing to the mismatch of the two vibration modes that dominate the efficiency of the USM, the generated lift force was only 0.25 gf while a flapping frequency exceeding 32 Hz is achieved at no loads (without wings).

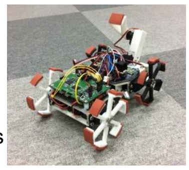
09:15–09:30	WeAT9.4

Design and Analysis of a Rotational Leg-type Miniature Robot with an Actuated Middle Joint and a Tail (RoMiRAMT)

Bokeon Kwak and Joonbum Bae

Department of Mechanical Engineering, UNIST, Korea

- A rotational leg-type miniature robot with an actuated biologically inspired middle joint and tail is proposed for stable locomotion and improved climbing ability. (size: 155 × 80 × 85 mm, weight: 593 g)
- The design parameters of the rotational legs were determined by 3D simulation.
- The maximum velocity of the robot is 2.58 m/s (16.65 body length) and the robot can climb an obstacle up to 95 mm of height (2.24 times of the leg length).

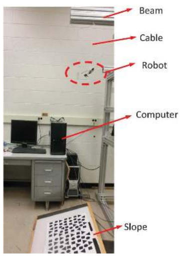


09:30–09:45	WeAT9.5

Non-vector Space Landing Control for a Miniature Tailed Robot

Jianguo Zhao[1], Hongyi Sheng[1], Ning Xi[1]
[1] Department of Electrical & Computer Engineering,
Michigan State University, USA

- Precise landing control for miniature robots is investigated;
- A miniature tailed robot is controlled to land on a slope with vision feedback;
- The control is based on a non-vector space control approach;
- The method can be used for precise landing control for miniature jumping, gliding, or flying robot.

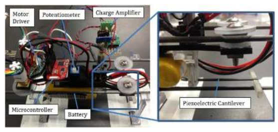


09:45–10:00	WeAT9.6

Structural Vibration for Robotic Communication and Sensing on 1D Structures

L. Maxwell Hill[1], Jerry Mekdara[1],
Barry Trimmer[1] and Robert White[1]
[1]Tufts University, USA

- Robot uses structural vibration to communicate and sense in 1D environments
- Inspired by techniques exhibited in many animals
- Demonstrates ability to communicate discrete commands and sense distance, using only vibration
- Can be applied to structural health monitoring, material transportation, and surveillance on 1D branching structures



Humanoid Robots 1

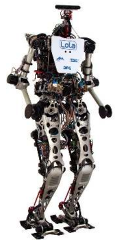
Chair *Abderrahmane Kheddar, CNRS-AIST JRL (Joint Robotics Laboratory), UMI3218/CRT*
Co-Chair *Francesco Nori, ISTITUTO ITALIANO DI TECNOLOGIA*

08:30–08:45	WeAT10.1

State Estimation for Biped Robots Using Multibody Dynamics

Robert Wittmann, Arne-Christoph Hildebrandt, Daniel Wahrmann, Daniel Rixen and Thomas Buschmann[1]
[1]Institute of Applied Mechanics, TU München, Germany

- **Kalman filter** with LIPM
  - Compensation for unknown disturbances while walking
  - Inclusion of multibody dynamics
  - Data fusion from inertial measurement unit and force/torque sensors
- **Real-time application** and experimental results

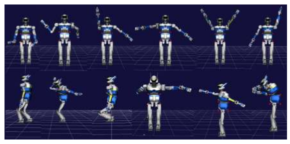


08:45–09:00	WeAT10.2

Identification of dynamics of humanoids: systematic exciting motion generation

Jovic Jovana[1], Frank Philipp[2], Adrien Escande[1], Ko Ayusawa[1], Eiichi Yoshida[1], Abderrahmane Kheddar[1,3], Gentiane Venture[1,4]
[1]CNRS-AIST JRL, Japan [2]University of Strasbourg, France
[3]CNRS-UM2, France [4]TUAT, Japan

- A new approach to determine **humanoid robot exiting trajectories for mass parameters identification**.
- The approach is based on observation of condition number of sub-regressor matrices.
- **Experimentally validated** on HRP-2 and HRP-4 humanoid robots.

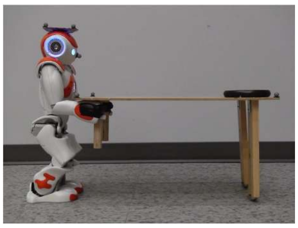


09:00–09:15	WeAT10.3

Humanoid Navigation and Heavy Load Transportation in a Cluttered Environment

Antoine Rioux, Wael Suleiman
University of Sherbrooke, Quebec, Canada

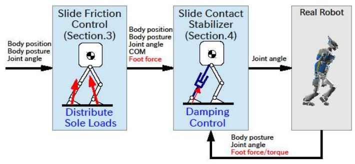
- Multi-primitive sets depending on the carried load
- Hands and arms are articulated to execute tight turns and ensure a safe transport by reducing the lateral swing effects on the load
- Motion capture system used for precise localization and occupancy grid generation
- System validated on a real humanoid robot (Nao robot)



09:15–09:30	WeAT10.4

Shuffle Motion For Humanoid Robot by Sole Load Distribution and Foot Force Control

Kunio Kojima and Shunichi Nozawa
and Kei Okada and Masayuki Inaba
Graduate School of Information Science and Technology, The University of Tokyo, Japan



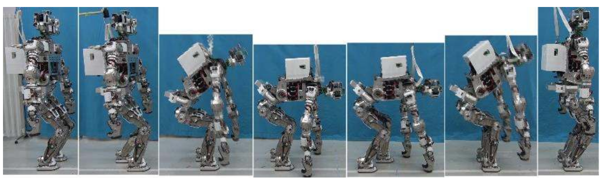
- Realize shuffle motion by a life-sized humanoid, HRP-2
- Slide Friction Control (S.F.C.): offline pattern generator
  - Adjust kinematic friction and sole loads
- Slide Contact Stabilizer (S.C.S.): online controller
  - Suppress friction vibrations by using damping control

09:30–09:45	WeAT10.5

Dynamic Gait Transition between Bipedal and Quadrupedal Locomotion

T. Kamioka, T. Watabe, M. Kanazawa, H. Kaneko, and T. Yoshiike, Honda R&D Co., Ltd.

- We propose an extended planning algorithm based on the DCM for an inverted pendulum with variable height and a flywheel.
- A sequence of bipedal and quadrupedal locomotion without intermediate stops was realized by the real humanoid robot.

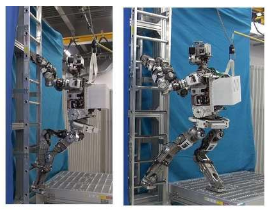


09:45–10:00	WeAT10.6

Robust Vertical Ladder Climbing and Transitioning between Ladder and Catwalk for Humanoid Robots

M.Kanazawa[1], S.Nozawa[2], Y.Kakiuchi[2], Y.Kanemoto[1], M.Kuroda[1], K.Okada[2], M.Inaba[2], T.Yoshiike[1]
[1]Honda R&D, Japan [2]The Univ of Tokyo, Japan

- Realize the robust climbing and descending of **a vertical ladder** and **bidirectional transitioning from ladders to catwalks**.
- Propose **robot posture estimator** and **footstep position controller**.
- Present a method of generating motion by optimizing the contact wrenches.



Ladder climbing Transitioning

Compliance and Impedance Control 2

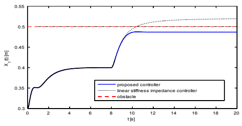
Chair *Bram Vanderborght, Vrije Universiteit Brussel*
Co-Chair *Achilles Theodorakopoulos, Aristotle University of Thessaloniki*

08:30–08:45	WeAT11.1

An Impedance Control Modification Guaranteeing Compliance Strictly Within Preselected Spatial Limits

Achilles Theodorakopoulos, George A. Rovithakis and Zoe Doulgeri
Aristotle University of Thessaloniki, Greece

- A Cartesian impedance controller is modified by adding a non-linear term creating an infinite stiffness at explicitly defined spatial hard bounds achieving:
  - ✓ Same compliance and performance characteristics away from the boundary
  - ✓ Guaranteed prevention of collision
- Comparative simulations are provided



08:45–09:00	WeAT11.2

Evaluating Human Motor Function of Lower Limbs in Periodic Motion during Pedaling Exercise

Tomohiro Miyazaki[1], Fumi Seto[1], Masashi Konyo[1] and Satoshi Tadokoro[1]
[1]Tohoku University, Japan

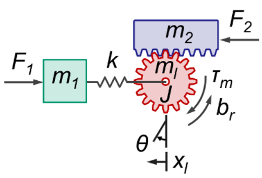
- An impedance estimation method of human lower limbs during dynamic pedaling excise as an index for evaluating motor functions.
- A multi-link model expressing the inertia and gravity of the lower limbs.
- Estimated stiffness and viscosity showed the periodic properties during pedaling excise under several conditions.

09:00–09:15	WeAT11.3

An Unlumped Model for Linear Series Elastic Actuators with Ball Screw Drives

Viktor L. Orekhov[1], Coleman S. Knabe[2], Michael A. Hopkins[2] and Dennis W. Hong[3]
[1]Booz Allen Hamilton, USA [2]Virginia Tech, USA [3]UCLA, USA

- Series elastic actuators are widely modeled using a lumped mass model.
- We propose a new unlumped model for linear SEAs which uses a rack & pinion to intuitively depict the mechanics of a ball screw.
- Results from hardware experiments are presented and compared to simulation results.



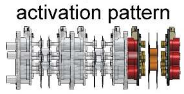
09:15–09:30	WeAT11.4

A selective recruitment strategy for exploiting muscle-like actuator impedance properties

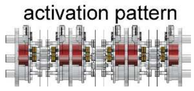
Joshua Schultz[1], Glenn Mathijssen[2,3], Bram Vanderborght[2] and Antonio Bicchi[3,4]
[1]University of Tulsa, USA [2]Vrije Universiteit Brussel, Belgium
[3]Università di Pisa, Italy, [4]Istituto Italiano di Tecnologia, Italy

- Discrete muscle-like actuation units have muscle-like resiliency properties
- Units are recruited similarly to skeletal muscle fibers
- Practically continuous forces can be realized even though each unit is Boolean
- By carefully choosing which units are recruited, the impedance of the actuator can be deliberately specified

High impedance activation pattern



Low impedance activation pattern

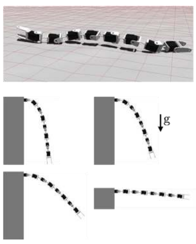


09:30–09:45	WeAT11.5

Role of Compliance on the Locomotion of a Reconfigurable Modular Snake Robot

Massimo Vespignani, Kamilo Melo, Stéphane Bonardi, and Auke J. Ijspeert
École Polytechnique Fédérale de Lausanne (EPFL), Switzerland

- Added in-series compliant elements to a simulated 8-DoF Modular Snake Robot
  - Two snake locomotion gaits
  - Different types of rough terrains
  - 8 stiffness levels tested
- Grid search and optimization to find fast and energy-efficient gaits
- Compliant and stiff elements lead to comparable performance

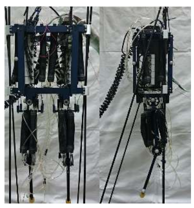


09:45–10:00	WeAT11.6

Impact Force Control Based on Stiffness Ellipse Method Using Biped Robot Equipped with Biarticular Muscles

Takeshi Kaneko, Kunihiro Ogata, Sho Sakaino and Toshiaki Tsuji
Graduate School of Science and Engineering
Saitama University, Japan

- This paper introduces the control method for the impact force considering the stiffness ellipse of a biped robot.
- Experimental results show that the impact force can be controlled well by adjusting the stiffness ellipse.
- This method is a good candidate for impact force control because the force is adjusted through the mechanical stiffness, which is independent of the control bandwidth.



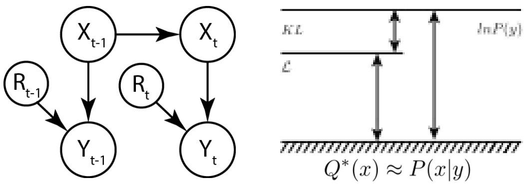
Marine Robotics 3

Chair *Galen Mullins, University of Maryland*
Co-Chair *P. Axel Hackbarth, Hamburg University of Technology*

08:30–08:45	WeAT12.1

A Variational Bayes Approach for Reliable Underwater Navigation

Georgios Fagogenis[1]and David Lane[2]
Ocean Systems Laboratory,Heriot-Watt University, Edinburgh, United Kingdom



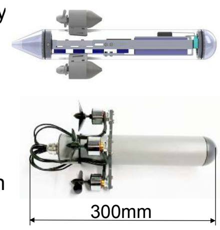
"An approximate answer to the right problem is worth a good deal more than an exact answer to an approximate problem." -- John Tukey.

08:45–09:00	WeAT12.2

HippoCampus: A Micro Underwater Vehicle for Swarm Applications

Axel Hackbarth, Edwin Kreuzer, Eugen Solowjow
Hamburg University of Technology

- Quadrotor design allows for great agility
- Suitable for multi-AUV research
- Small enough for confined test tanks
- Open hardware and open software
- Collaborative environmental exploration
- Onboard control and estimation

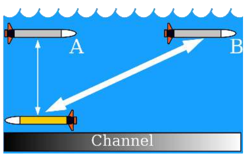


09:00–09:15	WeAT12.3

Belief Space Planning for Underwater Cooperative Localization

Jeffrey M. Walls, Stephen M. Chaves, Enric Galceran, and Ryan M. Eustice
University of Michigan, USA

- Within cooperative localization, robots augment internal sensors with inter-vehicle pose observations for position estimation.
- Vehicle network geometry greatly influences estimate quality.
- We employ belief space planning with a probabilistic channel model to plan 'server' vehicle paths to best localize a 'client' vehicle.

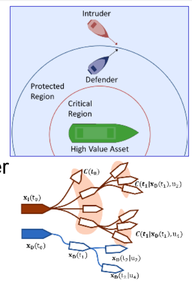


09:15–09:30	WeAT12.4

Adversarial Blocking Techniques for Autonomous Surface Vehicles using Model-Predictive Motion Goal Computation

Galen Mullins, Satyandra K. Gupta
University of Maryland, USA

- Developed blocking strategies for guarding high value naval assets via the use unmanned surface vehicles (USVs) as dynamic obstacles.
- Introduced a mirror-transformation pursuit method for radial blocking and a model-predictive method to estimate future intruder motions.
- Validated against information delayed and imperfect information environments using Monte Carlo simulation

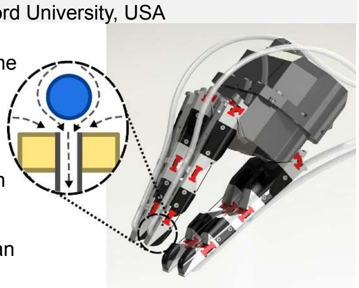


09:30–09:45	WeAT12.5

Suction Helps in a Pinch: Improving Underwater Manipulation with Gentle Suction Flow

Hannah Stuart, Matteo Bagheri, Shiquan Wang, Heather Barnard, Audrey Sheng, Merritt Jenkins and Mark Cutkosky
Stanford University, USA

- Pinching is an important capability for mobile marine robots handling light objects.
- Gentle suction flow at the fingertips improves friction and pinch security.
- Monitoring suction flow can measure contact quality.

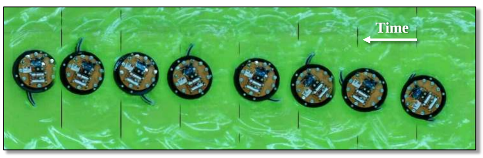


09:45–10:00	WeAT12.6

Momentum-Driven Single-Actuated Swimming Robot

Gilad Refael, Amir Degani,
Technion-Israel Institute of Technology

- Design & analysis of a simple minimalistic swimming mechanism
- The mechanism propels itself forward by oscillating its inner body in a symmetric fashion using a single actuator
- Using an asymmetric input, the mechanism is able to rotate in various curvatures



Grasping 2

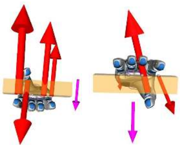
Chair *Maximo A. Roa, German Aerospace Center, DLR*
Co-Chair *Tokuo Tsuji, Kyushu university*

08:30–08:45	WeAT13.1

Simultaneous and Realistic Contact and Force Planning in Grasping

Katharina Hertkorn[1], Máximo A. Roa[1],
Thomas Wimböck[1], and Christoph Borst[1],
[1]German Aerospace Center (DLR), Germany

- Grasp planner that simultaneously considers contact points and forces
- Takes into account joint and torque limits of the robotic fingers
- Works with the real forces that the finger can apply (overcoming the traditional limitation of normalized contact forces)
- Low computational time (<20ms)



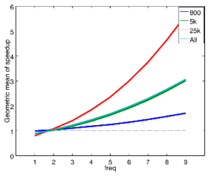
Pink: direction of gravity
Red: computed contact forces

08:45–09:00	WeAT13.2

Exact Calculation for Disturbance Force Rejection Grasp Quality Measure

Mana Borwornpadungkitti[1],
Watcharapol Watcharawisetkul[1],
Nattee Niparnan[1] and Attawith Sudsang[1]
[1]Chulalongkorn University, Thailand

- Propose a method to calculate the magnitude of minimal disturbance force applied to the object that breaks the grasp
  - Discretization of disturbance force direction is not required
  - Can outperform the original computation in term of accuracy and efficiency



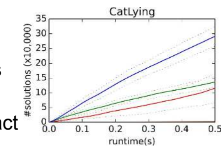
Speedup of our method over the original method

09:00–09:15	WeAT13.3

The Quickgrasp Algorithm for Grasp Synthesis

Watcharapol Watcharawisetkul[1],
Mana Borwornpadungkitti[1],
Nattee Niparnan[1] and Attawith Sudsang[1]
[1]Chulalongkorn University, Thailand

- This paper presents a concurrent grasp synthesis algorithm.
  - Calculate a large number of grasps with good quality in a short time
  - Takes as an input a set of 3D contact points and their normal vectors
  - Follows a stochastic approach
  - Selects concurrent points heuristically



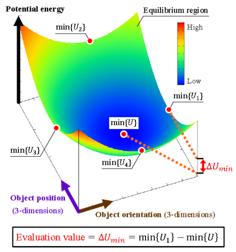
Number of found unique solutions. (Blue line is our approach)

09:15–09:30	WeAT13.4

Grasp Stability Evaluation based on Energy Tolerance in Potential Field

Tokuo Tsuji[1], Kosei Baba[1], Kenji Tahara[1],
Kensuke Harada[2], Ken'ichi Morooka[1]
and Ryo Kurazume[1]
[1]Kyushu University, Japan [2]AIST, Japan

- An evaluation method is proposed for grasp stability which takes into account the elastic deformation of fingertips from the viewpoint of energy.
- It is ensured that fingertips do not slip on grasped object surfaces if the external energy applied to the object is less than the evaluation value.
- The effectiveness of our method is verified through numerical examples.



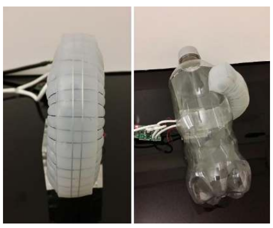
09:30–09:45	WeAT13.5

A Soft Pneumatic Actuator that Can Sense Grasp and Touch

Nicholas Farrow, Nikolaus Correll

University of Colorado, Boulder, USA

- Fiber reinforced soft pneumatic actuator with integrated **strain sensor** and **pressure sensor**
- Actuator can sense grasping an object and contact interactions with the environment
- Grasped cylindrical objects are distinguishable based on the grasp curvature (diameter)



09:45–10:00	WeAT13.6

Monolithic Fabrication of Sensors and Actuators in a Soft Robotic Gripper

R. Adam Bilodeau[1], Edward White[1],
Rebecca Kramer[1]
[1]Purdue University, USA

- An inflatable robotic gripper with integrated strain sensors providing a repeatable response to pneumatic actuation
- 3D printed mold manufacturing technique simultaneously creates a casting of both liquid metal and air channels in robot body
- Careful selection of sensor location provides measurable feedback during actuation capable of detecting events such as gripping an object

Flexible Arms

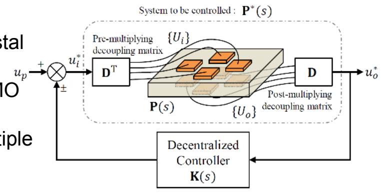
Chair *Thrishantha Nanayakkara, King's College London*
Co-Chair *Cai Meng, Beihang University*

08:30–08:45 WeAT14.1

Modal Decoupling for MIMO Self-Oscillating Systems – Application to Resonant Force Sensor Control

Davinson CASTAÑO-CANO[1;2], Mathieu GROSSARD[1] and Arnaud HUBERT[2;3]
[1]CEA-LIST, France [2]FEMTO-ST, France [3]UTC, France

- New method to control instantaneously MIMO oscillating systems
- Algorithm and hardware are implemented on a multidimensional resonant force sensor.
- Inspired by quartz crystal oscillator, the method is extended to the MIMO case as an alternative solution to control multiple resonances of a force sensor.

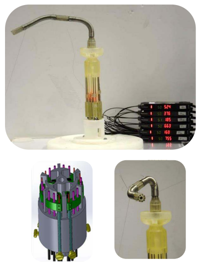


08:45–09:00 WeAT14.2

A 7.5mm Steiner chain fibre-optic system for multi-segment flex sensing

Sina Sareh[1], Yohan Noh[1], Tommaso Ranzani[2], Helge Wurdemann[1], Hongbin Liu [1], Kaspar Althoefer [1]
[1]King's College London, [2]Harvard University

- Highly Compact: 7.5mm in Diameter
- Inherently Safe: No Electricity at the Sensing Site
- Modular Steiner Chain Structure
- Stretchable
- Loopback Fiber-optic Design

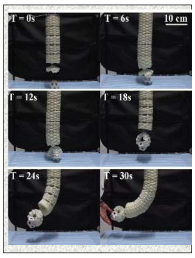


09:00–09:15 WeAT14.3

A Novel Soft Manipulator Based on Beehive Structure

Cai Meng, Weidong Xu, Haiyuan Li, and Tianmiao Wang
Beijing University of Aeronautics and Astronautics, China

- A novel soft continuum robot is designed and introduced in this paper.
- The basic structure of the robot is beehive hexagon structure.
- The robot is made up of Dow Corning GP silicone sealant and is pneumatic driven.
- From the tests, the soft manipulator has good flexibility and elastically deformation capability.

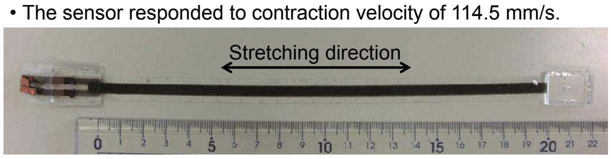


09:15–09:30 WeAT14.4

Design and Response Performance of Capacitance Meter for Stretchable Strain Sensor

Hiroyuki Nakamoto[1], Soushi Oida[1], Hideo Ootaka[2], Ichiro Hirata[3], Mitsunori Tada[4], Futoshi Kobayashi[1] and Fumio Kojima[1]
[1]Kobe University, Japan [2]Bando Chemical Industries, Ltd., Japan
[3]Hyogo Prof. Inst. Of Tech., Japan [4]AIST, Japan

- We designed a capacitance meter for a stretchable strain sensor.
- The strain sensor measured length of an artificial muscle.
- The measurement error was within 1.5 mm.
- The sensor responded to contraction velocity of 114.5 mm/s.

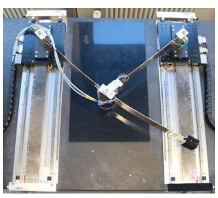


09:30–09:45 WeAT14.5

Friction Compensation, Gain Scheduling and Curvature Control for a Flexible Parallel Robot

Merlin Morlock[1], Markus Burkhardt[2], and Robert Seifried[1]
[1]Hamburg University of Technology, Germany
[2]University of Stuttgart, Germany

- **Experiments** are conducted for a parallel manipulator with a kinematic loop and a **highly flexible** link
- **Friction compensation** based on the Stribeck and LuGre models and **gain scheduling** are used to improve the position control of the drive trains
- A **curvature controller** based on a nonlinear flexible multibody system is introduced to actively damp the **oscillations**

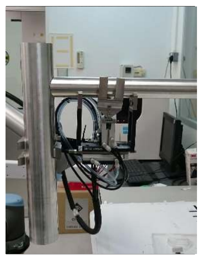


09:45–10:00 WeAT14.6

A Flexible Fixtureless Assembly of a T-Joint Frame Structures

Wenjie Chen[1], Xiong Li[1], Sheng Jie Teo[1], Wei Lin[1], Kin Huat Low[2]
[1]Singapore Institute of Manufacturing Technologies, Singapore
[2]Nanyang Technological University, Singapore

- A novel approach for building T-joint structures automatically using a Flexible Fixtureless Assembly Workcell
- Experiments show that the workcell can effectively eliminate the alignment error and successfully complete T-joint assembly task without the complex sensing system typically required in existing approaches.



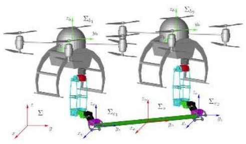
Cooperative Manipulators

Chair *Yiannis Karayiannidis, KTH Royal Insitute of Technology*
Co-Chair *Jae-Bok Song, Korea University*

08:30–08:45 WeAT15.1

Cooperative impedance control for multiple UAVs with a robotic arm

Fabrizio Caccavale, Gerardo Giglio,
Giuseppe Muscio, Francesco Pierri
University of Basilicata, 85100 Potenza, Italy

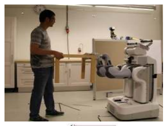


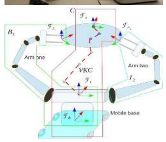
- Impedance control scheme for cooperative quadrotors equipped with a robotic arms.
- Two impedance control law aimed at limiting both the contact forces due to the object/environment interaction (external impedance) and the object internal stresses due to manipulator/object interaction (internal impedance).
- Simulation validation in Matlab/SimMechanics environment.

08:45–09:00 WeAT15.2

Cooperative control of a serial-to-parallel structure using a virtual kinematic chain in a mobile dual-arm manipulation application

Yuquan Wang, Christian Smith, Yiannis Karayiannidis
and Petter Ögren
KTH, Sweden



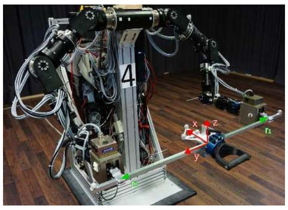


- It is non-trivial to compute the inverse kinematics for a mobile dual-arm manipulator as the mobile base is connected to both of the arms.
- We propose to use a Virtual Kinematic Chain (VKC) to specify the common motion of the two arms, instead of using the dual-arm kinematics directly.
- We verify the proposed approach with a PR2 robot simulator.

09:00–09:15 WeAT15.3

Dynamic Load Distribution in Cooperative Manipulation Tasks

Andrea Zambelli Bais[1], Sebastian Erhart[2],
Luca Zaccarian[3] and Sandra Hirche[2]
[1]University of Trento, Italy [2]Technische Universität München, Germany [3] CNRS, LAAS, France and University of Trento, Italy

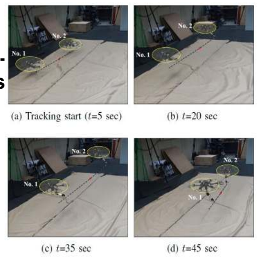


- Distribute desired load in a team of *heterogeneous* manipulators.
- *Static allocation*: constant weighting coefficients on robots.
- *Dynamic allocation*: time-varying wrench saturation limits.
- *Experimental evaluation* with two manipulators.

09:15–09:30 WeAT15.4

Path Planning and Control of Multiple Aerial Manipulators for a Cooperative Transportation

Hyeonbeom Lee[1], Hyoin Kim[1] and H. Jin Kim[1]
[1]Seoul National Univ., Korea, Rep.



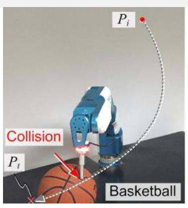
(a) Tracking start (t=5 sec) (b) t=20 sec (c) t=35 sec (d) t=45 sec

- **Aerial manipulator** consists of a hexacopter with 2-DOF robotic arm.
- A controller is designed based on **de-centralized closed-chain dynamics** for each aerial manipulator.
- The desired path for two aerial manipulators is obtained by **RRT***.
- **Two experimental results** :
  1) user-guided command tracking
  2) RRT*-planned trajectory tracking

09:30–09:45 WeAT15.5

Sensorless Collision Detection for Safe Human-Robot Collaboration

Sang-Duck Lee[1], Min-Cheol Kim[1] and Jae-Bok Song[1]
[1]Korea university, Korea

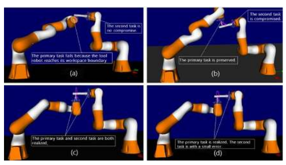


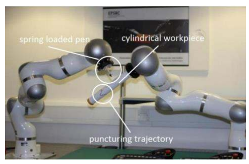
- A **sensorless collision detection** method using the external torque observer and friction model identification
- The friction model identification are carried out without the use of extra sensors.
- The experimental results prove the reliability of the proposed collision detection method.

09:45–10:00 WeAT15.6

Task-Priority Redundancy Resolution for Co-operative Control under Task Conflicts and Joint Constraints

A co-operative control framework for handling tasks conflict and joint constraints.
•Control dual-arm as a whole using Relative Jacobian
•Using Singularity-robust inverse kinematics
•Distributing exceeded joint velocity in null space





Human-Robot Interaction 3

Chair *Dominik Sieber, Technische Universität München*
Co-Chair *Joohyung Kim, Disney Research Pittsburgh*

11:20–11:35	WeCT1.1

Multimodal Joint Visual Attention Model for Natural Human-Robot Interaction

Joris Domhof, Aswin Chandarr,
Maja Rudinac and Pieter Jonker
[1]Delft University of Technology, The Netherlands

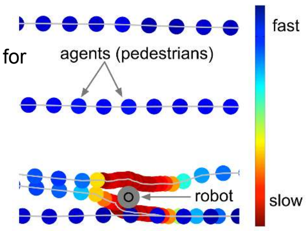
- JVA model detects object of interest according to the user
- Combination of bottom-up saliency and depth-based saliency with top-down cues pointing and gaze
- Gaze saliency map based on eye-tracker estimated gaze direction

11:35–11:50	WeCT1.2

Simulating the effect of a social robot on moving pedestrian crowds

Sachit Butail[1]
[1]Indraprastha Institute of Information Technology Delhi (IIITD), India

- Use social force model to simulate pedestrian crowds
- Model human-robot interaction for different robot designs from literature
- Add social contagion to model change in behavior of non-participating agents
- Results show that robot design choices dominate interaction

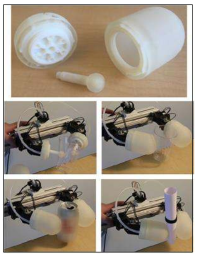


11:50–12:05	WeCT1.3

3D Printed Soft Skin for Safe Human-Robot Interaction

Joohyung Kim, Alexander Alspach and Katsu Yamane
Disney Research, USA

- Our goal is to develop a soft skin module for safe Human-Robot Interaction. A pressure feedback controller is implemented on a robotic system using 3D printed skin module with a built-in airtight cavity. By collision tests, we show that this module significantly reduces the impact forces due to collision. Also, the developed system is capable of very gentle physical interaction with soft objects.

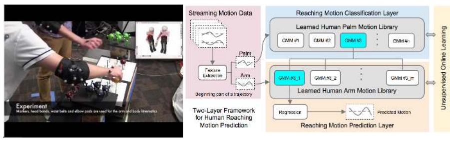


12:05–12:20	WeCT1.4

A Framework for Unsupervised Online Human Reaching Motion Recognition and Early Prediction

Ruikun Luo[1], Dmitry Berenson[1],
[1]Worecester Polytechnic Institute, USA

- Unsupervised online learning algorithm for motion recognition
- A two-layer framework for human motion prediction
- Requires no offline training or manually-labeled data
- Builds models on-the-fly and adapts to new people and new motion styles



12:20–12:35	WeCT1.5

Increasing Autonomy Transparency through Capability Communication in Multiple Heterogeneous UAV Management

Ting (Brendan) Chen[1], Duncan Campbell[1], Felipe Gonzalez[1], and Gilles Coppin[2]
[1]Queensland University of Technology, Australia [2]Telecom Bretagne, France

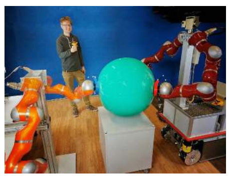
- Three types of cognitive and one type of objective performance measures to gauge the impact of autonomy transparency in managing multiple UAVs
- Four types: Cognitive Workload (CW), Situation Awareness (SA), Trust, Objective Performance
- At 95% confidence interval, all types improved when configuration had greater autonomy transparency

12:35–12:50	WeCT1.6

Multi-robot manipulation controlled by a human with haptic feedback

Dominik Sieber, Selma Music,
Sandra Hirche
Technische Universität München, Germany

- Interaction of a single human with a team of physically cooperating robots
- Human guides the multi-robot team based on leader-follower paradigm
- Controllability analysis suggests that human input needs to be measured by all robots
- Proposed approach is evaluated in full-scale multi-robot experiment



Unmanned Aerial Systems 5

Chair *Fabio Poiesi, Queen Mary University of London*
Co-Chair *Daniel Meier, ETH Zurich*

11:20–11:35	WeCT2.1

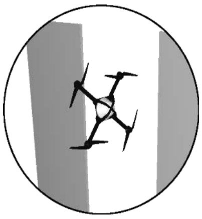
Enhancing sampling-based kinodynamic motion planning for quadrotors

Alexandre Boeuf, Juan Cortés,
Rachid Alami and Thierry Siméon
LAAS-CNRS, Toulouse, France

We propose two components:

- A suitable and computationally efficient quasi-metric to estimate distances in the state space of a quadrotor.
- An incremental state-space sampling technique that increases the probability of generating connectible states.

Their integration into sampling-based motion planning algorithms reduces CPU time by up to two orders of magnitude.

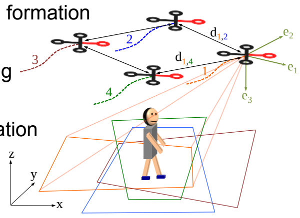


11:35–11:50	WeCT2.2

Distributed vision-based flying cameras to film a moving target

Fabio Poiesi and Andrea Cavallaro
Centre for Intelligent Sensing
Queen Mary University of London, UK

- Target following with cameras in formation
- Distributed vision-based servoing
- Geometrically constrained formation



11:50–12:05	WeCT2.3

Solar Powered UAV: Design and Experiments

Scott Morton, Ruben D'Sa,
and Nikolaos Papanikolopoulos
University of Minnesota, United States

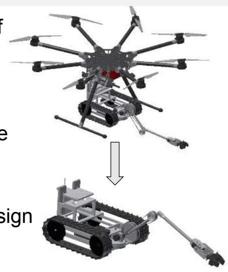
- Capability of day long flight.
- 4 meter wing span.
- 154 watts peak power.
- A discussion of our progress in solar UAV hardware: airframe, propulsion, electronics, processing, and sensing.

12:05–12:20	WeCT2.4

Optimization-based Design of a Novel Hybrid Aerial/Ground Mobile Manipulator Decomposition

David Findlay, Mohammad Jafarinasab,
Shahin Sirouspour,
McMaster university, Canada

- A hybrid system is proposed capable of executing both aerial and ground manipulation tasks.
- The mechanical design objective is to minimize the mass of the ground mobile manipulator.
- A robust bilevel nonlinear optimization approach is used in the mechanical design of the system.

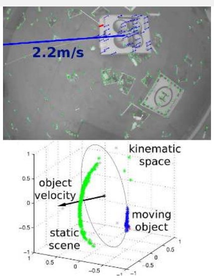


12:20–12:35	WeCT2.5

Detection and Characterization of Moving Objects with UAVs using Inertial-Optical Flow

Daniel Meier[1], Roland Brockers[2], Larry Matthies[2],
Roland Siegwart[1], and Stephan Weiss[2]
[1]ETH Zurich, Switzerland [2]NASA-JPL/CalTech, USA

- Extension of the continuous epipolar constraint definition to analyze consistent groups of OF measurements
- Two-stage clustering of consistent outlier groups in the *kinematic* and *geometric* feature space
- Characterize the metric motion of the objects in 3D space only requiring two consecutive monocular frames
- Real-time implementation on a UAV

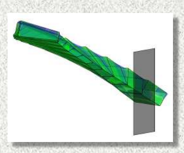


12:35–12:50	WeCT2.6

Energy-Optimal Path Planning for Six-Rotors on Multi-Target Missions

Kevin Vicencio[1], Tristan Korras[1],
Kenneth A. Bordignon[1] and Iacopo Gentilini[1]
[1]Embry-Riddle Aeronautical University, USA

- Energy consumption minimization of Unmanned Aerial System scheduled to visit multiple locations during each flight.
- Mathematical modeling of the target locations as four-dimensional non-convex neighborhoods and approximation using four-dimensional polyhedra.
- Fine-tuned aerodynamic aircraft modeling to simulate energy consumption and norm-energy correlation study.



3D projection of 4D neighborhood approximation

Robot Vision 5

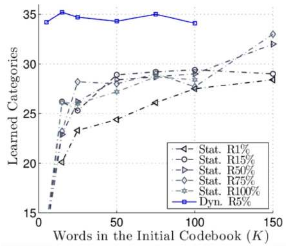
Chair *Pieter Abbeel, UC Berkeley*
Co-Chair *Michael Suppa, RoboCeption GmbH*

11:20–11:35 WeCT3.1

Concurrent Learning of Visual Codebooks and Object Categories in Open-ended Domains

M. Oliveira[1], L. Seabra Lopes[1],
G. Lim[1], S. Kasaei[1], A. Sappa[2] and A. Tomé[1]
[1]University of Aveiro, Portugal [2]Computer Vision Center, Spain

- Open-ended learning of object categories
- Online update of visual codebooks in a BOW model
- Learn more categories, with similar accuracy, requiring less examples when compared to offline codebooks



11:35–11:50 WeCT3.2

Detection of Ascending Stairs using Stereo Vision

Hannes Harms[1], Eike Rehder[1], Tobias Schwarze[1] and Martin Lauer[1]
[1]Karlsruhe Institute of Technology (KIT)

- Detection of concave and convex 3d line segments from depth data only
- Tracking of line segments and stair modelling in global world coordinates
- System runs in real time and outperforms accuracy of existing state-of-the-art methods
- Assistance system for visually impaired people
- Helmet with IMU + stereo camera rig

11:50–12:05 WeCT3.3

Optimized Color Models for High-Quality 3D Scanning

Karthik Narayan and Pieter Abbeel
University of California, Berkeley

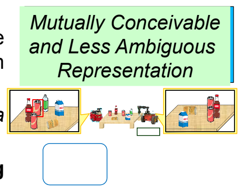
- We improve upon recently proposed optimization-based techniques for color-model estimation; our method jointly optimizes over camera positions and vertex colors to produce high-fidelity color models for 3D meshes.
- We show that 2D texture cues, vertex color smoothing, and texture-adaptive camera viewpoint selection significantly improve color model fidelity.

12:05–12:20 WeCT3.4

Cognitive Sharing of Object with Subgraph Matching and Entropy Minimization in MRS

Shodai Tomita, Kosuke Sekiyama,
Nagoya University, Japan

- Issue in Cognitive Sharing : A different viewpoint gives a different perspective.
- Proposed a representation of a unique geometric relation: **MELaR** (Minimum entropy Labeled-graph representation)
- Subgraph matching based on *Nema* and entropy minimization.
- Developed **the consensus-making algorithm to share the MELaR**

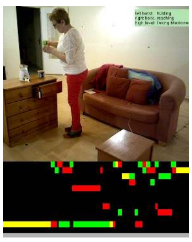


12:20–12:35 WeCT3.5

A Hierarchical Representation for Human Activity Recognition with Noisy Labels

Ninghang Hu[1,2], Gwenn Englebienne[2],
Zhongyu Lou[2] and Ben Kröse[2]
[1]UC, Berkeley, USA [2]University of Amsterdam, Netherlands

- Recognize human activities in a hierarchy representation
- Max-margin learning approach that allows labels to be **noisy, uncertain,** and **missing**
- Outperforming results on CAD-120 and Accompany dataset



12:35–12:50 WeCT3.6

Joint Categorization of Objects and Rooms for Mobile Robots

J.R. Ruiz-Sarmiento, C. Galindo,
and J. Gonzalez-Jimenez
System Engineering and Automation, University of Malaga, Spain

- Joint categorization of objects and rooms through a Conditional Random Field (CRF).
- Human Knowledge used in the CRF learning phase: real training datasets are not needed.
- Evaluation with the NYU2 dataset, achieving a success of ~70% categorizing both, objects and rooms.

Localization 1

Chair *Michael J Milford, Queensland University of Technology*
Co-Chair *Odest Chadwicke Jenkins, Brown University*

11:20–11:35	WeCT4.1

Robust Visual SLAM Across Seasons

Tayyab Naseer[1], Michael Ruhnke[1], Cyrill Stachniss[2] , Luciano Spinello[1] and Wolfram Burgard[1]
[1]University of Freiburg, Germany [2]University of Bonn, Germany

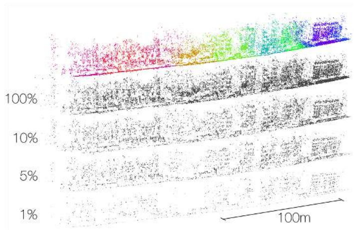
- Approach to visual SLAM that deals with large perceptual changes across seasons.
- Leverage sequential information for robust loop closure detection.
- Robust global image description using convolutional neural networks (CNNs) to achieve more distinctive image matching.
- Handles partially matching routes, visits to new places and loops in trajectories.

11:35–11:50	WeCT4.2

Keep it Brief: Scalable Creation of Compressed Localization Maps

Marcin Dymczyk[1], Simon Lynen[1], Michael Bosse[1] and Roland Siegwart[1]
[1]Autonomous Systems Lab, ETH Zurich

- Compact size **localization maps**
- Landmark reduction using **ILP** and **MIQP**
- **Partitioning of the map** to keep the optimization problem feasible

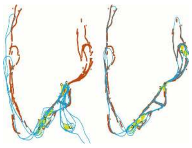


11:50–12:05	WeCT4.3

Robust Graph SLAM in Dynamic Environments with Moving Landmarks

Lingzhu Xiang[1], Zhile Ren[1], Mengrui Ni[1] and Odest Chadwicke Jenkins[1]
[1]Department of Computer Science, Brown University, USA

- Problem: Moving landmarks corrupt maps.
- We attach latent mobility variables to landmarks in a robust graph SLAM model.
- Landmark mobility is learned with the EM algorithm, and used to eliminate moving landmarks from graph optimization with robust covariance scaling.
- Experiments show effectiveness on real datasets in the Alcázar of Seville, and synthesized datasets in the Victoria Park.



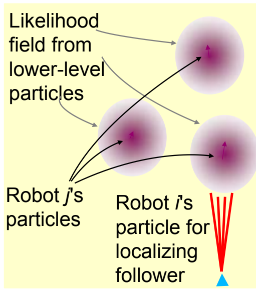
Without or with handling moving landmarks. Red: GPS; Blue: result

12:05–12:20	WeCT4.4

Localization and Tracking under Extreme and Persistent Sensory Occlusion

Kedar Marathe[1] and Prashant Doshi[2]
[1]Institute for AI, University of Georgia, USA [2]Computer Science Department, University of Georgia, USA

- **Problem:** Mobile robot must stay self-localized while tailing another robot (or human)
- **Challenge:** Extreme and persistent occlusion due to a dynamic obstacle. Traditionsal MCL fails
- **Approach:** Introduce novel particle weighting and adaptive sampling schemes for use with a **nested particle filter** that localizes subject robot and tracks another

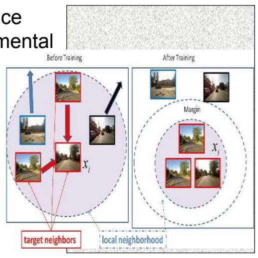


12:20–12:35	WeCT4.5

Distance Metric Learning for Feature-Agnostic Place Recognition

Zetao Chen, Stephanie Lowry, Adam Jacobson Zongyuan Ge and Michael Milford
Queensland University of Technology, Australia

- Learn distance metric to perform place recognition under changing environmental conditions;
- Cluster images captured at spatially proximal locations under different conditions, separated from frames captured at different places.



Networked Robots

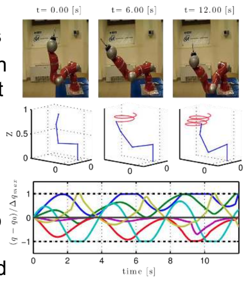
Chair *Alessandro De Luca, Sapienza University of Rome*
Co-Chair *Alejandro R. Mosteo, Centro Universitario de la Defensa*

11:20–11:35	WeCT5.1

Unilateral constraints in the Reverse Priority redundancy resolution method

Fabrizio Flacco and Alessandro De Luca
Sapienza University of Rome, Italy

- Some robot operative conditions are better defined by unilateral constraints
- The Reverse Priority method allows an efficient check on whether a constraint has to be activated, after having computed the unconstrained solution
- Smooth evolution of the joint velocity commands is also obtained
- Simulations with an Aldebaran Romeo humanoid robot and experiments with a KUKA LWR manipulator are reported

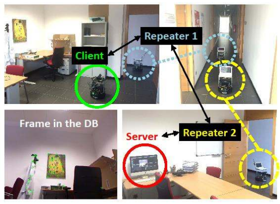


11:35–11:50	WeCT5.2

Visual Data Association in Narrow-Bandwidth Networks

Danilo Tardioli[1], Eduardo Montijano[1], Alejandro Mosteo[1]
[1]Centro Universitario de la Defensa, Zaragoza

- Solution for the problem of **matching features** from two **images** acquired by different robots in a **real network**
- Use a **vocabulary** to **reduce** the **size of the messages**
- Same quality than standard matching but at a higher frame rate
- **Real experiments** with up to 4 robots in the network

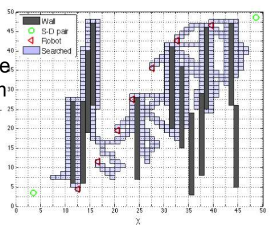


11:50–12:05	WeCT5.3

The Optimism Principle: A Unified Framework for Optimal Robotic Network Deployment in An Unknown Obstructed Environment

Shangxing Wang, Bhaskar Krishnamachari and Nora Ayanian
University of Southern California, USA

- A unified framework called LEONA that is general enough to permit optimizing the communication network for different utility functions in non-convex environments
- The approach is based on the principle of "optimism in the face of uncertainty" to allow the team of robots to form optimal configurations efficiently and rapidly without exploring the entire area

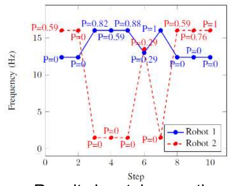


12:05–12:20	WeCT5.4

Dynamic Bandwidth Management Library for Multi-Robot Systems

Ricardo E. Julio[1], Guilherme S. Bastos[1]
[1]Federal University of Itajuba, Brazil

- A ROS-Based library to provide a way of maximizing bandwidth usage in multi-robot systems;
- Frequency of each communication channel, such as sensors, is controlled by the system using a priority based on the environment state and the available bandwidth.



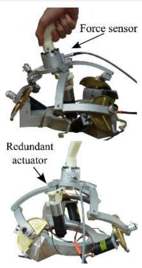
Results in a teleoperation application
(P = priority)

12:20–12:35	WeCT5.5

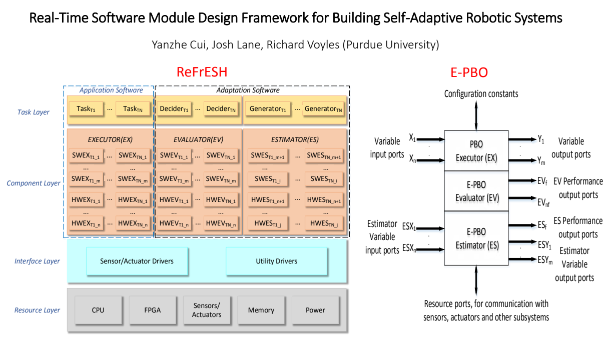
Optimal haptic control of a redundant 3-RRR Spherical Parallel Manipulator

Houssem Saafi, Med Amine Laribi, and Said Zeghloul
University of Poitiers, France

- A redundant actuator is added in a passive joint of a spherical parallel manipulator (SPM) to allow the haptic control in singular configurations.
- This SPM will be used as a haptic master device for a medical tele-operation system.



12:35–12:50	WeCT5.6



Medical Robots and Systems 1

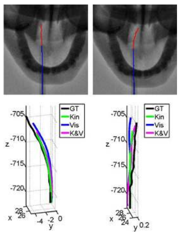
Chair *Norihiro Koizumi, The Univ. of Tokyo*
Co-Chair *Guang-Zhong Yang, Imperial College London*

11:20–11:35	WeCT6.1

Vision-Based Intraoperative Shape Sensing of Concentric Tube Robots

Alessandro Vandini, Christos Bergeles, Fang-Yu Lin and Guang-Zhong Yang
The Hamlyn Centre for Robotic Surgery, Imperial College London, UK

- The tracking of the robot in fluoroscopy is fused with the robot kinematics via 2D/3D non-rigid registration to achieve accurate and real-time 3D shape sensing.
- The clinical value of the proposed algorithm was demonstrated through both simulations and experiments.
- The results show that the proposed algorithm is more robust than kinematics or vision alone for robot shape estimation.


Qualitative results

11:35–11:50	WeCT6.2

New method for bone measurement by STA compensation through spatial interpolation

Simon Bouvel[1], Viviane Pasqui[1] and Guillaume Morel[1]
[1]Sorbonne Universités UPMC ISIR, France

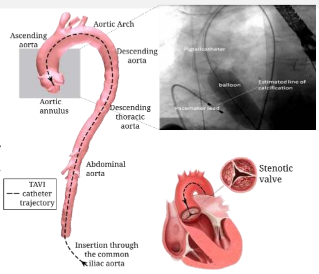
- Model-free bone motion measurement through Soft Tissue Artifact (STA) compensation.
- STA compensation is achieved with spatial interpolation of homogeneous transforms.
- The natural neighbors interpolation method was adapted for this problem.
- Validation with a robot manipulator on which soft tissue was attached, and motion capture technology.

11:50–12:05	WeCT6.3

Intuitive Teleoperation of Active Catheters for Endovascular Surgery

B. Rosa[1], A. Devreker[1], H. De Praetere[2], C. Gruijthuijsen[1], S. Portoles-Diez[1], et al.
[1]KU Leuven, Belgium [2]University Hospital Leuven, Belgium

Multi-DoF teleoperated catheters aim at providing surgeons improved visualization and catheter manoeuvrability. Kinematic dissimilarity problem between joystick and catheter workspaces can be solved by using appropriate mapping between joystick input and catheter output motion.

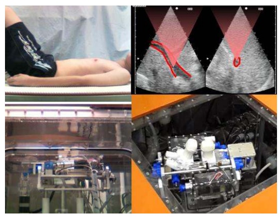


12:05–12:20	WeCT6.4

An extremely robust US based focal lesion servo system incorporating a servo recovery algorithm for a NIUTS

Norihiro Koizumi[1], Takakazu Funamoto[1], Joonho Seo[1], Hiroyuki Tsukihara[1], Hiroyuki Fukuda[2], Hideyo Miyazaki[1], Kiyoshi Yoshinaka[3], Takashi Azuma[1], Naohiko Sugita[1], Yukio Homma[1], Kazushi Numata[2], Yoichiro Matsumoto[4], and Mamoru Mitsuishi[1]
[1]The University of Tokyo, Japan [2]Yokohama City University, Japan [3]The National Institute of Advanced Industrial Science and Technology, Japan [4]RIKEN, Japan

- A novel robust servo recovery algorithm for Non-Invasive Ultrasound Theragnostic System: **NIUTS**.
- **First successful report** on semiautonomous servo recovery of lost body targets.
- This robust servo recovery method could provide an **indispensable tool** for precise, safe, and efficient treatments of tumors and stones.

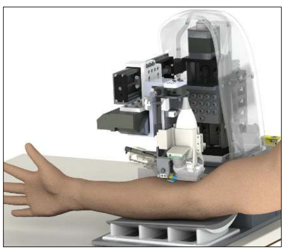


12:20–12:35	WeCT6.5

Real-time Needle Steering by a 9-DOF Image-Guided Autonomous Venipuncture Robot

Max Balter[1], Alvin Chen[1], Timothy Maguire[1] and Martin Yarmush[2]
[1]VascuLogic LLC, USA [2]Rutgers University, USA

- Developing a portable robot for automated venipuncture
- Combines 3D near infrared and ultrasound imaging, computer vision software, and a 9-DOF robot to servo the needle based on real-time feedback
- Funding support by NSF, NIH, and National Instruments Corp.

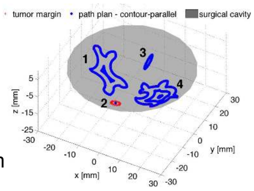


12:35–12:50	WeCT6.6

Path Planning for Semi-automated Simulated Robotic Neurosurgery

Danying Hu, Yuanzheng Gong, Blake Hannaford and Eric J. Seibel
University of Washington, USA

- Surgical tool path planning in semi-automated robotic surgery – brain tumor margin removal
- Three types of planning algorithms
- Behavior Tree integration
- System and algorithm validation on RAVEN^{TM} II surgical robotic platform
- Performance analysis



Motion and Path Planning 2

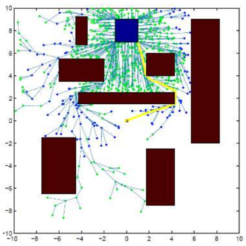
Chair *Christopher Burrows, Imperial College London*
Co-Chair *Panagiotis Tsiotras, Georgia Tech*

11:20–11:35	WeCT7.1

Machine Learning Guided Exploration for Sampling-based Motion Planning Algorithms

Oktay Arslan[1] and Panagiotis Tsiotras[2]
[1,2]Georgia Institute of Techgnology, USA

- Machine Learning inspired sampling technique to learn the relevant region of a motion planning problem
- Two-step approach : classification for predicting the label (free, obstructed) and regression for predicting the cost value function
- The proposed approach is integrated to RRT# algorithm and numerical simulations show its efficiency

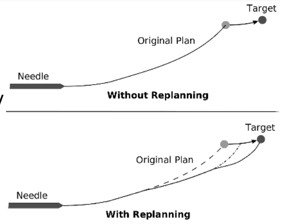


11:35–11:50	WeCT7.2

Smooth On-line Path Planning for Needle Steering with Non-linear Constraints

Christopher Burrows, Fangde Liu,
Ferdinando Rodriguez y Baena
Imperial College London, UK

- Target motion during needle intervention caused by tissue deformation is a common problem
- Here we present a computationally inexpensive planner which can be used on-line to control a steerable needle through soft tissue to a moving target while adhering to curvature and curvature derivative constraints

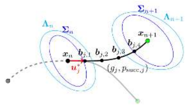


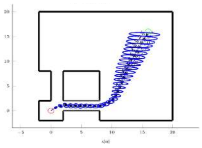
11:50–12:05	WeCT7.3

Heuristic Search in Belief Space for Motion Planning under Uncertainties

David Lenz[1], Markus Rickert[1],
Alois Knoll[2]
[1]fortiss GmbH, Germany [2]TU München, Germany

- Motion Planning for Non-Holonomic Robot:
  - Uncertainty in Motion
  - Uncertainty in Localization
  - Uncertainty in Map
- Graph Search in Belief Space
  - Heuristic guides search
  - Finds safe paths
  - Tradeoff between cost and risk



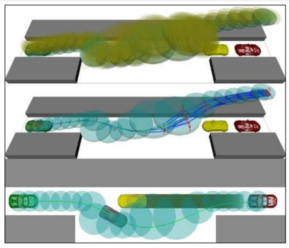


12:05–12:20	WeCT7.4

Kinodynamic Motion Planning with Space-Time Exploration Guided Heuristic Search for Car-Like Robots in Dynamic Environments

Chao Chen[1], Markus Rickert[1] and Alois Knoll[2]
[1]fortiss GmbH, Germany [2]Technische Universität München, Germany

- Space-time exploration investigates the free space regarding time evolution with cylinders to find a path corridor in dynamic environments.
- Heuristic search propagates the states following the path corridor with motion primitives to plan a valid motion.

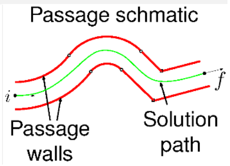


12:20–12:35	WeCT7.5

Smooth Path Planning for Passages with Heading and Curvature Discontinuities

Saurabh Upadhyay[1] and Ashwini Ratnoo[1],
[1]Indian Institute of Science, India

- Path planning based on Half-S shaped paths derived from Four Parameter Logistic (4PL) curves
- Simple analytic conditions for path generation and confinement in passage
- The generated path has inherent curvature continuity and zero end curvature which provides scalability and compatibility
- Proposed work can be applied in prescribed boundary transversals such as mines, corridors, tunnels, roads etc.

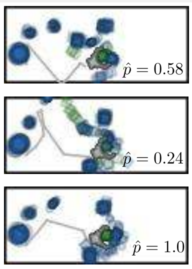


12:35–12:50	WeCT7.6

Robust Trajectory Selection for Rearrangement Planning as a Multi-Armed Bandit Problem

Michael C. Koval, Jennifer E. King,
Nancy S. Pollard and Siddhartha S. Srinivasa
Carnegie Mellon University, USA

- Frame planning under uncertainty as a trajectory selection problem
- Generate candidate trajectories using a kinodynamic state space planner
- Treat candidates as arms in a multi-arm bandit problem
- Allocate noisy rollouts among candidates to characterize probability of successful execution



Force and Tactile Sensing 3

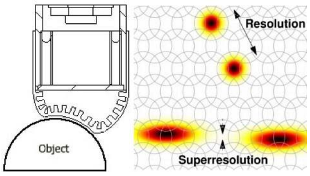
Chair *Francesco Nori, ISTITUTO ITALIANO DI TECNOLOGIA*
Co-Chair *Nathan Lepora, University of Bristol*

11:20–11:35	WeCT8.1

Superresolution with an optical tactile sensor

Nathan F. Lepora[1,2], Benjamin Ward-Cherrier[1,2]
[1]University of Bristol, U.K.
[2]Bristol Robotics Laboratory, U.K.

- Superresolution methods enable sensing accuracy to surpass the resolution limit (awarded 2014 Nobel Prize in Chemistry).
- Poor resolution is a common limitation of tactile sensors.
- We use Bayesian methods for superresolution to reach **0.1mm localization** for **4mm resolution**.
- Validated with a novel design of SDM optical tactile sensor.

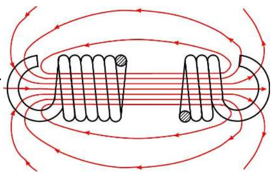


11:35–11:50	WeCT8.2

Force Sensing for Compliant Actuators Using Coil Spring Inductance

Joost van der Weijde[1], Erik Vlasblom[1],
Peter Dobbe[1], Heike Vallery[1,2] and Michael Fritschi
[1]Delft University of Technology [2]ETH Zurich

- Development of a new sensing method for spring deflection, using the spring's inductance.
- Comparison of theoretical inductance models and a semi-empirical fit on experimental data on their ability to predict spring deflection.
- The semi-empirical fit achieves an accuracy of 2%.

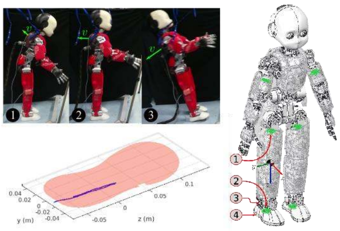


11:50–12:05	WeCT8.3

Multimodal Sensor Fusion for Foot State Estimation in Bipedal Robots Using the Extended Kalman Filter

Jorhabib Eljaik[1], Naveen Kuppuswamy[2]
and Francesco Nori[2]
[1]Istituto Italiano di Tecnologia - iCub Facility, Italy [2]Istituto Italiano di Tecnologia – RBCS Department, Italy

An Extended Kalman Filter was used to fuse a variety of sensors in order to estimate the dynamic state of a foot composed of contact and internal wrenches, velocities and orientation.

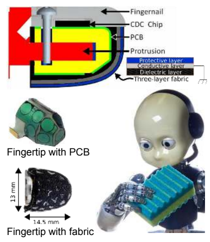


12:05–12:20	WeCT8.4

A New Design of a Fingertip for the iCub Hand

Nawid Jamali, Marco Maggiali, Francesco Giovannini,
Giorgio Metta and Lorenzo Natale
Istituto Italiano di Tecnologia, Italy

- Comprised of a flexible PCB and a novel multi-layer fabric that consists of: the dielectric layer, the conductive layer and the protective layer
- Can be deployed on curved surfaces and integrated with robotic hands.
- Robust, repeatable, and easy to manufacture
- Sensitivity of 0.05 N, low cross-talk with good spatial resolution



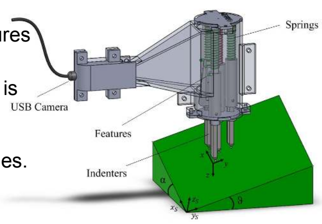
The proposed fingertip

12:20–12:35	WeCT8.5

Multi-axis Stiffness Sensing Device for Medical Palpation

Angela Faragasso, Agostino Stilli,
Joao Bimbo, Helge A Wurdemann and Kaspar Althoefer
King's College London, Centre for Robotics Research,
Department of Informatics, WC2 2LS London

- Composed of four linear indenters, four spherical features and a USB camera.
- The multi-directional stiffness is computed tracking the sliding movements of the spherical features in the camera's images.
- The sensing range and resolution can be easily customized.

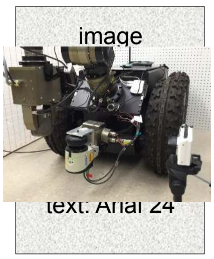


12:35–12:50	WeCT8.6

Data Correlation Approach for Slippage Detection in Robotic Manipulations Using Tactile Sensor Array

Yu Cheng, Chengzhi Su, Yunyi Jia and Ning Xi
Michigan State University

- We present two data correlation based approaches to detect slippage.
- 1-D correlation based approach is able to detect slippage under multiple conditions.
- 2-D correlation based approach is able to detect slippage velocity.
- They are all suitable for commercially available tactile sensor arrays.



Biologically-Inspired Robots 5

Chair *Tetsuya Ogata, Waseda University*
Co-Chair *Seiji Aoyagi, Kansai University*

11:20–11:35	WeCT9.1

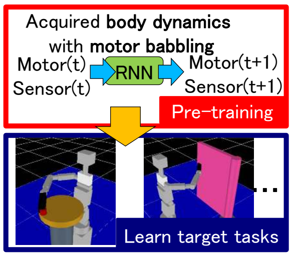
Effective Motion Learning for a Flexible-Joint Robot Using Motor Babbling

Kuniyuki Takahashi[1], Tetsuya Ogata[1], Hiroki Yamada[1], Hadi Tjandra[1] and Shigeki Sugano[1]
[1]Waseda University

<Purpose>
- Efficient dynamic motion learning for a flexible-joint robot

<Method>
- Train RNN with motor babbling before learning target task
- Classify motor babbling into active motion and passive motion

<Result>
- The learning time was reduced

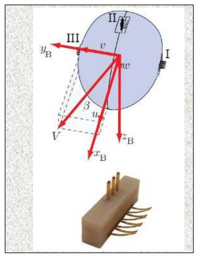


11:35–11:50	WeCT9.2

Bio-inspired Wind Frame State Sensing And Estimation for MAV Applications

Badri Ranganathan[1], Ivan Penskiy[1], William Dean[1] Sarah Bergbreiter[1] and Sean Humbert[1]
[1]University of Maryland College Park, USA

- Kapton based strain hair sensor was developed to detect velocity states
- Sensor was characterized mechanically and in wind tunnel
- 3 sensors were deployed on a fuselage shape in a wind tunnel
- Tests indicate successful estimation of velocity state based on static scheme from 3 hair sensors

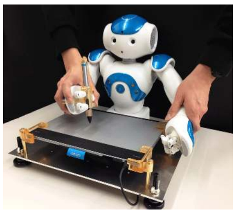


11:50–12:05	WeCT9.3

Neural Network based Model for Visual-motor Integration Learning of Robot's Drawing Behavior: Association of a Drawing Motion from a Drawn Image

Kazuma Sasaki[1], Hadi Tjandra[2], Kuniaki Noda[1], Kuniyuki Takahashi[2,3], and Tetsuya Ogata[1]
[1]Graduate School of Fundamental Science and Engineering Waseda University, Japan
[2]Graduate School of Creative Science and Engineering Waseda University , Japan
[3]Japan and Research Fellow of Japan Society for the Promotion of Science

- Focus: A reusable memory of temporal drawn picture image and motion in drawing experiences
- A neural network based model comprising a deep neural network and a recurrent neural network
- An experiment on learning drawing sequences and association of motion from a drawn picture using the learnt memory



12:05–12:20	WeCT9.4

Development of a peristaltic crawling robot for long-distance sewer pipe inspection with consideration of complex pipe line

Takeru Tomita[1], Tomoya Tanaka[1], and Taro Nakamura[1]
[1] Chuo University, Japan

- Development a peristaltic crawling robot by using a pneumatic artificial muscle
- This research has purpose of inspection inside sewer pipe of 100A(about 108[mm])
- The robot's structure can realize driving 100 [m] or more long-distance
- The robot can stably drive through horizontal, vertical and two types of bent pipes

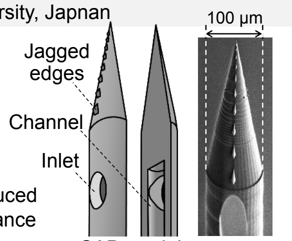
The robot consists of five joints, six unit sections, and the head section

12:20–12:35	WeCT9.5

Ultrafine Three-Dimensional (3D) Laser Lithographic Fabrication of Microneedle And Its Application to Painless Insertion And Blood Sampling Inspired by Mosquito

Masato Suzuki[1], Takahiro Sawa [1], Tomokazu Takahashi [1], and Seiji Aoyagi
[1]Kansai University, Japnan

- Developed microneedle is divided into two half parts, each is shaped like eaves-through.
- The combined halves act as one hollow microneedle, which can draw up human blood.
- The insertion resistance are reduced when the halves alternately advance mimicking mosquito's motion.



CAD model SEM image

Humanoid Robots 2

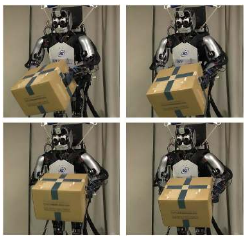
Chair *Ales Ude, Jozef Stefan Institute*
Co-Chair *Eiichi Yoshida, National Inst. of AIST*

11:20–11:35	WeCT10.1

Accelerating Synchronization of Movement Primitives: Discrete-Periodic Motion of Dual-Arm Humanoid Robot

Andrej Gams[1], Aleš Ude[1,2], and Jun Morimoto[2]
[1]Jožef Stefan Institute, Slovenia [2]ATR Computational Neuroscience Labs, Japan

- **Adaptation** of human demonstrated motion to the situation must be **fast**
- **Acceleration** of DMP adaptation based on learned coupling terms using **ILC** and **feedback error learning**, with synchronization of both **positions** and **velocities**
- Extended applicability shown in **modified discrete-periodic** DMP **formulation**; on a humanoid robot



11:35–11:50	WeCT10.2

Multiple Contact Planning for Minimizing Damage of Humanoid Falls

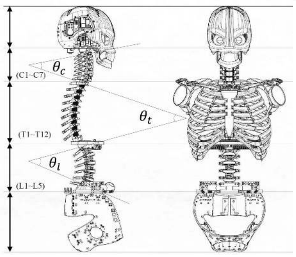
Sehoon Ha and C. Karen Liu
Georgia Institute of Technology

11:50–12:05	WeCT10.3

Development of Musculoskeletal Spine Structure that Fulfills Great Force Requirements in Upper Body Kinematics

Toyotaka Kozuki, Yotaro Motegi, K. Kawasaki, Y. Asano, T. Shirai, S. Ookubo, Y. Kakiuchi, K. Okada, M. Inaba
The University of Tokyo, Japan, JSK Laboratory

- Spine structure imitating human vertebrae.
- Fulfills great force required for abduction of upper limb.
- Simulate human body behavior when subject to exterior force

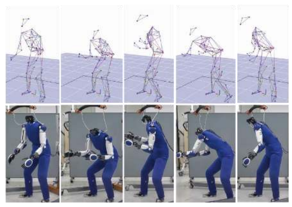


12:05–12:20	WeCT10.4

Motion Retargeting for Humanoid Robots Based on Identification to Preserve and Reproduce Human Motion Features

Ko Ayusawa, Mitsuharu Morisawa, and Eiichi Yoshida
Intelligent Systems Research Institute, AIST, Japan

- Motion retargeting method from human to humanoid robot is presented.
- The method can evaluate the ability of the preservation of the original characteristics of human motion.
- It utilizes the geometric parameters identification technique.
- The human captured motions are retargeted to humanoid robot HRP-4.

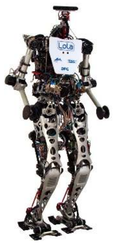


12:20–12:35	WeCT10.5

Real-Time Pattern Generation Among Obstacles for Biped Robots

Arne-Christoph Hildebrandt, Daniel Wahrmann, Robert Wittmann, Daniel Rixen and Thomas Buschmann[1]
[1]Institute of Applied Mechanics, TU Muenchen, Germany

- Biped navigation among **obstacles**
- Reacts in **less than a step time** to
  - **user commands**
  - **environment changes**
- Online **whole-body collision avoidance**
- Only **on-board** sensing
- **Real-time application** and experimental results



12:35–12:50	WeCT10.6

Contact involving whole-body behavior generation based on contact transition strategies switching

Shintaro Noda, Shunichi Nozawa, Yohei Kakiuchi, Kei Okada and Masayuki Inaba
The University of Tokyo

- Propose a whole-body behavior generation algorithm involving contact transition strategies switching function.
- Especially focus on the walk-type and slide-type switching.
- Show two results of generating standing up behavior and sitting on seat behavior.

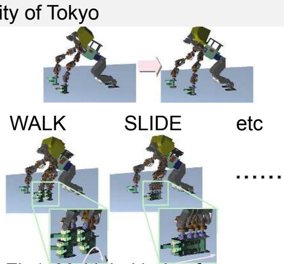


Fig1. Multiple kinds of strategies for contact transition

Multi-Robot Coordination

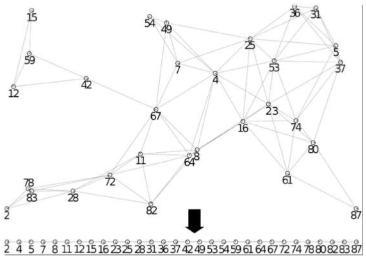
Chair *Cristian Secchi, Univ. of Modena & Reggio Emilia*
Co-Chair *Christian Gerwoud Rozemuller, Delft Technical University*

11:20–11:35	WeCT11.1

A Parallel Distributed Strategy for Arraying a Scattered Robot Swarm

Dominik Krupke[1], Michael Hemmer[1], James McLurkin[2], Yu Zhou[2] and Sándor P. Fekete[1]
[1]TU Braunschweig, Germany [2]Rice University, Houston, TX, USA

Sorting of swarm robots:
- O(n) time
- O(n) travel distance per robot
- $O(n^2)$ messages



11:35–11:50	WeCT11.2

Conducting multi-robot systems: gestures for the passive teleoperation of multiple slaves

Cristian Secchi, Lorenzo Sabattini, Cesare Fantuzzi
University of Modena and Reggio Emilia, Italy

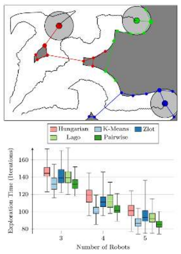
- Teleoperating multiple agents both as an amorphous group (**group mode)** and as a set of robots tracking desired trajectories (**tracking mode)**
- Tracking mode implements the conductor-orchestra paradigm
- A passive behavior is guaranteed despite of the switch of the teleoperating mode
- Human/Hardware in the loop experiments

11:50–12:05	WeCT11.3

Workload Partitioning for Multi-Robot Exploration through Pairwise Optimization

Lukas Klodt[1] and Volker Willert[1]
[1]Technische Universität Darmstadt, Germany

- Cooperative procedure for balanced **target allocation** in highly dynamic multi-robot applications like exploration
- No all to all communication required, suitable for **distributed** settings
- Theoretical analysis and statistical evaluations provided
- Comparisons show: the presented algorithm is competitive with the best performing centralized approach



12:05–12:20	WeCT11.4

On the Need for a Coordination Mechanism for Task Completion in a Cooperative Team

Chris Rozemuller[1], Koen V. Hindriks[1] and Mark A. Neerincx[1]
[1]Delft University of Technology, The Netherlands

- For a **foraging task**, a **cooperative MAS** may require a **coordination mechanism** depending on: task configuration, decision function, number of agents.
- Our contribution is a **formal analysis** of **required conditions** for **task completion**
- Introducing a **formal task model** of a foraging task
- Main results: Communication or implicit coordination are **not always required**.
- Applications in **rescue robotics**

12:20–12:35	WeCT11.5

Multi-Robot Task Acquisition through Sparse Coordination

Steven D. Klee[1], Guglielmo Gemignani[2], Daniele Nardi[2] and Manuela Veloso[3]
[1]Carnegie Mellon University, USA
[2]Sapienza University of Rome, Italy

- Enable users to teach multiple robots how to cooperate through natural language interactions.
- Extend the Instruction Graph formalism to support queries on the state of other robots.
- Demonstrate our contribution on a Baxter and a CoBot.

12:35–12:50	WeCT11.6

Decentralised Submodular Multi-Robot Task Allocation

Pau Segui-Gasco[1], Hyo-Sang Shin[1], Antinios Tsourdos [1] and V. Jesús Segui[2]
[1]Cranfield, UK [2]Universitat Politècnica de València, Spain

- Decentralised Task Allocation with guarantees.
- We have to allocate, tasks to agents. Each agent has a submodular utility function, we maximize the sum. This condition captures diminishing marginal returns.
- For monotone submodular utility functions we have 1-1/e ~ 63% approximation, while for nonmonotone submodular functions we get a1/e ~ 37% approximation.
- We solve a continuous relaxation and then round the result.
- To enable the decentralisation we use use Max-Consensus.

Learning Control

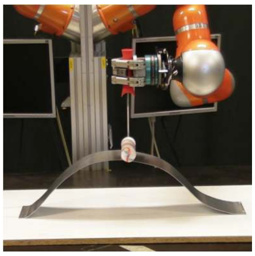
Chair *Gerhard Neumann, TU Darmstadt*
Co-Chair *Bojan Nemec, Jozef Stefan Institute*

11:20–11:35	WeCT12.1

Force Adaptation with Recursive Regression Iterative Learning Controller

Bojan Nemec, Tadej Petrič and Aleš Ude
Jožef Stean Institute, Slovenia

- Control signal encoded with Radial Basis Functions (RBF) and updated in the current iteration cycle
- Improved robustness and adaptation speed of the ILC
- Reduced computational burden
- Demonstrated on force-based surface following tasks

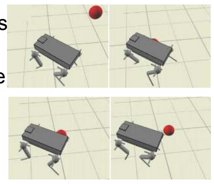


11:35–11:50	WeCT12.2

Direct State-to-Action Mapping for High DOF Robots Using ELM

Jemin Hwangbo, Christian Gehring, Dario Bellicoso, Peter Fankhauser, Roland Siegwart and Marco Hutter
Autonomous Systems Lab, ETH Zurich, Switzerland

- We generate multiple optimal trajectories by varying commands and initial conditions
- We emulate realistic disturbances to explore possible regions in the state space
- We combine the information from the optimal trajectories to build an ELM network which becomes our controller
- We demonstrate the method with a full 3D quadruped robot model



11:50–12:05	WeCT12.3

pyRobots: A toolset for robot executive control

Séverin Lemaignan[1], Anahita Hosseini[1], and Pierre Dillenbourg[1]
[1]École Polytechnique Fédérale de Lausanne, Switzerland

- **pyRobots** is a set of Python-based tools focused on the needs of high-level executive control of robots.
- It provides lightweight notations for **asynchronous tasks**, **resource management**, **frames management**.
- It integrates seamlessly with **existing middlewares** like ROS.
- It provides dedicated logging and debugging tools.

12:05–12:20	WeCT12.4

Constraint-Based Task Programming with CAD Semantics…

Nikhil Somani[1], Andre Gaschler[1], Alexander Perzylo[1], Markus Rickert[1] and Alois Knoll[2]
[1]fortiss, Germany [2]Technische Universität München, Germany

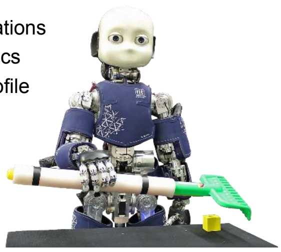
- Constraint-based task programming
  - Underspecified robot tasks
  - Robot tasks modeled as operational or configuration space constraints
- Geometric constraints as task parameters
  - Constraints between BREP geometries
- Execution and control of constraint tasks
  - Solving prioritized constraints
  - Jogging in the nullspace of solved tasks

12:20–12:35	WeCT12.5

Model-Free Probabilistic Movement Primitives for Physical Interaction

Alexandros Paraschos[1], Elmar Rueckert[1], Jan Peters[1,2] and Gerhard Neumann[3]
[1]TU-Darmstadt, Germany [2]MPI Tuebingen, Germany

- Learn new skills from demonstrations
- Operate under unknown dynamics
- Reproduce the learned force profile
- Variable stiffness controller derived in closed form

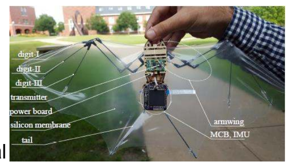


12:35–12:50	WeCT12.6

Lagrangian Modeling and Flight Control Of Articulated-Winged Bat Robot

A. Ramezani, X. Shi, S.-J Chung, S. Hutchinson,
[1]University of Illinois, Champaign-Urbana, IL, USA

- Systematic flight control design based on the mathematics of parametrized manifolds and calculus of variation.
- B2 is a biomimetic MAV that possesses similar morphological properties to a bat in order to duplicate bats' powered flight.



AI Reasoning Methods

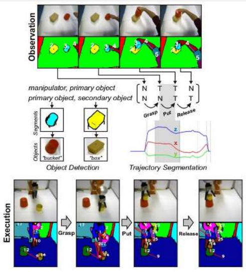
Chair *Florentin Wörgötter, University of Göttingen*
Co-Chair *Joachim Hertzberg, University of Osnabrueck*

11:20–11:35	WeCT13.1

Semantic Parsing of Human Activities using On-line Learned Models for Robot Imitation

E. E. Aksoy, M. Aein, M. Tamosiunaite, and F. Wörgötter
University of Göttingen, Third Institute of Physics, Germany

- A novel a novel method for semantic decomposition and recognition of hum manipulation activities
- Detection of sequential and concurren (overlapping) manipulation streams
- Extraction of basic action primitives
- Evaluation on a new egocentric activit dataset which contains 120 different samples of 8 single manipulations

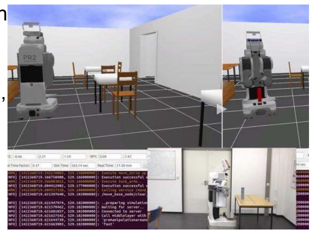


11:35–11:50	WeCT13.2

Integrating physics-based Prediction with Semantic Plan Execution Monitoring

S. Rockel[1], Š. Konečný[2], S. Stock[3,4], J. Hertzberg[3,4], F. Pecora[2] and J. Zhang[1]
[1]Univ. of Hamburg, Germany [2]Örebro Univ., Sweden [3]Osnabrück Univ., Germany [4]DFKI Robotics Innovation Center, Germany

- Online prediction of robot action results for plan adaptation
- Integration of HTN planning, Semantic Execution Monitoring, Functional Imagination
- Simulation validation
- Proof of concept on a PR2 robot with Gazebo

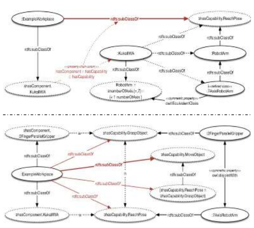


11:50–12:05	WeCT13.3

Expressing and Reasoning on Features of Robot-Centric Workplaces using Ontological Semantics

Stefan Zander[1]and Ramez Awad[2]
[1]FZI, Germany [2]Fraunhofer IPA, Germany

- Aggregation, propagation, and interlinkage of features pertaining to robots and robot-centric workplaces
- Computation of complex capabilities of compound components, e.g. “GraspObject” ⊓ “ReachPose” → “Move Object”
- Deduction of potential hazards for a given workplace configuration

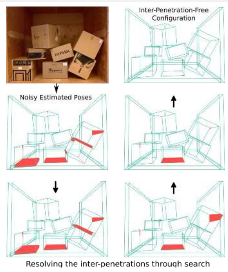


12:05–12:20	WeCT13.4

A Principle of Minimum Translation Search Approach for Object Pose Refinement

Rasoul Mojtahedzadeh[1], Achim J. Lilienthal[1]
[1]Centre for Applied Autonomous Sensor Systems (AASS)
Örebro University, Sweden

- Noisy pose estimates may correspond to overlapping models of rigid objects
- We propose a search method to resolve inter-penetrations between objects and thus find a geometrically consistent model of the environment
- Results in simulation and real world experiments show that the proposed method also reduces the average total error in the initially estimated poses

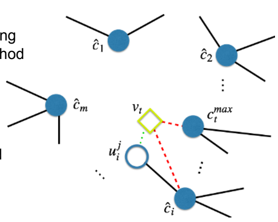


12:20–12:35	WeCT13.5

Semi-supervised Online Learning for Efficient Classification of Objects in 3D Data Streams

Ye Tao[1], Rudolph Triebel[1], and Daniel Cremers[1]
[1]Dep. of Computer Science, TU Munich, Germany

- Novel online classification approach for large streams of 3D data (point clouds)
- Combination of a novel efficient online clustering approach and a semi-supervised learning method
- Our method reduces the required amount of interaction with a human supervisor and is adaptive to new environments
- Experiments on large benchmark data sets show a faster computation time and a reduced amount of label queries



Gripper and Hand Design

Chair *Yasuhisa Hirata, Tohoku University*
Co-Chair *Lionel Birglen, Ecole Polytechnique de Montreal*

11:20–11:35	WeCT14.1

Enhancing Versatility and Safety of Industrial Grippers with Adaptive Robotic Fingers

Lionel Birglen,
Ecole Polytechnique de Montreal, Canada

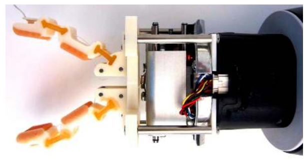
- New adaptive mechanical fingers transform industrial grippers into underactuated hands.
- Automatic switch between precision and power grasps.
- Kinetostatic analysis and comparison to existing designs.
- Inherently compliant and collision safe if properly designed.

11:35–11:50	WeCT14.2

The Baxter Easyhand: A Robot Hand That Costs $150 US in Parts

Giulia Franchi[1], Andreas ten Pas[2],
Robert Platt[2] and Stefano Panzieri[1]
[1]University of Roma Tre, Italy [2]Northeastern University, USA

A new 3D printed hand derived from the Yale T42 hand, specifically designed to be mounted on the Baxter robot from Rethink robotics. Smaller than most other 3D printed hands and powered by the native Baxter gripper actuator. Cheaper, lighter, and easier to interface with than other robot hands available for Baxter.



11:50–12:05	WeCT14.3

A Novel Nonlinear Compliant Link on Simple Grippers

Zhiwei Zhang[1], Alberto Rodriguez[2],
and Matthew Mason[1]
[1]Carnegie Mellon University, USA [2]MIT, USA

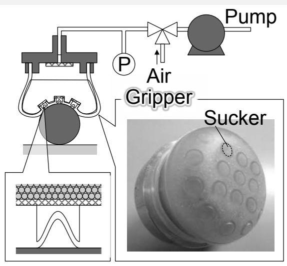
- **Bi-directionality:** by antagonistic arrangement of a compression and an extension spring;
- **Increasing stiffness:** by asymmetric geometry of two bars;
- **Experiment** showed it had some nonlinearity; was able to act as a contact sensor.

12:05–12:20	WeCT14.4

Vacuum gripper imitated Octopus Sucker -Effect of liquid membrane for absorption-

Tomokazu Takahashi[1], Masato Suzuki[1] and Seiji Aoyagi[1]
[1]Kansai University, Japan

- We proposed a flexible vacuum gripper bio-inspired octopus suction cup for handling and assembling the industrial parts.
- The fabricated gripper can attached the various object: flat, curvature, uneven and groove surface, even with liquid.
- The maximum attachment force of gripper was 46 N.



12:20–12:35	WeCT14.5

Underactuated Robot Hand for Dual-Arm Manipulation

Kengo Yamaguchi[1], Yasuhisa Hirata[1],
and Kazuhiro Kosuge[1]
[1]Tohoku University, Japan

- We propose a robot hand referred to as uGRIPP (Underactuated Gripper for Power and Precision Grasp)
- uGRIPP has novel underactuated fingers for a power grasp, a precision grasp and a dual-arm palm grasp

Distributed Robot Systems

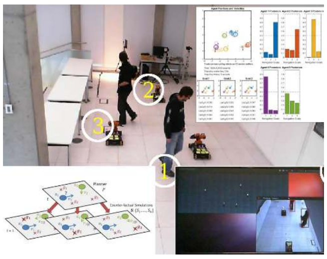
Chair *Seth Hutchinson, University of Illinois*
Co-Chair *Alcherio Martinoli, EPFL*

11:20–11:35	WeCT15.1

Counterfactual Reasoning about Intent for Interactive Navigation in Dynamic Environments

Alejandro Bordallo Micó[1], Fabio Previtali[2], Nantas Nardelli[1], Subramanian Ramamoorthy[1]
[1]University of Edinburgh [2]Sapienza University

- Navigation goal inference
  $P(g_i|v_j^t) = P(v_j^t|g_i)P(g_i)$
- *Interactive* motion model through HRVOs
- *Online* learning of model parameters for 20 agents
- *Uncertainty* from tracking as well as goal prediction



11:35–11:50	WeCT15.2

ABC-Center: Approximate-Center Election in Modular Robots

André Naz[1], Benoît Piranda[1], Seth Copen Goldstein[2] and Julien Bourgeois[1]
[1]FEMTO-ST Institute, France [2]Carnegie Mellon University, USA

- Iterative algorithm for electing an approximate-center in modular robots.
- Complexity: O(1) space per module and O(kd) time with k the number of iterations and d the diameter of the system.
- Evaluated on Blinky Blocks, both on hardware and through simulations.
- Suitable for large modular robot ensembles with low memory resources.

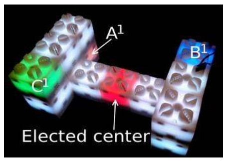


Fig: ABC-Center running on hardware Blinky Blocks.

11:50–12:05	WeCT15.3

Distributed PSO - Particle Allocation and Neighborhood Topologies for the Learning of Cooperative Robotic Behaviors

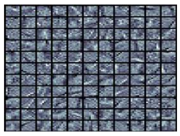
Iñaki Navarro, Ezequiel Di Mario, Alcherio Martinoli
École Polytechnique Fédérale de Lausanne, Switzerland

- Automatic synthesis of robotic controllers for coordinated movement.
- 5 distributed noise-resistant variations of Particle Swarm Optimization (PSO):
  - Particle allocation.
  - Neighborhood.
  - 4 variations successful.
- Fitness evaluation: individual and local.
- Learning in simulation, test in real robots.

12:05–12:20	WeCT15.4

D4L: Decentralized Dynamic Discriminative Dictionary Learning

Alec Koppel[1], Garrett Warnell[2], Ethan Stump[2] and Alejandro Ribeiro[1]
[1]University of Pennsylvania, Philadelphia, PA, USA
[2]U.S. Army Research Laboratory, Adelphi, MD, USA

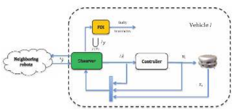


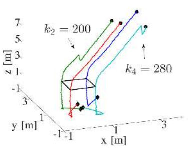
12:20–12:35	WeCT15.5

Discrete-time distributed control and fault diagnosis for a class of linear systems

Alessandro Marino[1], Francesco Pierri[2],
[1]University of Salerno, Italy [2]University of Basilicata, Italy

- Discrete-time decentralized fault diagnosis scheme for cooperative mobile robots with general linear dynamics.
- A local observer is used by each agent to estimate the overall state of the team
- The same local observer is adopted to monitor the state of health of other agents.
- Numerical simulations in order to validate the proposed approach.



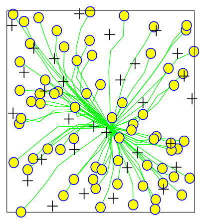


12:35–12:50	WeCT15.6

Distributed Robust Convergence Algorithm for Multi-Robot Systems in the Presence of Faulty Robots

Hyongju Park[1], Seth Hutchinson[1],
[1]Beckman Institute, Univ. of Illinois at Urbana-Champaign, USA

- We propose a distributed control policy to achieve rendezvous by a set of robots even when some robots in the system do not follow the prescribed policy
- Our main result is a provably correct algorithm that achieves convergence in the face of faulty robots under a few assumptions on the network topology
- We show via simulation results that our algorithm performs well in the face of faulty robots while other algorithms do not



Human-Robot Interaction 4

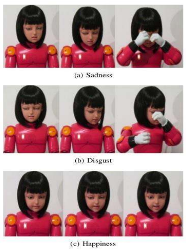
Chair *Aaron Steinfeld, Carnegie Mellon University*
Co-Chair *Amir Aly, ENSTA-ParisTech*

14:00–14:15	WeDT1.1

Multimodal Adapted Robot Behavior Synthesis within a Narrative HRI

Amir Aly[1], Adriana Tapus[2]
[1,2]ENSTA ParisTech, France

- Generating adapted multimodal robot behavior using speech, head and arm gestures, and facial expressions.
- Facial expressions are generated through the highly expressive ALICE robot.
- Speech is synthesized using Mary-TTS engine, through which a vocal pattern for each target emotion is designed.
- Gestures are generated based on the prosodic cues of speech.



14:15–14:30	WeDT1.2

Leader Tracking for a Walking Logistics Robot

Michal Perdoch[1,2], David M.Bradley[1], Jonathan K.Chang[1], Herman Herman[1], Peter Rander[1], and Anthony Stentz[1]
[1]NREC, CMU, USA [2]CVL, ETH Zurich, Switzerland

- A part of a real-time multi-modal perception system for walking logistics pack mule **LS3**
- Passive **tracking** and **reconstruction** of leader's trajectory for autonomous navigation through challenging off-road, environments (forests, deserts, meadows, night)
- Extensive field testing and quantitative evaluation on more than **60 hours** of manually labeled datasets
- **99.4%** correct tracking performance with less than **0.05%** FPs

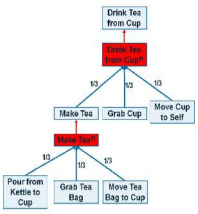
Acknowledgments: **DARPA**, NREC, Boston Dynamics, JPL, MCWL

14:30–14:45	WeDT1.3

Context-Based Intent Understanding Using an Activation Spreading Architecture

Mohammad Taghi Saffar[1], Mircea Nicolescu[1], Monica Nicolescu[1] and Banafsheh Rekabdar[1]
[1]University of Nevada Reno, USA

- A novel real-time vision-based **intent recognition** system based on Activation Spreading Networks (ASN)
- Precision and formality of symbolic plan recognizers by utilizing Hierarchical Task Networks (HTN)
- Flexibility and performance of distributed neural-based approaches with ASNs
- Early and real-time detection of complex hierarchical intentions



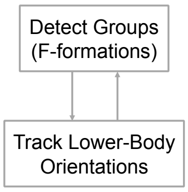
14:45–15:00	WeDT1.4

Parallel Detection of Conversational Groups of Free-Standing People and Tracking of their Lower-Body Orientation

Marynel Vázquez[1,2], Aaron Steinfeld[1], Scott E. Hudson[1,2]
[1]Carnegie Mellon University [2]Disney Research Pittsburgh

We propose an alternating optimization procedure to help robots reason about group interactions in public, open spaces.

This procedure tracks the lower body orientation of free-standing people in a scene, and estimates their conversational groups by detecting F-formations.



15:00–15:15	WeDT1.5

A Novel MPC Approach to Optimize Force Feedback for Human-Robot Shared Control

Ali Safavi, Loi Huynh, Hadi Rahmat-Khah, Ehsan Zahedi and Mehrdad H. Zadeh[1]
Kettering University, USA[1]

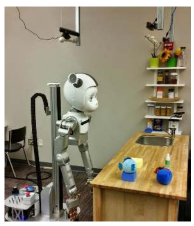
- A novel combination of model predictive control (MPC) and neural networks for human-robot shared control
- The robot controls the movement of the users by predicting the motion from an HMM model of a task and optimizes the force using genetic algorithm (GA)
- The results show that this approach is promising in controlling movements and improving the performance of users

15:15–15:30	WeDT1.6

Real-Time Changes to Social Dynamics in Human-Robot Turn-Taking

Justin S. Smith, Crystal Chao, Andrea L. Thomaz
Georgia Institute of Technology, USA

- Changing robot turn-taking behavior can cause changes in social dynamics
- Robot turn-taking behavior regulated by CADENCE
- Evaluated switching turn-taking parameters on turn boundaries vs. on timer
- User study with 15 participants
- Social dynamics changed most when parameters switched at turn boundaries



Calibration and Identification 1

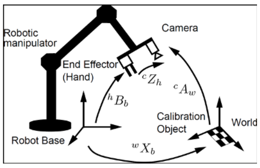
Chair *Jan Oberländer, FZI Forschungszentrum Informatik, Karlsruhe*
Co-Chair *Humphrey Hu, Carnegie Mellon University*

14:00–14:15	WeDT2.1

Parameterizations for Reducing Camera Reprojection Error for RWHE Calibration

Amy Tabb[1], Khalil Ahmad Yousef[2]
[1]USDA-ARS-AFRS, USA [2]The Hashemite University, Jordan

- We discuss the **R**obot-**W**orld, **H**and-**E**ye (**RWHE**) calibration problem modeled as the linear relationship AX = ZB.
- We parameterize the rotation components using Euler angles for the unknowns (X and Z matrices).



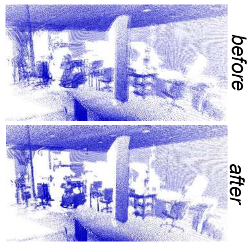
- Propose two methods to find a solution using Levenberg-Marquadt iterative approach.
- Our methods produce high calibration accuracy and results.

14:15–14:30	WeDT2.2

Fast Calibration of Rotating and Swivelling 3-D Laser Scanners Exploiting Measurement Redundancies

Jan Oberländer[1], Lars Pfotzer[1], Arne Roennau[1] and Rüdiger Dillmann[2]
[1]FZI Forschungszentrum Informatik; [2]KIT – Karlsruhe, Germany

- Automatic sensor self-calibration from a single 3-D scan of a targetless environment
- Support for the two most common scanner geometries
- Fast quality measure calculation by avoiding negligible terms and decimating the point cloud
- Good calibration results in seconds

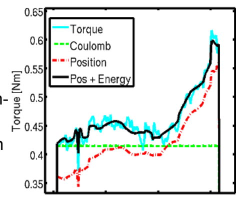


14:30–14:45	WeDT2.3

Modeling and Identification of Position and Temperature Dependent Friction Phenomena without Temperature Sensing

Fredrik Bagge Carlson, Anders Robertsson and Rolf Johansson
Dept. Automatic Control, Lund University, Sweden

- Modeling of position and temperature dependent joint friction
- Position dependence modeled with linear-in-parameters RBF-network
- Temperature effects created by input friction power modeled and identified, no need for temperature sensing

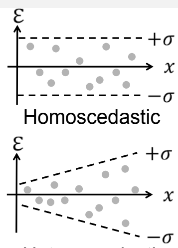


14:45–15:00	WeDT2.4

Parametric Covariance Prediction for Heteroscedastic Noise

Humphrey Hu, George Kantor
Carnegie Mellon University, United States of America

- Real noise **heteroscedasticity** (state-dependency) causes issues for estimation
- Can **predict** noise covariance matrices to compensate
- Modified Cholesky decomposition (LDL) allows for **efficient** covariance regression
- Show **improved filter consistency** on simulated and physical range-bearing localization datasets



15:00–15:15	WeDT2.5

Unsupervised model-free camera calibration algorithm for robotic applications

Guglielmo Montone[1], J. Kevin O'Regan[1], Alexander V. Terekhov[1]
[1]Université Paris Descartes, France

In the paper an algorithm for the calibration of a camera is presented. The algorithm do not assume any model of the camera and do not need any human supervision.

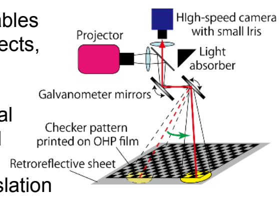
Tested in simulated environment, the proposed algorithm, outperforms the main unsupervised and model-free calibration algorithm in the literature. In figure, from top to bottom, the original image showed to camera, the image in the plane of photoreceptors for a non-calibrated fish-eye camera, the result of calibration.

15:15–15:30	WeDT2.6

Mirror-based High-speed Gaze Controller Calibration with Optics and Illumination Control

Tomohiro Sueishi[1], Hiromasa Oku[2] and Masatoshi Ishikawa[1]
[1]The University of Tokyo, Japan [2]Gunma University, Japan

- A high-speed gaze controller enables 3D measurement of dynamic objects, but precise calibration is needed
- Retroreflective pattern and coaxial illumination deepen depth of field
- Bundle adjustment for large translation of center of projection including mirror thickness



Visual Navigation 1

Chair *Michael J Milford, Queensland University of Technology*
Co-Chair *Helen Oleynikova, ETH Zürich*

14:00–14:15	WeDT3.1

Building Beliefs: Generation of Observation Likelihoods for Changing Environments

Stephanie Lowry[1] and Michael Milford[1]
[1]ARC Centre of Excellence for Robotic Vision, Queensland University of Technology, Australia


In unchanging conditions, different places can look similar
In changing conditions, the same place can appear very different

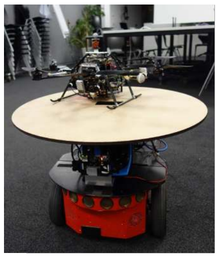
- A localization likelihood model must avoid aliasing in unchanging conditions but allow matching in changing conditions
- A 'dual-model' approach achieves both goals
- We present an online method for generating observation models

14:15–14:30	WeDT3.2

Real-Time Visual-Inertial Localization for Aerial and Ground Robots

Helen Oleynikova, Michael Burri, Simon Lynen and Roland Siegwart
Autonomous Systems Lab, ETH Zurich

- Visual-inertial based localization, on-board and in real time.
- Verified on datasets with external ground truth, taken from MAV flight in realistic conditions.
- Experiment showing autonomous helicopter-MAV landing to showcase localization accuracy and on-board performance.

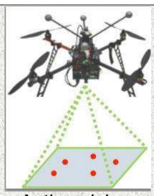


14:30–14:45	WeDT3.3

Rotation Free Active Vision

Omar Tahri[1], Paolo Robuffo Giordano[2] and Youcef Mezouar[3]
[1,3] Institut Pascal, France [2] CNRS at Irisa and Inria Rennes, France

- New active vision scheme is proposed
- The knowledge of rotational velocities is not required
- Robustness to strong noise on rotational velocities

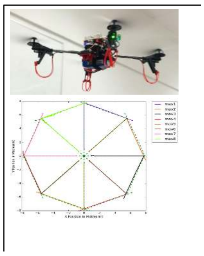

Active vision using a quadrotor

14:45–15:00	WeDT3.4

Scalable Distributed Collaborative Tracking and Mapping with Micro Aerial Vehicles

Richard Williams[1], Boris Konev[1], and Frans Coenen[1]
[1]University of Liverpool, United Kingdom

- This paper addresses the problem of autonomous cooperative navigation with teams of light-weight **Micro Aerial Vehicles** is GPS-denied environments.
- We present a partially distributed framework for **collaborative**, **visual**, **multi-robot localisation** and **mapping**.
- We show how this framework can be used to enable autonomous operations for large teams of **Micro Aerial Vehicles**.

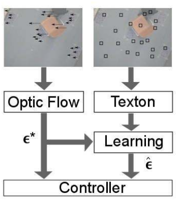


15:00–15:15	WeDT3.5

Optical flow for self-supervised learning of obstacle appearance

H.W. Ho[1], C. De Wagter[1], B.D.W Remes[1] and G.C.H.E. de Croon[1]
[1]Delft University of Technology, The Netherlands

- A novel setup of self-supervised learning, in which optical flow provides the supervised outputs is introduced.
- Roughness estimated from optical flow can be used to detect obstacles and find a safe landing site for a drone. The drone learns the obstacle appearance represented by texton distributions based on roughness. After learning, the drone can detect obstacles without moving.

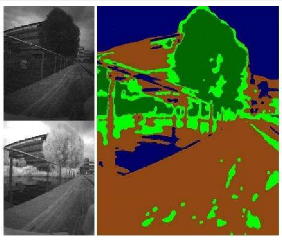


15:15–15:30	WeDT3.6

Autonomous Vegetation Identification for Outdoor Aerial Navigation

Caterina Massidda[1], Heinrich H. Bülthoff[1], and Paolo Stegagno[1]
[1]Max Planck Institute for Biological Cybernetics, Germany

- A low-cost low-weight **camera-array** setup for simultaneous **spectral analysis** and **stereo-vision**
- Online **classification of the environment** and extraction of vegetation and water bodies
- **3D reconstruction** of the detected materials


example of classification

Localization 2

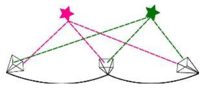
Chair *Anton Josef Ledergerber, ETH Zurich*
Co-Chair *Philippe Bonnifait, Univ. of Technology of Compiegne*

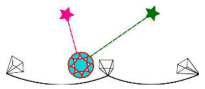
14:00–14:15	WeDT4.1

Metric Localization using Google Street View

Pratik Agarwal, Wolfram Burgard, Luciano Spinello
University of Freiburg, Germany

- Accurate metric localization in geotagged panoramas (street view) using odometry and monocular images
- Modeled as a two step nonlinear least squares optimization problem
- Submeter accuracy in robot experiments
- Experiments with Google Tango in a real world setting


First optimization

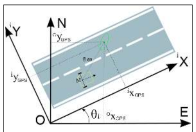

Second optimization

14:15–14:30	WeDT4.2

Road Invariant Extended Kalman Filter for an Enhanced Estimation of GPS Errors Using Lane Markings

Zui Tao, Philippe Bonnifait,
Sorbonne Universités, Université de technologie de Compiègne, CNRS Heudisyc UMR 7253, France

- Object: Improve the localization performance by fusing GPS, lane marking measurements and digital map.
- An enhanced shaping model of GPS errors is proposed. An algebraic observability study is conducted to prove the observability of the state modeling.
- An extended Kalman filter is designed to be implemented in the road-oriented frame to conserve the observability.

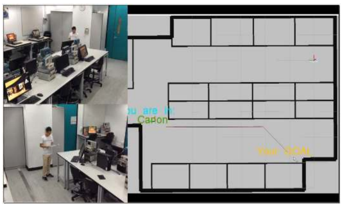

^iX-O-^iY is a road-oriented frame of road i. E-O-N is the local ENU frame.

14:30–14:45	WeDT4.3

Visible Light Communication-based Indoor Localization using Gaussian Process

Kejie Qiu[1], Fangyi Zhang[2], Ming Liu[3]
[1]HKUST, Hong Kong [2]QUT, Australia [3]CityU, Hong Kong

- A set of low-cost modulated LEDs are used as beacons to realize precise indoor localization.
- We model the luminous distribution of an indoor environment using Gaussian Process.
- A real demo is given.

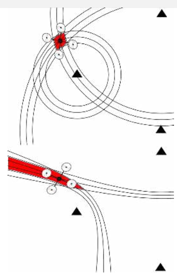


14:45–15:00	WeDT4.4

A Robot Self-Localization System using One-Way Ultra-Wideband Communication

Anton Ledergerber, Michael Hamer, Raffaello D'Andrea,
Institute for Dynamic Systems and Control, ETH Zurich

- Scalable, GPS-like UWB system for localization
- Up to 1 kHz update rate with TOA measurements
- Real-time applicable due to low computational costs
- Affordable due to low hardware costs
- Qualitative comparison of TOA/TDOA measurements updates

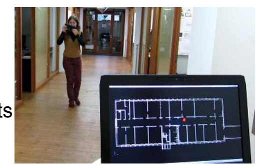


15:00–15:15	WeDT4.5

Accurate Indoor Localization for RGB-D Smartphones and Tablets given 2D Floor Plans

W. Winterhalter, F. Fleckenstein, B. Steder, L. Spinello, W. Burgard
University of Freiburg, Germany

- Efficient approach to localize an RGB-D smartphone or tablet
- The used map is a floor plan, e.g., an architectural drawing
- Particle filter to estimate 6DoF pose
- Sensor model handles disagreements between floor plans and sensor data
- Experiments for global localization and tracking

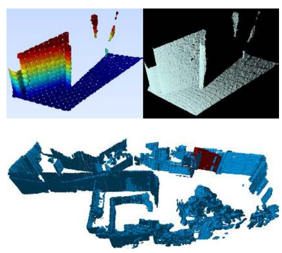


15:15–15:30	WeDT4.6

IRON: A Fast Interest Point Descriptor for Robust NDT-Map Matching and its Application to Robot Localization

T. Schmiedel, E. Einhorn, H.-M. Gross
Ilmenau University of Technology, Germany

- Introduction of a novel keypoint detector and descriptor for the high-speed alignment of 3D depth maps
- Results of an evaluation using over 9,000 depth images from publicly available datasets
- Assessment of registration speed
- Application of the presented approach to robot pose tracking and robot one-shot localization



Parallel Robots

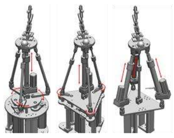
Chair *Andreas Pott, Fraunhofer-Gesellschaft*
Co-Chair *Shaoping Bai, Aalborg University*

14:00–14:15 WeDT5.1

Design and Analysis of Parallel Robots for a Flexible Fixturing System with Performance Atlases

Bing Li[1], Peng Xu[1,2], Hongjian Yu[1]
Yunjiang Lou[1] and Xiaojun Yang[1]
[1]Harbin Institute of Technology Shenzhen Graduate School, China
[2]The Hong Kong Polytechnic University, Hong Kong

- Propose a novel flexible fixturing system for sheet metal assembly with parallel robots
- Structure synthesis is presented by taking account several performance indices
- Performance indices atlases are expressed in the design space
- The prototype of the fixturing system is developed and the experimental results agree well with the simulation results

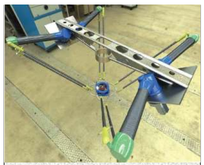


14:15–14:30 WeDT5.2

Parametric Optimal Design of a Parallel Schoenflies-Motion Robot under Pick-And-Place Trajectory Constraints

Guanglei Wu[1], Shaoping Bai[1], Preben Hjørnet[2]
[1]Aalborg University, Denmark [2]Blue WorkForce, Denmark

- Ragnar robot with rectangular workspace is introduced for PnP application
- Parametric models of transmission quality, elasto-statics and dynamics are developed for optimal design
- A multi-objective optimization problem is formulated to optimize design parameters for robot design
- A Ragnar robot is prototyped from the Pareto-front for validation



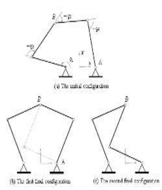
The rendered CAD model of Ragnar Robot

14:30–14:45 WeDT5.3

Projection-Based Modeling and Control of Constraint Mechanical Systems Using Non-Minimum Set of Coordinates

Farhad Aghili
Concordia University, CSA, Canada

- Projection-based dynamics model in terms of non-minimum sets of coordinates.
- Constraint mass matrix remains *positive definite* and its *condition number* is minimized.
- Skew-symmetric property of Coriolis matrix.
- Simulation of systems with changing topology, degrees-of-freedom, and having redundant or singular constraints.
- Feedback control of dependent coordinate, which uniquely defines the configurations.

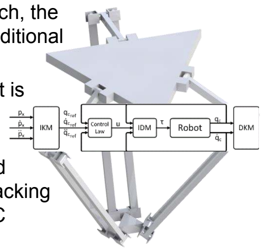


14:45–15:00 WeDT5.4

Stable Model-Based Control Scheme for Parallel Robots Using Additional Sensors

Pablo Bengoa, Asier Zubizarreta, Itziar Cabanes,
Aitziber Mancisidor and Eva Portillo
University of the Basque Country (UPV/EHU), Spain

- A new model based control approach, the stable Extended CTC, that uses additional sensors.
- The asymptotic stability of the robot is demonstrated.
- The use of redundant information increases controller robustness and performance, allowing to reduce tracking error with respect to traditional CTC approaches.

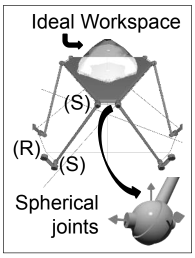


15:00–15:15 WeDT5.5

Workspace analysis of a 6-RSS parallel robot considering non-ideal spherical joints

Rafael Cisneros-Limón[1], José Luis Vázquez-González[2]
and José Rafael Mendoza-Vázquez[3]
[1]AIST, Japan [2]UDLA-P, Mexico [3]ITP, Mexico

- This paper gives an analytical description for the ideal and the real workspace of a 6-RSS parallel robot
- The ideal workspace is defined only by geometrical constraints and described as a set of inequalities representing a 3D volume that encloses valid attitudes
- The real workspace (a subset of the ideal one) is determined by the mechanical constraints at the spherical joints

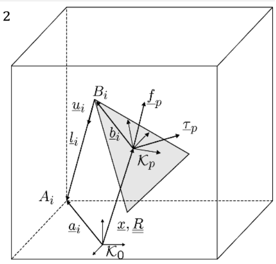


15:15–15:30 WeDT5.6

On the Forward Kinematics of Cable-Driven Parallel Robots

Andreas Pott[1], Valentin Schmidt[1],
[1]Fraunhofer IPA, Germany

- $g(\boldsymbol{r},\boldsymbol{R},\boldsymbol{l}) = \sum\left[\|\boldsymbol{a}_i - \boldsymbol{r} - \boldsymbol{R}\boldsymbol{b}_i\|_2^2 - l_i^2\right]^2$
- Convex for 2T and 3T Robots: one solution within machine frame
- 1R2T case: one solution within machine frame and ideal l_i
- Least Squares Approach: approximate Forward Kinematics
- $\boldsymbol{r} = \frac{\|\boldsymbol{\alpha}_i\|_2^2 - \|\boldsymbol{\alpha}_{i+1}\|_2^2 - l_i^2 + l_{i+1}^2}{2(\boldsymbol{\alpha}_i^T - \boldsymbol{\alpha}_{i+1}^T)}$



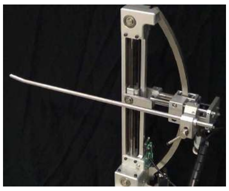
Medical Robots and Systems 2

Chair *Peng LI, The Chinese University of Hong Kong*
Co-Chair *Heinz Woern, KIT Karlsruhe Institute of Technology*

14:00–14:15 WeDT6.1

A New Robotic Uterine Positioner for Laparoscopic Hysterectomy with Passive Safety Mechanisms: Design and Experiments

H.M. Yip, Z. Wang, D. Navarro-Alarcon, P. Li, Y.-H. Liu and T.H. Cheung
The Chinese University of Hong Kong, HKSAR

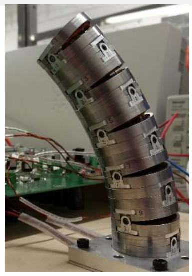


- A 3-DOF robotic uterine positioner is designed, developed and tested
- Safety is addressed from a mechanical perspective:
  (1) An in-body RCM
  (2) Use of the LAAG RCM mechanism
  (3) Decoupled joint motion
  (4) Use of passive safety mechanisms

14:15–14:30 WeDT6.2

Towards a Follow-the-Leader Control for a Binary Actuated Hyper-Redundant Manipulator

Svenja Tappe, Jan Pohlmann, Jens Kotlarski, and Tobias Ortmaier
Leibniz Universität Hannover, Germany



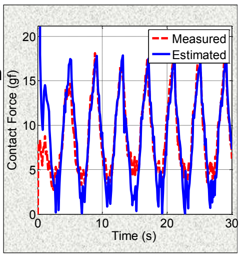
- Electromagnetically actuated, snake-like robot for flexible endoscopy
  - good resistance with respect to manipulation forces
  - active control of each actuator
- Adaption of classical follow-the-leader control methods with continuous interpolation to binary actuation concept
- Optimized switching sequences for an appropriate path following performance

14:30–14:45 WeDT6.3

A Robotics-Assisted Catheter Manipulation System with Real-Time Force Estimation

Mahta Khoshnam[1,2], Iman Khalaji[1,2], and Rajni V. Patel[1,2]
[1]Canadian Surgical Technologies and Advanced Robotics (CSTAR), [2] Western University, Canada

- The proposed system
  - places the ablation tip at the target;
  - estimates the contact force based on the position and orientation of the distal end in real-time;
  - displays position and force information via the user interface.
- Experimental validation shows good accuracy in tip positioning and force estimation.



14:45–15:00 WeDT6.4

Registration of a Robotic System to a Medical Imaging System

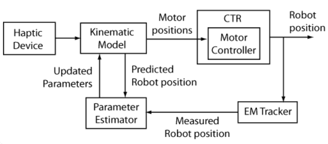
Abhinav Gulhar[1,2], Danilo Briese[1,2], Philip W. Mewes[2] and Georg Rose[1]
[1]Institute for Medical Engineering, Otto von Guericke University, Magdeburg, Germany [2]Siemens Healthcare GmbH, Germany

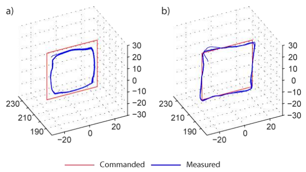
A method and accuracy evaluation for the registration of a robotic system to a medical imaging system without the use of any tracking device or X-ray imaging for robot assisted medical interventions is presented. The registration is realized by a series of landmark transformations by manually moving and guiding the robot to distinct landmarks on the imaging system using a KUKA LWR iiwa.

15:00–15:15 WeDT6.5

Real-time Adaptive Kinematic Model Estimation of Concentric Tube Robots

- On-line estimator to adaptively update the parameters of the robot kinematics model





- Improves the accuracy of the trajectory tracking
- Adapts to the variation of the robot model

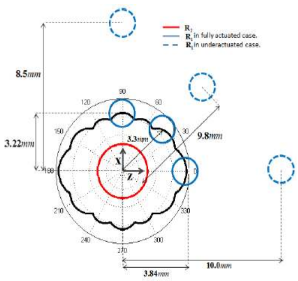
Chunwoo Kim, Seok Chang Ryu and Pierre E. Dupont
Pediatric Cardiac Bioengineering Lab, Boston Children's Hospital

15:15–15:30 WeDT6.6

Stabilizing the Relative Position of Millirobots inside an MRI Scanner Considering Magnetic Interaction Forces

Alina Eqtami[1] and Pierre E. Dupont[1],
[1]Boston Children's Hospital, Harvard Medical School, U.S.A.

- **Goal:** Navigation of magnetic millirobots inside fluid-filled passageways through clinical MRI.
- **Novelty:** Consideration of *interaction forces* between the magnetic robots.
- **Results:** Pairs of robots can be stabilized at separation distances 2.5-3 times the lower bound on separation distance.



Motion and Path Planning 3

Chair *Jonathan Butzke, Carnegie Mellon University*
Co-Chair *Robert James Webster III, Vanderbilt University*

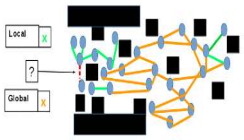
14:00–14:15	WeDT7.1

Improved Roadmap Connection via Local Learning for Sampling Based Planners

Chinwe Ekenna, Diane Uwacu
Shawna Thomas and Nancy Amato
Texas A&M University, College Station, USA

- Biases learning to connection attempts within dynamic neighborhood.
- Removes the need to partition in heterogeneous environments.
- Finds solution paths faster for single and multi-query scenarios and builds roadmaps with better coverage and connectivity

Global vs Local Learning

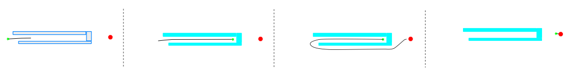


14:15–14:30	WeDT7.2

Safe Receding Horizon Control for Aggressive MAV Flight with Limited Range Sensing

Michael Watterson[1] and Vijay Kumar[1],
[1]University of Pennsylvania, USA

- Fast, aggressive trajectory generation for multirotor MAVs in cluttered 3D environments
- Real time re-planning in partially observed environments with limited sensing radius
- Safety insurance by maintaining stopping control policy
- Completeness with ability to plan through all observed space



★ Robot Goal ○ Sensor Radius Obstacles Observed

14:30–14:45	WeDT7.3

3-D Exploration with an Air-Ground Robotic System

Jonathan Butzke[1], Andrew Dornbush[1],
and Maxim Likhachev[1]
[1]Carnegie Mellon University, USA

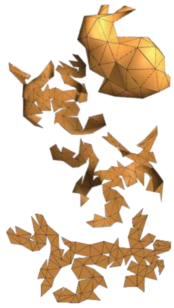
- Real world 3-D exploration using a heterogeneous system of air and ground vehicles
- Planner determines goal location to maximize information gain for all vehicles currently searching for designated Object of Interest
- Vision-based object detection system with human oversight

14:45–15:00	WeDT7.4

Continuous Unfolding of Polyhedra – a Motion Planning Approach

Zhonghua Xi and Jyh-Ming Lien
George Mason University, USA

- Cut along the edges of the polyhedron
- Generate non-overlapping unfolding using heuristic methods
- Sample only in the discrete configuration domain (hinge is either fully unfolded or folded to the target angle)
- Achieve much higher probability of generating valid configurations
- Able to find unfolding paths for Polyhedra with hundreds of DOF

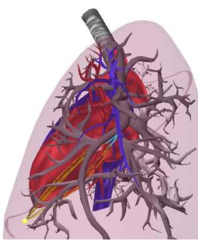


15:00–15:15	WeDT7.5

Motion Planning for a Three-Stage Multilumen Transoral Lung Access System

A. Kuntz[1], L. G. Torres[1],
R. H. Feins[1], R. J. Webster III[2], and R. Alterovitz[1]
[1]UNC-Chapel Hill, USA [2]Vanderbilt University, USA

- Three-stage continuum robotic device consists of a bronchoscope, a concentric tube robot, and a steerable needle
- Designed to enable early-stage lung cancer diagnosis
- Our motion planner computes actions for each of the system's stages
- Avoids sensitive anatomical obstacles to reach suspicious lung nodules

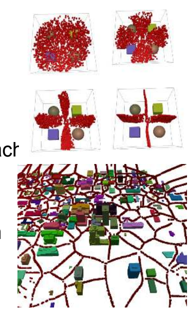


15:15–15:30	WeDT7.6

Fast Medial-Axis Approximation via Max-Margin Pushing

Guilin Liu[1], Jyh-Ming Lien[1]
[1]George Mason University, USA

- Advantage: provide a fast way to sample dense configurations on the approximate edges of MA
- Training Data: contact space and obstacle space
- Sampling on MA: a retraction based approach
  - Pushing Direction: derivative of SVM classification function
  - Pushing Step Size: SVM classification score.



Cellular and Modular Robots

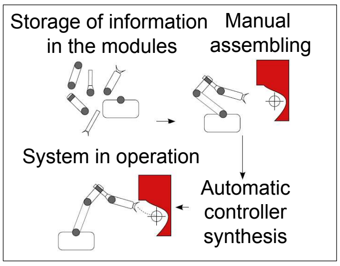
Chair *Ahsan Nawroj, Yale University*
Co-Chair *Matthias Althoff, Technische Universität München*

14:00–14:15	WeDT8.1

Automatic Centralized Controller Design for Modular and Reconfigurable Robot Manip.

Andrea Giusti, Matthias Althoff
Technische Universität München, Germany

- Model-based control schemes are synthesized on-the-fly using modular information.
- A novel notation for characterization of heterogeneous modules is presented.

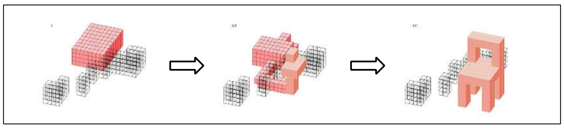


14:15–14:30	WeDT8.2

Complete Reconfiguration Algorithm For Sliding Cube-shaped Modular Robots with only Sliding Motion Primitive

Hiroshi Kawano
NTT Corporation, Japan

- Proposed algorithm assumes usage of 2 x 2 x 2 meta-module.
- Proposed reconfiguration algorithm is complete for a connected robot structure with more than 24 meta-modules.
- Proposed algorithm can be applied in an environment with obstacles.
- Module movement is managed by void control policy.

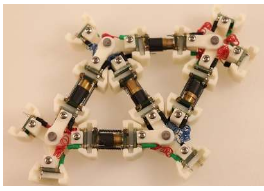


14:30–14:45	WeDT8.3

Design of Mesoscale Active Cells for Networked, Compliant Robotic Structures

Ahsan Nawroj[1], John Swensen[1], and Aaron Dollar[1]
[1]Yale University, USA

- We present the design of Active Cells (~2cm long SMA actuators), and their connections en masse to create articulated mesh robots (MACROs).
- Constitutive modeling of cells and nodes, design optimization, and simple control strategy for small meshes are provided.

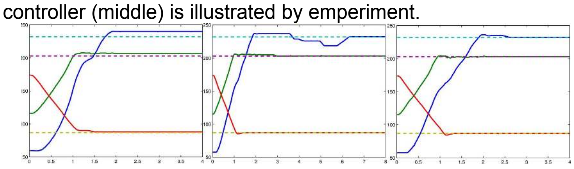


14:45–15:00	WeDT8.4

Modelling and control for position-controlled modular robot manipulators

Zilong Shao[1,2,3], Gang Zheng[2,3], Denis Efimov[2,3] and Wilfrid Perruquetti[1,2,3]
[1]ECLille, France [2]Inria-Lille, France [3]CRIStAL, France

Position-conctrolled robots with simple built-in controllers present steady-state error (left). As a solution, firstly a local-level model is established and identified; then an auxiliary a daptive controller is proposed and implemented (right), improvement over integral controller (middle) is illustrated by emperiment.

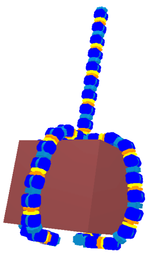


15:00–15:15	WeDT8.5

Collective Grasping for Non-cooperative Objects using Self-reconfigurable Robots

Tianmiao Wang, Haiyuan Li, Cai Meng
Beihang University, China

- The modular self-reconfigurable robots can grasp the unknown objects of different sizes and shapes, improving adaptation ability in space.
- The reconfigured structure depends on a grasp quality metric that can guarantee the stability of grasping.
- Each self-contained robot uses its own sensors and actuators to grasp an object in collective and distributed way

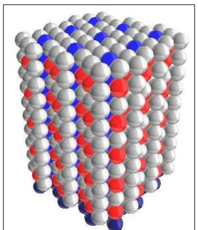


15:15–15:30	WeDT8.6

Efficient modular-robotic structures to increase the force-to-weight ratio of scalable collective actuators

P. Hołobut[1], M. Kursa[1], Jakub Lengiewicz[1]
[1] IPPT PAN, Warsaw, Poland

- Scalable collective actuators to make Programmable Matter of useful strength
- Force-to-weight ratio limits are analyzed
- Applies to large module ensembles
- Strength proportional to volume
- Two types of connections: strong (fixed) and weak (reconfigurable)
- Examples of high-strength actuators
- Analytical results & DEM simulations


collective actuator

Climbing Robots

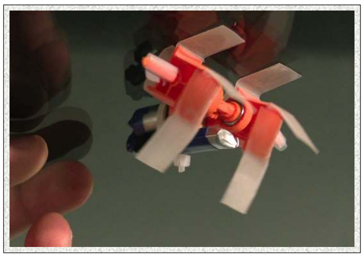
Chair *Anibal de Almeida, IROS 2012 General Chair*
Co-Chair *Andrew Horchler, Case Western Reserve University*

14:00–14:15	WeDT9.1

Walking inverted on ceilings with wheel-legs and micro-structured adhesives

William Breckwoldt[1], Kathryn Daltorio[1], Lars Heepe[2], Andrew Horchler[1], Stanislav Gorb[2], Roger Quinn[1]
[1]Case Western Reserve University, US. [2]Kiel University, Germany

- Inverted Mini-Whegs uses Mushroom-Shaped Adhesive MicroStructured feet
- Walks inverted on glass ceilings at 1.8 body-lengths/sec
- Prototype for modeling future inverted climbing robots

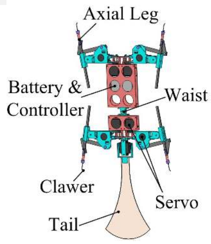


14:15–14:30	WeDT9.2

Analysis on the Dynamic Climbing Forces of a Gecko Inspired Climbing Robot Based on GPL Model

Wei Wang, Shilin Wu,
Peihua Zhu and Rong Liu
Beihang University, China

- Dynamic analysis was made on the bio-inspired GPL model
- The anomalies line between supporting feet and its effect on driving forces was found.
- Principia of configuration design and gait planning were proposed based on our analysis.
- Force measuring experiment was carried out which enforced our prediction

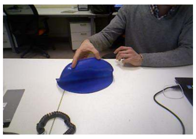


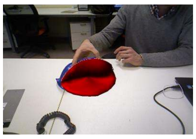
14:30–14:45	WeDT9.3

Real-Time Tracking of 3D Elastic Objects with an RGB-D Sensor

Antoine Petit[1], Vincenzo Lippiello[1], Bruno Siciliano[1]
[1]Universita degli Studi di Napoli Federico II, Italy

- Prior visual segmentation of the object
- Physical modeling of the elasticity using an FEM approach
- Rigid ICP to track rigid motions
- Non-rigid registration:
- Nearest neighbor searches
- Computation of deformations based
- on resulting external forces
- Real-time, synthetic and real data
- validation



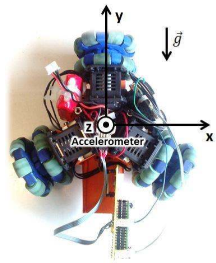


14:45–15:00	WeDT9.4

State estimation and path following on curved vertical surfaces with Omniclimber robots

M. Tavakoli,L. Sgrigna,C. Viegas, A.T. de Almeida
Institute of Systems and Robotics, University of Coimbra, Portugal

- Path following with Omnidirectional Climbing Robot
- Kinematics of omnidirectional wheels on curved surfaces
- Orientation control based on filtered accelerometer data

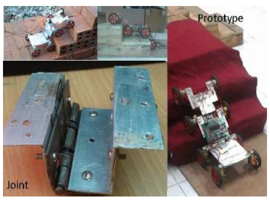


15:00–15:15	WeDT9.5

Stair Climbing Using a Compliant Modular Robot

Sri Harsha T[1], Mihir Shah[2], Phani Teja S[3], Avinash Siravuru[4], Suril V. Shah[5] and Madhava Krishna K[6]
[1]IIIT-H, India [2]IIIT-H, India [3]IIIT-H, India [4]CMU, USA
[5]IIIT-H, India [6]IIIT-H, India

- Active Wheel Passive Joint 3-Module Robot
- Analysis of phases during Stair Climbing
- Optimally designed springs based on the obtained moment profiles at the joints through the analysis
- Simulation and Experimentation of a prototype



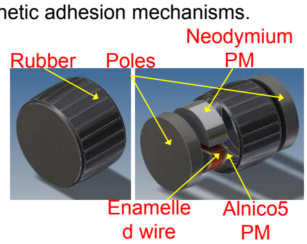
15:15–15:30	WeDT9.6

Design of an Active Magnetic Wheel with a Varying EPM Adhesion Mechanism

Francisco Ochoa-Cardenas[1], Tony J. Dodd[1],
[1]The University of Sheffield, United Kingdom

Main advantages of the proposed wheel design:

- **Power Consumption:** Requires just a small fraction of the energy compared to other magnetic adhesion mechanisms.
- **Controllability of the adhesion force**
- **Working cycle:** Time for switching between states in the order of milliseconds,
- **Low Temperature Rise:** It is active for a very short periods of time.



Humanoid Robots 3

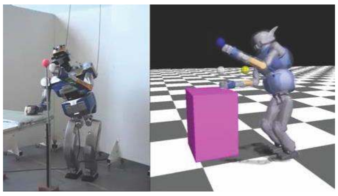
Chair *Olivier Stasse, CNRS*
Co-Chair *Maren Bennewitz, University of Bonn*

14:00–14:15	WeDT10.1

Whole-body Model Predictive Control Applied to the HRP-2 Humanoid Robot

J. Koenemann[1,2], A. Del Prete[1], Y. Tassa[3]
E. Todorov[4], O. Stasse[1], M. Bennewitz[2] and N. Mansard[3]
[1]LAAS-CNRS, France, [2] Univ. Freiburg, Germany, [3] Google, UK,
[4] Univ. Washington, USA

- Whole-body MPC applied to a HRP-2 humanoid robot
- Using MuJoCo dynamics engine
- **Multicontacts**
- **Self-collision** avoidance
- **100 ms** for 1 s of preview

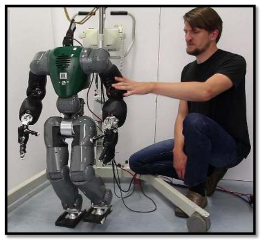


14:15–14:30	WeDT10.2

Online Regeneration of Bipedal Walking Gait Optimizing Footstep Placement and Timing

Przemyslaw Kryczka[1], Petar Kormushev[1,2],
Nikos G. Tsagarakis[1] and Darwin G. Caldwell[1]
[1]Italian Institute of Technology, Italy [2]Imperial College London, UK

- **Simultaneous** optimization of the **step placements and durations**
- Improved disturbance rejection
- Online gait pattern regeneration based on an estimated robot state
- Performance verified on a humanoid robot COMAN subjected to lateral pushes

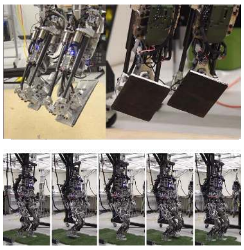


14:30–14:45	WeDT10.3

Embedded Joint-Space Control of a Series Elastic Humanoid

Michael Hopkins[1], Stephen Ressler[1], Derek Lahr[1],
Alexander Leonessa[1], and Dennis Hong[2]
[1]Virginia Tech, USA [2]UCLA, USA

- This paper presents a compliant joint-space control approach using linear series elastic actuators.
- A custom dual-axis motor controller tracks joint torques and velocities using an inner actuator force loop featuring a disturbance observer based on the open-loop plant.
- The controller enables compliant walking using the THOR humanoid.

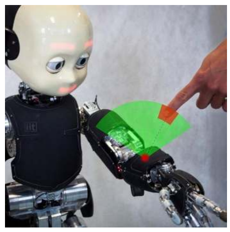


14:45–15:00	WeDT10.4

Learning peripersonal space representation through artificial skin for avoidance and reaching with whole body surface

A. Roncone, M. Hoffmann, U. Pattacini and G. Metta
Istituto Italiano di Tecnologia (IIT), Italy

- Learning of a multi-sensory, tactile-visual representation is built up through interaction with the environment
- The learned representation extends the tactile system into the nearby space, and predicts contacts with the whole body of the robot
- Validation through sensory-based guidance of the motor actions (avoidance and reaching with any body part)

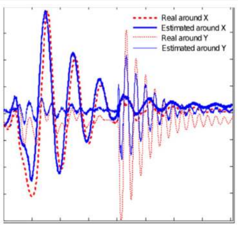


15:00–15:15	WeDT10.5

Estimation of Contact Forces and Kinematics of a Humanoid Robot Using Only IMUs

Alexis Mifsud[1], Mehdi Benallegue[1] and Florent Lamiraux[1]
[1]LAAS-CNRS, France

- Use **only inertial measurement units**, and contact information
- Rely on **Newton/Euler dynamics** together with **elasticity model**
- Accurately **observe of the floating base kinematics** of a humanoid robot
- **Estimate contact forces** and torques **without force sensor**
- Precisely **track** the position of the **ZMP**



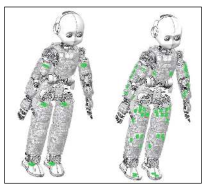
Real ZMP Vs estimation

15:15–15:30	WeDT10.6

Simultaneous state and dynamics estimation in articulated structures

Francesco Nori, Naveen Kuppuswamy, Silvio Traversaro
Istituto Italiano di Tecnologia, Italy

- Simultaneous estimation of kinematic (joint positions, velocities), dynamic (forces, torques and accelerations)
- Sensors considered : accelerometers, gyroscopes, force/torque, encoders
- Full body coordinates considered.
- Maximum-a-posteriori estimates of quantities with a Bayesian Network to exploit sparsity speeding up computations



Multi-Agent Coordination

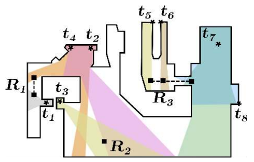
Chair *Zhi Yan, Ecole des Mines de Douai*
Co-Chair *Katie Genter, The University of Texas at Austin*

14:00–14:15 WeDT11.1

Visibility-Based Persistent Monitoring with Robot Teams

Pratap Tokekar[1] and Vijay Kumar[2]
[1]Virgnia Tech, U.S.A. [2]University of Pennsylvania, U.S.A.

- Find robot paths such that each given target is visible from at least one path.
- Robots stop (for *t* time) to obtain a measurement.
- Path time = Travel time + Number of stops x *t*.
- Minimize maximum (over all robots) path time.
- NP-hard. Reduction to the art gallery and watchman route problem.



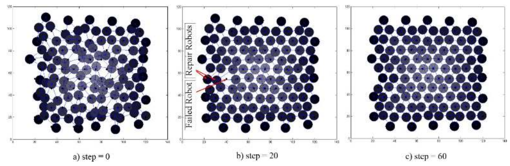
- **Result:** 4-approximation algorithm for the special case of street polygons.

14:15–14:30 WeDT11.2

A Gradient-Based Self-Healing Algorithm for Mobile Robot Formation

Zhe Liu, Jianjun Ju, Weidong Chen, Xiangyu Fu, and Hesheng Wang
Department of Automation, Shanghai Jiao Tong University, China

- We investigate the distributed self-healing problem of robot formation after one or more robots have been damaged.
- A gradient-based algorithm is presented which can restore both the formation topology and the motion synchronism with the least number of repair robots involved.
- Simulation results show that the proposed algorithm can restore the formation topology with the fewer repair robots and lower energy consumptions.

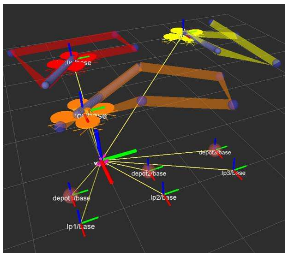


14:30–14:45 WeDT11.3

Multi-Robot Persistent Coverage with Stochastic Task Costs

Derek Mitchell[1], Nilanjan Chakraborty[2], Katia Sycara[1] and Nathan Michael[1]
[1]Carnegie Mellon University, USA [2]Stony Brook University, USA

- Deploy a team of robots performing tasks over long durations
- Energy requirements to perform tasks are initially unknown and learned over time
  - Uncertain measurements treated as stochastic
- Robots execute tasks (blue markers) while maintaining sufficient supply of energy via recharging at stations (red markers)

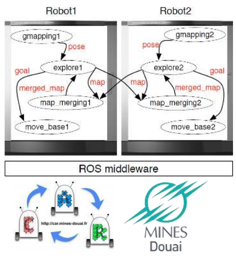


14:45–15:00 WeDT11.4

Metrics for Performance Benchmarking of Multi-robot Exploration

Zhi Yan, Luc Fabresse, Jannik Laval and Noury Bouraqadi
Ecole des Mines de Douai, 59508 Douai, France

- **Performance metrics:** *exploration time, exploration cost, exploration efficiency, map completeness,* and *map quality.*
- **Benchmark parameters:** *robot, fleet,* and *environment.*
- **Simulation testbed:** *MORSE robotics simulator, ROS middleware,* and *computer cluster.*

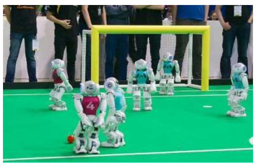


15:00–15:15 WeDT11.5

Benchmarking Robot Cooperation without Pre-Coordination in the SPL Drop-In Player Competition

Katie Genter[1], Tim Laue[2] and Peter Stone[1]
[1]The University of Texas at Austin, USA
[2]University of Bremen, Germany

- New RoboCup Standard Platform League (SPL) competition
- Ad hoc teams comprised of robots originating from different RoboCup teams
- Introduces the competition setup, rules, and scoring metrics
- Summarizes and analyzes player strategies

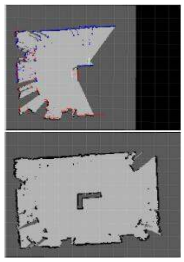


15:15–15:30 WeDT11.6

A Hybrid Approach for Multiple-robot SLAM with Particle Filtering

Sajad Saeedi[1], Michael Trentini[2], and Howard Li[1]
[1]University of New Brunswick, Canada
[2]Defence Research and Development Canada-Suffield, Canada

- In this paper, a hybrid algorithm for multiple-robot SLAM is proposed that combines the advantages of particle filtering and map merging.
- The uncertainty of the relative poses is taken into account .
- Information is updated in batch mode which reduce the time complexity.
- Experiments were done with view-based SLAM.



Model Learning

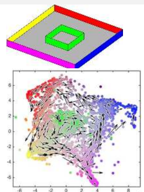
Chair *Tomohiro Shibata, Kyushu institute of technology*
Co-Chair *Johannes Andreas Stork, KTH Royal Institute of Technology*

14:00–14:15	WeDT12.1

Learning Predictive State Representations for Planning

Johannes A. Stork, Carl Henrik Ek, and Danica Kragic
KTH Royal Institute of Technology,
Stockholm, Sweden

- PSR model dynamical systems in observables **without task semantic**
- Learn **interpretable** PSRs with relevant semantic for planning
- **P-PSR:** Include prior information in PSR learning
- Improved planning performance



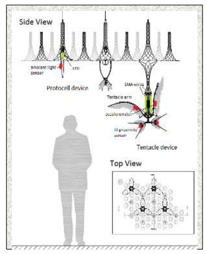
P-PSR: navigating room with colored walls

14:15–14:30	WeDT12.2

Curiosity-Based Learning Algorithm for Distributed Interactive Sculptural Systems

Matthew T. K. Chan[1], Rob Gorbet[1],
Philip Beesley[1] and Dana Kulić[1]
[1]University of Waterloo, Canada

- Novel reinforcement learning algorithm for interaction with human participants within an interactive sculptural installation.
- Algorithm is a distributed adaptation of curiosity-based learning.
- Interactive sculpture system consists of multiple interconnected sensor and actuator nodes; sensors are both proprioceptive and sensitive to participants' actions and movements.

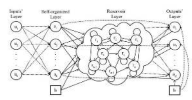


14:30–14:45	WeDT12.3

Real-time Deep Learning of Robotic Manipulator Inverse Dynamics

Athnansios S. Polydoros[1], Lazaros Nalpantidis[1],
and Volker Krüger[1]
[1]Aalborg University, Denmark

- Deep neural network of 2 hidden layers: a self-organised and a recurrent reservoir.
- Learning incrementally using GHL on inputs' and Bayesian linear regression on outputs' weights.
- Evaluated on 5 different datasets and compared to 3 state of the art algorithms.
- Better adaptability on real-time changes of the inverse dynamics mapping compared to the sate of the art algorithms



Structure of the deep neural network

14:45–15:00	WeDT12.4

Kernel Density Estimation for Target Trajectory Prediction

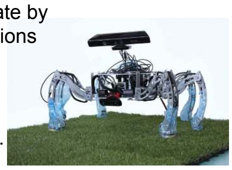
Vahab Akbarzadeh, Christian Gagné, Marc Parizeau
Université Laval, Québec, Canada

15:00–15:15	WeDT12.5

Learning Terrain Types with Pitman-Yor Process Mixture models for a Legged Robot

Patrick Dallaire[1], Krzysztof Walas[2],
Philippe Giguère[1] and Brahim Chaib-draa[1]
[1]Université Laval, Canada [2]Politechnika Poznańska, Poland

- Walking robot with a foot-mounted Force/Torque sensor.
- Terrain classification and terrain clustering is done through learning **Pitman-Yor process mixture of Gaussians**.
- Classification achieves 82% success rate by learning non-Gaussian feature distributions for each terrain + Maximum Likelihood.
- Clustering achieves 51% *pairwise correct classification* by assuming **Bayesian nonparametrics** on terrains.

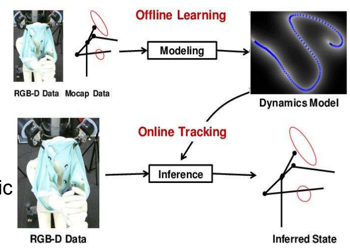


15:15–15:30	WeDT12.6

Cloth Dynamics Modeling in Latent Spaces and Its Application to Robotic Clothing Assistance

Nishanth Koganti[1], Jimson Gelbolingo Ngeo[1,2],
Tomoya Tamei[1], Kazushi Ikeda[1] and Tomohiro Shibata[1,2]
[1]NAIST, Ikoma, Japan [2]KIT, Kitakyushu, Japan

- Propose modeling of cloth dynamics using Shared GP-LVM
- Learnt dynamics model applied to estimate human-cloth relationship.
- Method applied to Robotic Clothing Assistance task.



Formal Methods in Robotics and Automation

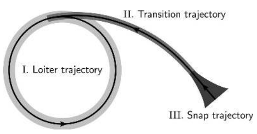
Chair *Andrey Rusakov, ETH Zürich*
Co-Chair *Daniel Althoff, Carnegie Mellon University*

14:00–14:15	WeDT13.1

Online Trajectory Safety Verification for Unmanned Flight with Offline Computed Robust Invariant Sets

Daniel Althoff[1], Matthias Althoff[2], Sebastian Scherer[3]
[1]CMU, USA [2]TUM, Germany [3]CMU, USA

- Novel method for computing robust control invariant sets (RCIS) based on reachability analysis
- Offline computed RCIS used to online verify trajectories
- Simulation results for an unmanned helicopter in partially-known environments in the presence of wind disturbances and sensor noise

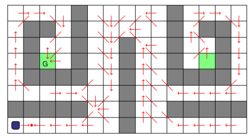


14:15–14:30	WeDT13.2

Synthesizing Cooperative Reactive Mission Plans

Rüdiger Ehlers[1], Robert Könighofer[2], and Roderick Bloem[2]
[1]U. of Bremen and DFKI, Germany [2]TU Graz, Austria

- Standard generalized reactivity(1) synthesis often produces high-level robot controllers that actively work towards the falsification of the assumptions about the environment.
- This is problematic in environments with humans – working against the environment assumptions means working against the humans in this case.
- We present an approach to synthesize **cooperative robot controllers** that do not have this problem.



14:30–14:45	WeDT13.3

VISPEC: A graphical tool for elicitation of MTL requirements

Bardh Hoxha[1], Nikolaos Mavridis[2], and Georgios Fainekos[1]
[1]Arizona State University, USA
[2]Massachusetts Institute of Technology, USA

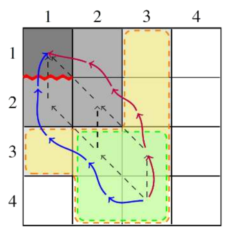
- One of the main barriers preventing widespread use of formal methods is the elicitation of formal specifications.
- In this work, we present a graphical tool designed for the development and visualization of formal specifications.
- The tool is evaluated using a usability study with cohorts from the student community and industry.
- Finally, we present applications of our tool for defining specifications for operation of robotic surgery and autonomous quadcopter safe operation.

14:45–15:00	WeDT13.4

Online Horizon Selection in Receding Horizon Temporal Logic Planning

Vasumathi Raman[1], Mattias Fält[2], Tichakorn Wongpiromsarn[3] and Richard M. Murray[1]
[1]Caltech, USA, [2]Lund University, Sweden, [3]TCELS, Thailand

- Reactive switching between short horizon problems to satisfy high-level requirements in linear temporal logic.
- Goal-dependent invariant provides winning initial conditions for each short horizon problem.
- Search-and-rescue example illustrates advantage over prior approaches.



15:00–15:15	WeDT13.5

Concurrency Patterns for Easier Robotic Coordination

Andrey Rusakov[1], Jiwon Shin[1], Bertrand Meyer[1,2]
[1]Chair of Software Engineering, ETH Zürich, Switzerland
[2]Software Engineering Lab, Innopolis University, Kazan, Russia

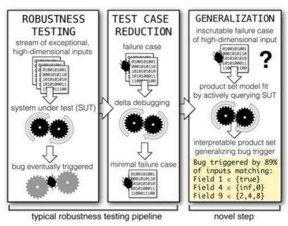
- Concurrency design patterns are reusable design solutions which can simplify development of concurrent robotics applications, such that even novice concurrent programmers can benefit from them.
- Six known concurrency design patterns:
  Future, Periodic timer, Invoke later, Cooperative cancellation, Guarded suspension and Active object are demonstrated to help solving common robotic coordination tasks.
- The paper discusses advantages, disadvantages and applicability of these patterns in robotics and how modern programming frameworks - ROS, Urbi and Roboscoop can support them.

15:15–15:30	WeDT13.6

Learning product set models of fault triggers in high-dimensional software interfaces

Paul Vernaza, David Guttendorf, Michael Wagner and Philip Koopman
The National Robotics Engineering Center, Carnegie Mellon University, Pittsburgh, PA

- Novel learning method assists in diagnosis of software faults by producing a concise summary of conditions that trigger faults
- Method is well-suited to bugs triggered via high-dimensional software interfaces found in robotics applications
- Active queries used to efficiently deduce the conditions



Industrial Robots

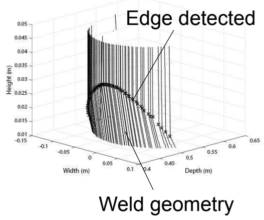
Chair *Norbert Krueger, University of Southern Denmark*
Co-Chair *Luca Simoni, University of Brescia*

14:00–14:15	WeDT14.1

Identification and Reconstruction of Complex Weld Geometry Based on Modified Entropy

S. Keshmiri, Y. Z. Tan, X. Zheng, S. M. Ahmed, Y. Wu, W. F. Lu, C. M. Chew, and C. K. Pang
National University of Singapore, Singapore

- Edge detection of complex weld geometry based on a modified entropy-type cost function
- Volume of reconstructed weld geometry estimated using point cloud model
- Simulation results demonstrate efficient identification and reconstruction in the presence of Gaussian noise

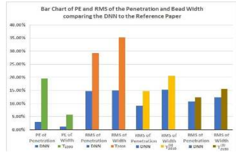


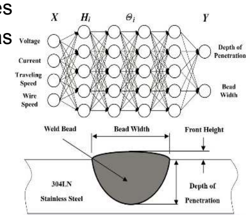
14:15–14:30	WeDT14.2

Application of Deep Neural Network in Estimation of the Weld Bead Parameters

Soheil Keshmiri, Xin Zheng, Lu Wen Feng, Chee Khiang Pang, Chee Meng Chew
National University of Singapore, Singapore

- Four-hidden-layer neural network
- Feed-forward procedure
- Back-propagation for weights updates
- The results of proposed algorithm has been compared to the literatures.



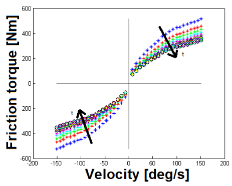


14:30–14:45	WeDT14.3

Friction Modeling with Temperature Effects for Industrial Robot Manipulators

Luca Simoni[1], Manuel Beschi[2], Giovanni Legnani[1] and Antonio Visioli[1]
[1]University of Brescia, Italy [2]ITIA-CNR, Italy

- Friction torque decreases with temperature mainly due to changes in lubricant properties
- Two models are developed to consider temperature effects on friction torque:
  - 4 parameters model
  - 6 parameters model
- A procedure for the parameter estimation is given

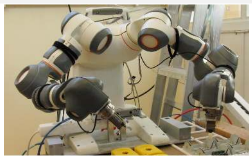


14:45–15:00	WeDT14.4

Sensorless Friction-Compensated Passive Lead-Through Programming for Industrial Robots

A. Stolt[1], F. Bagge Carlson[1], M.M. Ghazaei Ardakani[1], I. Lundberg[2], A. Robertsson[1], and R. Johansson[1]
[1]Lund University, Sweden [2]ABB Robotics, Sweden

- Based on feedforward gravity torques while disabling the low-level joint controllers
- Performance is improved by adding friction compensation
- Small external torques detected using low-level controllers with increased integral gain
- Evaluation on two different industrial robots

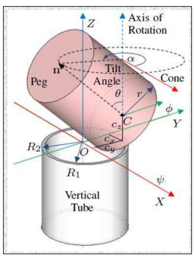


15:00–15:15	WeDT14.5

Depth-based Localization for Robotic Peg-in-tube Assembly

Arun Dayal Udai[1], Ravi Prakash Joshi[1], and Subir Kumar Saha[1]
[1]Indian Institute of Technology Delhi, India

- The paper presents a thorough geometrical analysis of the ‘peg-in-tube’ assembly process.
- A novel algorithm based on depth measurements of peg center to perform ‘peg-in-tube’ task is proposed.
- The results are demonstrated on a KUKA KR5 Arc industrial robot.



15:15–15:30	WeDT14.6

Using Task Descriptions for Designing Optimal Task Specific Manipulators

Sarosh Patel, and Tarek Sobh
Robotics Intelligent Sensing & Control (RISC) Lab
University of Bridgeport, USA

Computing the optimal geometric structure of manipulators is one of the most intricate problems in contemporary robot kinematics. In this work, we define, develop and test a methodology that can generate optimal manipulator structures based on the task requirements. Another objective of this work is to guarantee task performance under user defined joint constraints. Using this methodology, task-specific optimal manipulator structures can be generated that guarantee task performance under a set of operating constraints.

Intelligent Transportation Systems

Chair *Andrei Vatavu, Technical University of Cluj-Napoca*
Co-Chair *Enric Galceran, University of Michigan*

14:00–14:15 WeDT15.1

Modeling and Tracking of Dynamic Obstacles for Logistic Plants using Omnidirectional Stereo Vision

Andrei Vatavu, Arthur D. Costea and Sergiu Nedevschi
Technical University of Cluj-Napoca, Romania,
http://cv.utcluj.ro

- **Objective:** an obstacle detection and tracking solution applied to Automated Guided Vehicles (AGVs).
- **Main Tasks:**
  - Omnidirectional stereo perception
  - Digital Elevation Map computation
  - Object Hypothesis extraction
  - Object Classification
  - Object Tracking

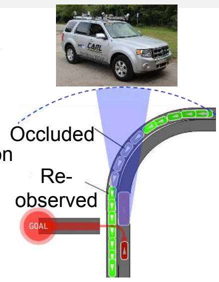
14:15–14:30 WeDT15.2

Augmented Vehicle Tracking under Occlusions for Decision-Making in Autonomous Driving

Enric Galceran, Edwin Olson, and Ryan M. Eustice

University of Michigan

- Method for tracking vehicles passing through prolonged occlusions (e.g., a car occluded by a large truck on a highway).
- Augments standard tracking methods by adding driver models, multi-hypothesis belief representation, and data association of (re-) observed tracks.
- Evaluated on simulations and on real-world tracking data from an autonomous vehicle.

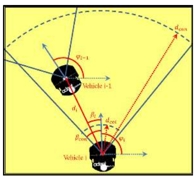


14:30–14:45 WeDT15.3

Decentralized 2-D Control of Vehicular Platoons under Limited Visual Feedback

Chris Verginis[1], Charalampos P. Bechlioulis[1],
Dimos D. Dimarogonas[2] and Kostas J. Kyriakopoulos[1]
[1]National Technical University of Athens, Greece
[2]Kungliga Tekniska Hogskolan, Sweden

- 2-D vehicular platoon formation problem
  - Avoid collisions
  - Avoid connectivity breaks due to limited visual feedback
- Decentralized control protocol
  - Only camera feedback required
- Designer-specified performance functions determine explicitly the transient and steady state performance

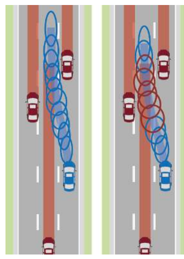


14:45–15:00 WeDT15.4

Real-Time Trajectory Optimization under Motion Uncertainty using a GPU

Steffen Heinrich[1], André Zoufahl[2]
and Raùl Rojas[2]
[1]Volkswagen AG, Germany [2]Freie Universität Berlin, Germany

- Sampling-based planning method considering motion uncertainty
- Implementation of an exhaustive search (DP) algorithm on a GPGPU
- Stochastic model based on a Linear-Quadratic Gaussian (LQG)
- Addresses challenges of indecisive planning behaviors

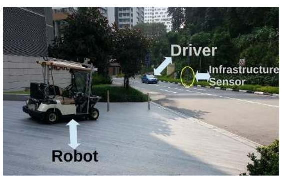


15:00–15:15 WeDT15.5

Towards Autonomous Navigation of Unsignalized Intersections under Uncertainty of Human Driver Intent

Volkan Sezer [1], Tirthankar Bandyopadhyay[2],
Daniela Rus[3], Emilio Frazzoli [3] and David Hsu [4]
[1]Istanbul Technical University, Turkey, [2]CSIRO, Australia
[3]Massachusetts Institute of Technology, USA, [4] National University of Singapore, Singapore

The problem of vehicle interaction at an intersection merging scenario is formulated as an intention aware planning problem using the tools from Mixed Observability Markov Decision Process (MOMDP).



Human-Robot Interaction 5

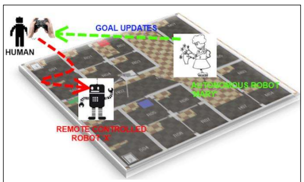
Chair *Baris Akgun, Georgia Institute of Technology*
Co-Chair *Markus Eisenbach, Ilmenau University of Technology*

16:50–17:05 WeFT1.1

A Human Factors Analysis of Proactive Support in Human-robot Teaming

Yu Zhang, Vignesh Narayanan, Tathagata Chakraborti and Subbarao Kambhampati
Arizona State University

- Evaluation of proactive support in HRT via a realistic USAR task in simulation to start the investigation of this ability
- Results show that humans generally prefer robots with the proactive support ability
- Results show that teaming with robots with PS ability increases human's cognitive load



An USAR task in which a human remotely controls a robot while working with an intelligent robot.

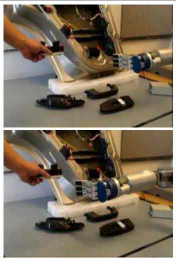
17:05–17:20 WeFT1.2

Exploring the Effect of Robot Hand Configurations in Directional Gestures

Sara Sheikholeslami, AJung Moon, Elizabeth A. Croft
University of British Columbia, Canada

we studied the efficacy of a three-fingered robotic gripper in communicating directional instructions to human partners:

- Study I: Identifying Human Hand Gestures
- Study II: Human Perception of Human Hand Gestures
- Study III: Human Perception of Robot Hand Gestures



17:20–17:35 WeFT1.3

User Recognition for Guiding and Following People with a Mobile Robot in a Clinical Environment

Markus Eisenbach, Alexander Vorndran, Sven Sorge, and Horst-Michael Gross
Ilmenau University of Technology, Germany

- **Motivation from application scenario:** a mobile robot coaches stroke patients during their self-training for rehabilitative follow-up care
- **Our approach:** appearance-based person re-identification to resolve ambiguities in tracking
- **Main contribution:** novel components for metric learning and probabilistic track-based verification
- **Experimental evaluation:** confirmation of state-of-the-art performance on two benchmark datasets & comprehensive live tests during rush-hour times in the stroke rehab clinic

17:35–17:50 WeFT1.4

Evaluation of GUI and Kinesthetic Teaching Methods for Constrained-Keyframe Skills

Andrey Kurenkov[1], Andrea Thomaz[1], and Baris Akgun[1]
[1]Georgia Institute of Technology, United States

- We propose LfD method for learning skills as sequences of constraints
- We introduce a GUI for displaying the learned skill, altering it, or specifying it directly without demonstrations
- We compare 3 methods of teaching such skills (Kinesthetic, GUI, and K-GUI)
- We discuss the results of a user study, including that K-GUI teaching is the most preferred, and the GUI the least preferred

17:50–18:05 WeFT1.5

UAV, Do You See Me? Establishing Mutual Attention Between an Uninstrumented Human and an Outdoor UAV In Flight

Mani Monajjemi, Jake Bruce, Abbas Sadat, Jens Wawerla and Richard Vaughan
Simon Fraser University, Canada

- The first demonstration of establishing mutual attention between an outdoor UAV and an uninstrumented human user
- Autonomous UAV detects the familiar periodic arm-waving gesture and gives feedback to the user
- All computation performed on-board using a monocular camera

18:05–18:20 WeFT1.6

Social Context Perception for Mobile Robots

Aastha Nigam and Laurel D. Riek
University of Notre Dame, USA

- **Problem**: Robot perception is poor in dynamic, human-centric environments.
- **Solution**: Biologically-inspired, holistic, *context-based perception* algorithms.
- **Approach**: Enable robots to quickly assess context using fast-to-compute, global multimodal features (e.g., GIST, volume).
- **Results**: Successfully classified context across extremely noisy data. This work will enable more robust robot perception.


Robot learned to assess interruptibility & context

Calibration and Identification 2

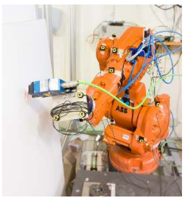
Chair *Federico Vicentini, National Research Council of Italy*
Co-Chair *Meng CHEN, Institute of Aerospace System Engineering Shanghai*

16:50–17:05 WeFT2.1

Six DOF Eye-to-Hand Calibration from 2D Measurements Using Planar Constraints

Fredrik Bagge Carlson, Rolf Johansson and Anders Robertsson
Dept. Automatic Control, Lund University, Sweden

- Find transformation between laser sensor and tool flange or body
- Robust iterative method, solving only systems of linear equations
- Handles very large errors in the initial estimate
- Requires no special calibration objects or patterns, only arbitrarily placed planar surfaces (e.g. three walls in a corner)

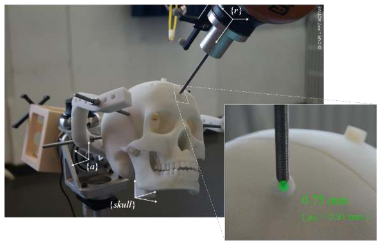


17:05–17:20 WeFT2.2

Analysis and Compensation of Calibration Errors in a Multi-robot Surgical Platform

Federico Vicentini[1], Paolo Magnoni[1], Matteo Giussani[1] and Lorenzo Molinari Tosatti[1]
[1]National Research Council (CNR), ITIA, Italy

- **robot-assisted neuro-surgery**
  - ✓ accuracy <1 mm
  - ✓ Active Headframe
  - ✓ floating target
- **Volumetric compensation:** correction transform trained off line

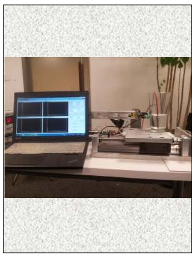


17:20–17:35 WeFT2.3

The Calibration Device & Method of Humanoid Finger Sensor Based on Multimodal Perception

Chen Meng[1], Tang Ping[1], Han Dong[2]
[1]Institute of ASES, China [2]NUAA, China

- **Humanoid finger sensor** is as the calibrated object
- **Least Square** method**, Frequency Spectrum Analysis** method, **Fast Fourier Transform** are used to process the measured data and signals
- By way of calibration device, **contact force**, **temperature**, **material attributes** of the touched objects, could be calculated or predicted quickly and precisely

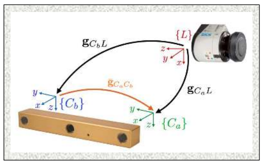


17:35–17:50 WeFT2.4

Exploiting Known Unknowns: Scene Induced Cross-Calibration of Lidar-Stereo Systems

Terry Scott, Akshay Morye, Pedro Piniés, Lina Paz, Ingmar Posner and Paul Newman
University of Oxford, UK

- Automatic, data-driven calibration of stereo camera to laser scanner.
- Scene need not be co-observed simultaneously by both modalities.
- Optimisation decoupled into a *lower* and *upper* level.
- Lower level - Image-Laser registration using Normalised Information Distance.
- Upper level – Pose graph optimisation with known constraints.

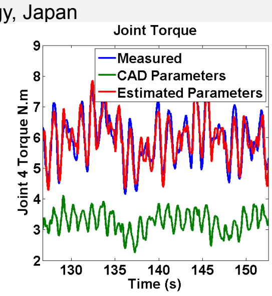


17:50–18:05 WeFT2.5

Constrained Dynamic Parameter Estimation using the Extended Kalman Filter

Vladimir Joukov[1], Vincent Bonnet[2], Michelle Karg, Gentiane Venture[2], and Dana Kulić[1]
[1]University of Waterloo, Canada [2]Tokyo University of Agriculture and Technology, Japan

- Real time parameter estimation of a manipulator and its load using Extended Kalman Filter.
- Constraints imposed on estimated parameters through Sigmoid functions.
- Improves manipulator joint torque prediction for control applications.



18:05–18:20 WeFT2.6

MSG-Cal: Multi-sensor Graph Calibration

Jason Owens[1], Philip Osteen[2] and Kostas Daniilidis[3]
[1]US Army Research Lab, USA [2]Engility Corp., USA [3]University of Pennsylvania, USA

- Optimally fuse data from an arbitrary sensor configuration
- Create high quality color/depth reconstructions of the environment
- Develop general, flexible framework to solve the multi-sensor calibration problem
- Global calibration improves accuracy compared to *best* pairwise calibration for real dataset

Visual Navigation 2

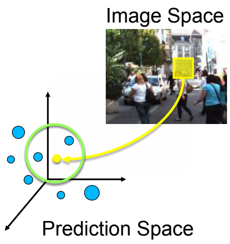
Chair *Hsueh-Cheng Wang, MIT*
Co-Chair *H. Jin Kim, Seoul National University*

16:50–17:05 WeFT3.1

PROBE: Predictive Robust Estimation for Visual-Inertial Navigation

Valentin Peretroukhin[1], Lee Clement[1], Matthew Giamou[1], and Jonathan Kelly[1]
[1]University of Toronto, Canada

- We present a machine-learning technique to predict the quality of visual features with respect to navigation estimates.
- Our method uses training data to build a model from a prediction space to a scalar weight.
- We show accuracy improvements over RANSAC on the KITTI dataset and our own experimental data.

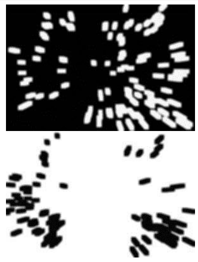


17:05–17:20 WeFT3.2

Entropy Based Keyframe Selection for Multi-Camera Visual SLAM

Arun Das, Steven L. Waslander
University of Waterloo, Canada

- Existing visual SLAM approaches take little consideration for specific keyframe selection.
- We propose two entropy based methods, CPER and PPFD, which insert keyframes to directly improve the system's ability to localize.
- CPER strengthens existing map points, while PPFD evaluates point matches for future tracking.

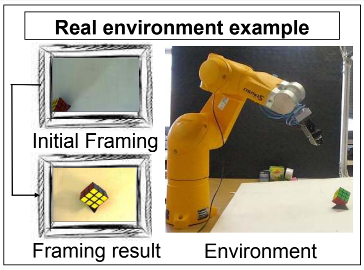


17:20–17:35 WeFT3.3

Good feature for framing: Saliency-based Gaussian mixture

Zaynab Habibi[1], El Mustapha Mouaddib[1], and Guillaume Caron[1]
[1]Université de Picardie Jules Verne, France, MIS Laboratory

- A new photometric feature: **saliency-based Gaussian Mixture**
- Automatic camera control for **relevant framing** based on this feature
- Validation in **real** and **virtual** environment

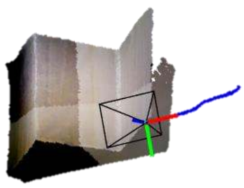


17:35–17:50 WeFT3.4

Robust Visual Odometry to Irregular Illumination Changes with RGB-D camera

Pyojin Kim[1], Hyon Lim[1] and H. Jin Kim[1]
[1]Seoul National University, South Korea

- **Goal :** Estimate trajectory of the camera frame under sudden, irregular illumination changes.
- **Contribution :** Parameters of affine illumination change model are employed for active compensation.
- **Evaluation :** Comparative test with other direct VO methods under significant illumination changes.



17:50–18:05 WeFT3.5

Adaptive Visual Trajectory Tracking of Nonholonomic Mobile Robots based on Trifocal Tensor

Bingxi Jia, Jian Chen, Kaixiang Zhang
Zhejiang University, China

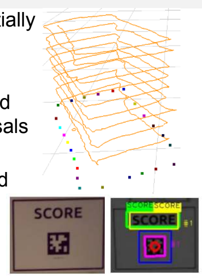
- Visual trajectory tracking task in large workspace;
- Trifocal tensor based approach in general scene;
- Key frame strategy for global continuous pose estimation, extending the workspace;
- Adaptive controller in consideration of unknown depth and extrinsic parameters;
- Simulation based on V-REP for performance evaluation.

18:05–18:20 WeFT3.6

Bridging Text Spotting and SLAM with Junction Features

H.-C. Wang[1], C. Finn[2], L. Paull[1], M. Kaess[3], R. Rosenholtz[1], S. Teller[1], and J. Leonard[1]
[1]MIT, USA [2]UC Berkeley, USA [3]CMU, USA

- **Text Spotting** (TS) and **SLAM** are potentially complementary.
- Problem: Existing TS methods are slow.
- Proposed solution: **Junction features** and scene priors that can refine region proposals for fast and reliable text detection.
- Accurately decoded text features are used in graphical SLAM for **loop closure**.
- SLAM helps reject false text detections through location priors.



Localization 3

Chair *Zeyang Xia, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences*
Co-Chair *Gian Diego Tipaldi, University of Freiburg*

16:50–17:05	WeFT4.1

Global Localization by Soft Object Recognition from 3D Partial Views

Fernando Ribeiro[1], Susana Brandão[1,2], João P. Costeira[1] and Manuela Veloso[2]
[1]Instituto Superior Técnico, Portugal
[2] Carnegie Mellon University, USA

- We contribute an algorithm for **global localization** in human environments with information rich landmarks, such as furniture, that an **autonomous robot** can observe with a **depth sensor**;
- We assume a **knowledge map** and use landmarks' (i) **relative position,** obtained directly from depth sensor; and (ii) **class and pose,** obtained indirectly from observed landmarks' 3D surfaces;
- We take into account that common depth sensors' observations are noisy and possibly ambiguous by: (i) using **soft recognition**; and (ii) representing 3D surfaces with a noise resilient, pose dependent descriptor: the **Partial View Heat Kernel** (PVHK).

17:05–17:20	WeFT4.2

Set Membership Approach to the Kidnapped Robot Problem

Benoît Desrochers[1], Simon Lacroix[2], and Luc Jaulin[1]
[1]ENSTA-Bretagne, France [2]LAAS/CNRS, France

This article depicts an algorithm which matches the output of a Lidar with an initial terrain model to estimate the absolute pose of a robot using an interval based algorithm.

17:20–17:35	WeFT4.3

A Dependence Maximization Approach towards Street Map-based Localization

Kiyoshi Irie[1,2], Masashi Sugiyama[3], Masahiro Tomono[1]
[1]Chiba Institute of Technology, Japan
[2]Tokyo Institute of Technology, Japan
[3]University of Tokyo, Japan

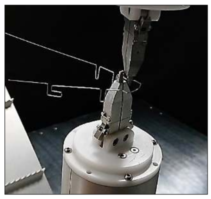
- Localization using 2D street maps (e.g. Google Map)
- Exploits latent dependence between regions in the map and sensor data
- Performs localization by maximizing a Mutual Information-based measure
- Does not recognize road areas or road boundaries
- Does not restrict robots on roads

17:35–17:50	WeFT4.4

Motion Planning and Control of a Robotic System for Orthodontic Archwire Bending

Hao Deng, Zeyang Xia*, Shaokui Weng, Yangzhou Gan, Jing Xiong*, Yongsheng Ou and Jianwei Zhang
Shenzhen Institutes of Advance Technology, Chinese Academy of Sciences

- This study aimed to resolve time-consuming and low accuracy issues of clinical appliance preparation;
- A robotic system for accurate orthodontic archwire bending was designed;
- Sampling-based motion planner and bending control strategies was proposed;
- Simulation on platform with MoveIt and experiments on physical robotic system were conducted.



17:50–18:05	WeFT4.5

An Efficient Pose Estimation for Limited-Resourced MAVs using Sufficient Statistics

I. Senthooran[1], J. C. Barca[1], J. Kamruzzaman[2], M. Murshed[2] and H. Chung[1]
[1]Monash University, Australia [2]Federation University, Australia

- A computationally efficient RGB-D based pose estimation solution for less computationally resourced MAVs.
- Uses sufficient statistics for improving the computation time of RANSAC-based outlier detection step in pose estimation.
- Further increase in efficiency by reducing the problem size to 4-DOF using attitude data from an Attitude and Heading Reference System (AHRS).
- Our algorithm saves up to 94% of computing time for the RANSAC-based procedure while maintaining/improving the accuracy.

18:05–18:20	WeFT4.6

Accurate Localization with Respect to Moving Objects via Multiple-Body Registration

J. Röwekämper, B. Suger, W. Burgard, G. D. Tipaldi
University of Freiburg, Germany

- Accurate localization of a mobile robot relative to an object that can be moved in the environment.
- Relies only on laser range finders.
- Relative pose estimation with respect to multiple objects at taught locations.
- Achieves highly accurate pose estimates using multi-body ICP.

Mechanism Design 1

Chair *Hyouk Ryeol Choi, Sungkyunkwan University*
Co-Chair *Hai-Jun Su, The Ohio State University*

16:50–17:05 WeFT5.1

Probe suspension mechanism design for nano machining system

Zhiyong Guo, Yanling Tian, Dawei Zhang
Tianjin University, China

- Displacement based nano machining system
- A probe suspension with amplification mechanism is designed
- Theoretical analysis of the probe suspension
- The physical dimension of the probe suspension is optimized
- Finite element analysis is implemented for the probe suspension

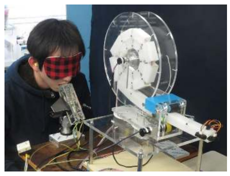
Probe system

17:05–17:20 WeFT5.2

A Joystick Interface for Tongue Operation with Adjustable Reaction Force Feedback

Shinya Kajikawa[1], Kyohei Takahashi[1], and Akihide Mihara[1]
[1]Tohoku gakuin university, Japan

- Joystick interface operated by tongue for disabled person.
- Two degrees of freedom and adjustable stiffness against operation.
- Adjustable reaction force feedback can be realized and used for safe and effective operation of outer equipment.

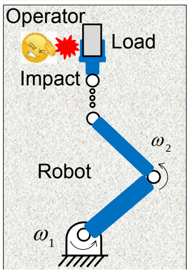


17:20–17:35 WeFT5.3

Dynamic Modeling of A 2D Compliant Link for Safety Evaluation in Human-Robot Interactions

Yu She[1],Deshan Meng[2], Hongliang Shi[1] and Hai-jun Su[1]
[1]The Ohio State University, USA
[2]Harbin Institute of Technology Shenzhen Graduate School, China

- Safety is a premium concern for co-robotic systems;
- It has been studied that using compliant links in a robot can greatly reduce the injury level;
- The injury level can be evaluated and quantified by a dynamic model;
- In this paper, an efficient and yet accurate dynamic model of compliant links is built and verified, and the injury level are determined.

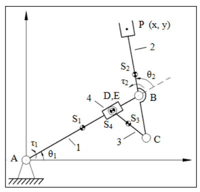


17:35–17:50 WeFT5.4

The Design of Arm Linkages with Decoupled Dynamics Taking into Account the Payload

Vigen Arakelian[1,2], Jiali Xu[2] and Jean-Paul Le Baron[2]
[1]IRCCyN, France [2]INSA of Rennes, France

- This paper deals with a new dynamic decoupling principle for serial manipulator with Scott-Russel mechanism and optimal redistribution of moving masses.
- The goal is to simplify the controller design by reducing the effects of complicated manipulator dynamics. In this case, it is easy to take into account the payload.

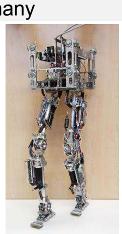


17:50–18:05 WeFT5.5

A Systematic Approach to the Design of Embodiment with Application to Bio-inspired Compliant Legged Robots

Stefan Kurowski[1], Oskar von Stryk[1],
[1]Technische Universität Darmstadt, Germany

- Legged robots with highly elastic actuation have large potential regarding performance, robustness and energy efficiency
- New engineering design methodology derived from 8 main **design principles for embodiment agents** (Pfeifer & Bongard 2007) and 9th principle “efficient versatility”
- **Optimization process for embodied agent design:** dynamic model-based, multi experiment, multi objective, tailoring active & passive dynamics and control



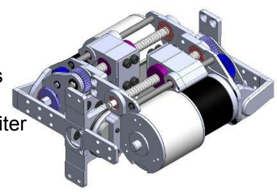
Application: Musculoskeletal BioBiped2 robot

18:05–18:20 WeFT5.6

Design of Back-drivable Joint Mechanism for In-pipe Robot

Ho Moon Kim[1] , Seung Ung Yang[1], Yun Seok Choi[1], Hyeong Min Mun[1], Chan Min Park[1] and Hyouk Ryeol Choi[1]
[1] Sungkyunkwan University, KOREA

- Back-drivable joint mechanism
  - using ball-screw and spur gears
  - 2 pitch joint & 1 roll joint
  - Scenario for passing through miter
- Experiments
  - Backdrivability experiment
  - Paylaod experiment



< Back-drivable Joint >

Medical Robots and Systems 3

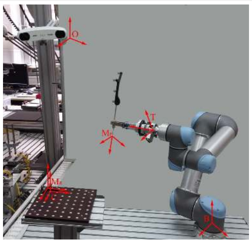
Chair *Guang-Zhong Yang, Imperial College London*
Co-Chair *Konrad Leibrandt, Imperial College London*

16:50–17:05	WeFT6.1

Medical applicability of a low-cost industrial robot arm guided with an optical tracking system

Filip Šuligoj, Bojan Jerbić, Marko Švaco, Bojan Šekoranja, Dominik Mihalinec, Josip Vidaković
University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Croatia

- The aim of this paper is to measure and assess medical applicability of a low-cost, lightweight industrial robot arm (Universal robot UR5) guided with the medically certified optical tracking system (Polaris Vicra) to positions registered from a CT scan

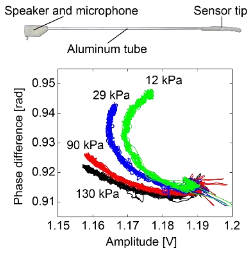


17:05–17:20	WeFT6.2

Softness Measurement by Forceps-Type Tactile Sensor Using Acoustic Reflection

Tomohiro Fukuda[1], Yoshihiro Tanaka[1], Michitaka Fujiwara[2] and Akihito Sano[1]
[1]Nagoya Institute of Technology, Japan
[2]Nagoya University, Japan

- Sensor is available in laparoscopic surgery
- Sensor is simple and biocompatible by using acoustic reflection
- Profile curvature of the sensor output reflects the softness of the target tissue based on contact area and force

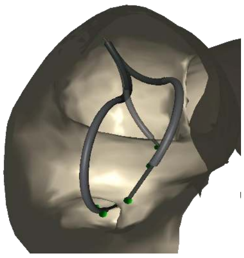


17:20–17:35	WeFT6.3

On-Line Collision-Free Inverse Kinematics with Frictional Active Constraints for Effective Control of Unstable Concentric Tube Robots

Konrad Leibrandt[1], Christos Bergeles[1], and Guang-Zhong Yang[1]
[1]Imperial College London, United Kingdom

- On-line local inverse kinematics for concentric tube robots, considering anatomy collisions and instabilities.
- Leveraging multi-core computer architectures to calculate real-time local inverse kinematics.
- Fricitional active constraints for safe, effective and precise telemanipulation.

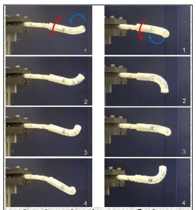


17:35–17:50	WeFT6.4

Towards a SMA-Actuated Neurosurgical Intracerebral Hemorrhage Evacuation (NICHE) Robot

Jun Sheng and Jaydev P. Desai
University of Maryland, College Park, USA

- This paper presents a meso-scale robot for Neurosurgical Intracerebral Hemorrhage Evacuation (NICHE).
- Pairs of antagonistic shape memory alloy wires enable bi-directional motion of bending joints.
- A torsion joint formed by a pair of antagonistic SMA torsion springs is installed at the distal end.

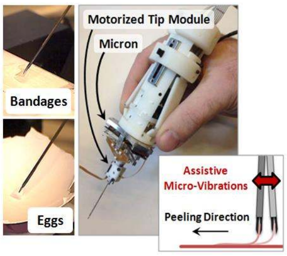

Articulation of the robot tip

17:50–18:05	WeFT6.5

Effects of Micro-Vibratory Modulation during Robot-Assisted Membrane Peeling

Berk Gonenc[1], Peter Gehlbach[2], Russell H. Taylor[1] and Iulian Iordachita[1]
[1]CISST ERC, Johns Hopkins University, USA
[2]Wilmer Eye Institute, Johns Hopkins School of Medicine, USA

- An experimental exploration of how micro-vibration amplitude and frequency affect membrane peeling forces.
- A micromanipulator (Micron) and a force-sensing micro-forceps were combined.
- Peeling experiments on bandages and inner shell membrane of raw chicken eggs.



18:05–18:20	WeFT6.6

Design and Control of Robotic Exoskeleton with Balance Stabilizer Mechanism

Lei Li[1], K.H. Hoon[1], Adela Tow[2], P.H. Lim[2] and K. H. Low[1]
[1]Nanyang Technological University, Singapore [2]Tan Tock Seng Hospital, Singapore

- An additional balance stabilizer mechanism is added onto a robotic exoskeleton to provide additional propulsion and stabilizing force.
- Polynomial function is used as the base function for trajectory generation.
- The stability of the system is evaluated using ZMP criteria. The unstable trajectory is re-shaped by using COG jacobian method.

Motion and Path Planning 4

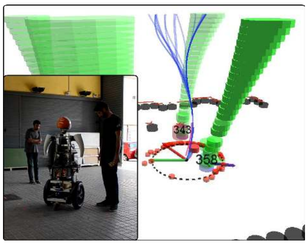
Chair *Noa Agmon, Bar Ilan University*
Co-Chair *Lydia Tapia, University of New Mexico*

16:50–17:05	WeFT7.1

Multi-Objective Cost-to-Go Functions on Robot Navigation in Dynamic Environments

Gonzalo Ferrer[1] and Alberto Sanfeliu[1]
[1]IRI (CSIC-UPC), Spain

- We introduce the Anticipative Kinodynamic Planning (AKP): robot navigation algorithm in dynamic urban environments that seeks to minimize its disruption to nearby pedestrians while navigating.
- Multiple objectives are considered to find the best robot navigation path.
- A cost-to-go function builds the planning tree, improving w.r.t. a Euclidean approach.
- Steering heuristics reduce the calculation requirements to satisfy real time constraints.

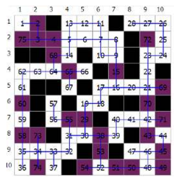


17:05–17:20	WeFT7.2

Online Robotic Adversarial Coverage

Roi Yehoshua and Noa Agmon
Bar Ilan University, Israel

- Robot must visit every point in a target area that contains threats
- The map of threats is unknown in advance
- **Goal**: find a coverage path that maximizes robot's survivability
- We suggest a frontier-based coverage algorithm
- Frontiers are chosen based on the risk and cost of the path to them, and the safety of the area reachable from them



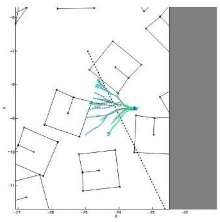
Online coverage path in an adversarial environment

17:20–17:35	WeFT7.3

Stochastic Ensemble Simulation Motion Planning in Stochastic Dynamic Environments

Hao-Tien Chiang, Nathanael Rackley, and Lydia Tapia
University of New Mexico, USA

- Uses Monte Carlo simulation (offline) to predict potential future positions (in workspace) of stochastically moving obstacles
- A tree-based planner (online) utilizes the Monte Carlo result to plan a collision-free trajectory
- Results show high success rate even in environments with 300-900 stochastic dynamic obstacles and 7 degree of freedom robot



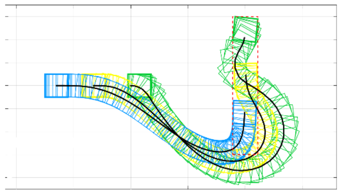
(above) squares: moving obstacles; gray: static obstacles; star: robot

17:35–17:50	WeFT7.4

Time-Optimal Trajectory Planning for Tractor-Trailer Vehicles via Simultaneous Dynamic Optimization

Bai Li[1], Kexin Wang[1], and Zhijiang Shao[1,2]

[1]Zhejiang University, China
[2]State Key Laboratory of Industrial Control Technology, China



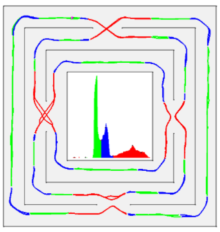
Optimizing based on a comprehensive kinematic model will solve the complicated trajectory planning problem in a clean way, with no additional efforts needed..

17:50–18:05	WeFT7.5

Using n-grams of spatial densities to construct maps

Renan Maffei, Vitor Jorge, Vitor Rey, Guilherme Franco, Mariane Giambastiani, Jéssica Barbosa, Mariana Kolberg and Edson Prestes
UFRGS

- Efficient place recognition method using a laser range finder
- Matches sequences of words
- Words are built from sets of similar observations, encoding spatial density information, number of observations and orientation

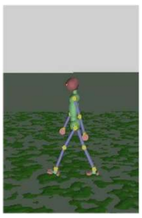


18:05–18:20	WeFT7.6

Adaptive Motor Patterns and Reflexes for Bipedal Locomotion on Rough Terrain

Qi Liu, Jie Zhao, Steffen Schuetz and Karsten Berns
Robotics Research Lab, Department of Computer Science, University of Kaiserslautern, Germany

The Bio-inspired Behavior-Based Bipedal Locomotion Control (B4LC) system consists of motor patterns and reflexes. By combining the Particle Swarm Optimization and the reinforcement learning method, a learning unit is implemented in the B4LC system with an optimization module and a learning module. The simulated bipedal robot with optimized motor patterns and learned reflexes performs stable locomotion on even and uneven terrains.



Biomimetics

Chair *Taro Nakamura, Chuo University*
Co-Chair *Nicholas S. Szczecinski, Case Western Reserve University*

16:50–17:05	WeFT8.1

Mixing of Solid Propellant by Peristaltic Pump Based on Bowel Peristalsis

Shun Yoshihama[1], Ryosuke Ban[1], Akihiro Iwasaki[2], Hiroto Habu[3] and Taro Nakamura[1]
[1]Chuo University, Japan, [2]The Graduate University for Advanced Studies (SOKENDAI), Japan, [3]JAXA, Japan

- We proposed a novel manufacturing process for solid propellants using the peristaltic pump.
- We also confirmed the potential for mixing two identical highly viscous fluids and a solid and highly viscous fluid with the peristaltic pump.
- The production in the peristaltic pump is mixed, to some extent, by performing the pendulum movement in a horizontal state.

17:05–17:20	WeFT8.2

Development of Seabed Excavation Robot with Peristaltic Crawling

M. Nagai[1], A. Mizushina[1], T. Nakamura[1], F. Sugimoto[2], K. Watari[2], H. Nakajo[2], and H. Yoshida[2]
[1]Chuo University, Japan [2]Japan Agency for Marine-Earth Science and Technology(JAMSTEC), Japan

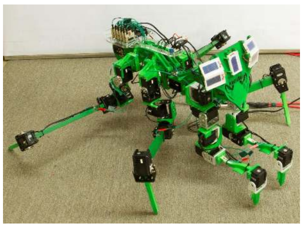
- An excavation robot with peristaltic crawling for deep sea floor exploration is proposed.
- For development of propulsion unit, performance experiment of oil hydraulic artificial muscle under water pressure (up to 5MPa) is conducted.
- The robot using pneumatic artificial muscle is developed and successfully excavate soil to a depth of 490 mm.

17:20–17:35	WeFT8.3

Introducing MantisBot: Hexapod Robot Controlled by a High-Fidelity, Real-Time Neural Simulation

NS Szczecinski[1], DM Chrzanowski[1], DW Cofer[2], AS Terrasi[1], DR Moore[1], JP Martin[1], RE Ritzmann[1], RD Quinn[1]
[1]Case Western Reserve University, USA [2]NeuroRobotic Technologies, USA

- First step toward goal-directed motion: reflex-based posture controller
- All control implemented as a computational neuroscience model of CPGs and reflexes in insects
- Neural dynamics directly leveraged to tune behaviors

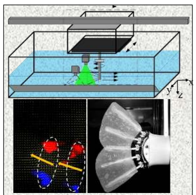


17:35–17:50	WeFT8.4

Hydrodynamic function of a robotic caudal fin: effects of kinematics and flow speed

Ziyu Ren[1], Tianmiao Wang[1], and Li Wen[1]
[1]Beihang University, China

- A multiple-material flexible robotic model was implemented to study the hydrodynamic function of the fish caudal fin. Hydrodynamic force, wake structure and kinematics were simultaneously measured under different motion programs and flow speeds in a water tank.
- Based on robotic experimental data, we hypothesized that the fish caudal fin may function as a “flexible vectoring propeller” during swimming, and may be responsible for the high maneuverability of fishes.



Robotic caudal fin model

17:50–18:05	WeFT8.5

Row-bot: An Energetically Autonomous Artificial Water Boatman

H Philamore[1,3], J Rossiter [1,3], A Stinchcombe[2,3], I Ieropoulos [2,3]
[1]University of Bristol, UK [2]Bristol BioEnergy Centre, UWE, UK
[3]Bristol Robotics Lab, UK

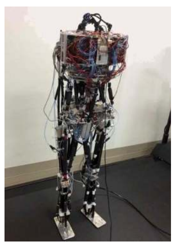
- Energetically autonomous swimming robot.
- Powered by single microbial fuel cell (MFC) using commercially available voltage step-up hardware.
- Bio-inspired actuation powered by a bio-inspired energy source.

18:05–18:20	WeFT8.6

Understanding Function of Gluteus Medius in Human Walking from Constructivist Approach

Hirofumi Shin[1], Shuhei Ikemoto[1], and Koh Hosoda[1]
[1]Osaka University, Japan

- We focused on the gluteus medius which contributes the pelvis stability in human walkings.
- It seems to support the pelvis in the stance phase but in the swing phase thanks to the muscle arrangement.
- The hypothesis was validated in an experiment using the developed musculoskeletal humanoid robot.



Range Sensing

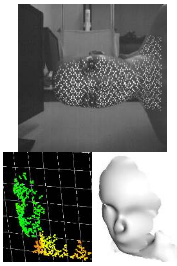
Chair *Markus Vincze, Vienna University of Technology*
Co-Chair *Nakju Doh, Korea University*

16:50–17:05	WeFT9.1

High-speed 3D Sensing with Three-view Geometry using a Segmented Pattern

Satoshi Tabata[1], Shohei Noguchi[2],
Yoshihiro Watanabe[1] and Masatoshi Ishikawa[1]
[1]University of Tokyo, Japan [2]Sony Corporation, Japan

- Our high-speed 3D sensing system consists of a projector and two cameras.
- By projecting a well-designed segmented pattern and using three-viewpoint epipolar constraints, the proposed system can obtain 3D points at 450-500 fps in real time.



17:05–17:20	WeFT9.2

Contextual Classification of 3D Laser points with Conditional Random Fields in Urban Environments

Yan Zhuang[1], Yisha Liu[2], Guojian He[1] and Wei Wang[1]
[1]Dalian University of Technology, China
[2]Dalian Maritime University, China

- A novel Optimal Bearing Angle (OBA) image is proposed to overcome the limitations of texture information losing and image blurring caused by the UGV's on-the-fly navigation.
- The center of points belonging to each segmented OBA image patch is assigned as CRF graph node, so that a simplified CRF graph structure is constructed for online contextual classification of 3D laser points in urban environments.
- Total 29-dimensional features are extracted from both the raw 3D laser points and the corresponding OBA images.

17:20–17:35	WeFT9.3

Real-Time Tracking of 3D Elastic Objects with an RGB-D Sensor

Antoine Petit, Vincenzo Lippiello, Bruno Siciliano
Universita degli Studi di Napoli Federico II, Italy

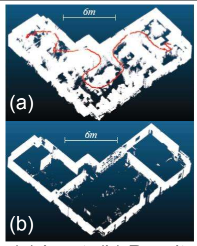
- Prior visual segmentation of the object
- Physical modeling of the elasticity using an FEM approach
- Rigid ICP to track rigid motions
- Non-rigid registration:
  - Nearest neighbor searches
  - Computation of deformations based
  - on resulting external forces
  - Real-time, synthetic and real data
- validation

17:35–17:50	WeFT9.4

Convex Cut: A Realtime Pseudo-Structure Extraction Algorithm for 3D Point Cloud Data

ChangHyun Jun[1], Jihwan Youn[1], Jongmoo Choi[2],
Gérard Medioni[2], and Nakju Lett Doh[1]
[1]Korea University, South Korea [2]Univ. of Southern Califonia, USA

- Output: **Pseudo-Structure** (approximation of real structure of indoor environments)
  - Get dependable & static feature in dynamic environments
  - Get a principal 3D model of the space
- **Realtime, Ligthweight** (50k points: 24ms)
  - Can be used as a pre-processor module
  - Application: SLAM in dynamic env., 3D scan matching, efficient dense map



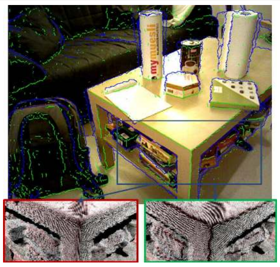
(a) Input, (b) Result

17:50–18:05	WeFT9.5

Fast and Accurate Normal Estimation by Efficient 3d Edge Detection

Richard Bormann[1], Joshua Hampp[1], Martin Hägele[1],
and Markus Vincze[2]
[1]Fraunhofer IPA, Germany [2]Vienna Univ. of Technology, Austria

- fast and accurate **3d edge detection** algorithm for **depth** and **surface discontinuities** (ca. 90% accuracy at 30 Hz)
- simple **extension** of **established normal estimation** algorithms for **edge-awareness**
- **novel edge-aware**, fast (23 Hz), accurate, and robust **normal estimation approach**

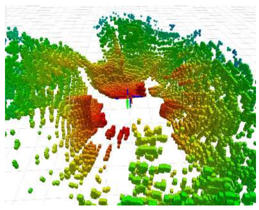


18:05–18:20	WeFT9.6

Omnidirectional Visual Obstacle Detection using Embedded FPGA

Pascal Gohl, Dominik Honegger, Sammy Omari,
Markus Achtelik, Marc Pollefeys and Roland Siegwart
ETH Zürich, Switzerland

- Embedded real-time system with four stereo cameras
- Efficient polar-coordinate mapping for low latency obstacle detection
- Omnidirectional perception allows for complex MAV maneuvers in cluttered environments



Humanoid Robots 4

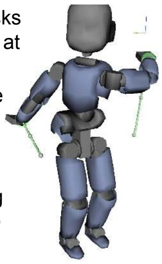
Chair *Tomomichi Sugihara, Graduate School of Engineering, Osaka University*
Co-Chair *Luca Colasanto, École Polytechnique Fédérale de Lausanne (EPFL)*

16:50–17:05 WeFT10.1

Variance Modulated Task Prioritization in Whole-Body Control

Ryan Lober[1], Vincent Padois[1] and Olivier Sigaud[1]
[1]Université de Pierre et Marie Curie, France

- In whole-body control, assigning priorities to tasks helps manage conflicts between them but often at the detriment of their overall performance.
- Many tasks, like reaching, are variable in nature and may not require such rigid prioritization schemes.
- We show how this task variance can be used to automatically modulate task priorities, rendering the overall behavior of the robot, more robust to perturbation and task conflicts.

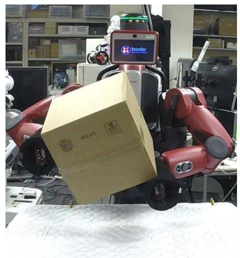


17:05–17:20 WeFT10.2

Whole-body Holding Manipulation by Humanoid Robot based on Transition Graph of Object Motion and Contact

Masaki Murooka[1], Yuto Inagaki[1], Ryohei Ueda[1], Shunichi Nozawa[1], Yohei Kakiuchi[1], Kei Okada[1] and Masayuki Inaba[1]
[1]The University of Tokyo

- Plan the whole-body holding manipulation by humanoid robot.
- Transition graph, which represents object pose and grasp contact, is generated.
- Transition motion is planned by searching the feasible path on the graph.
- The real robot, Baxter and HRP-2 carry handleless large objects by whole-body holding manipulation.



17:20–17:35 WeFT10.3

Continuously satisfying constraints with contact forces in trajectory optimization for humanoid robots

Benjamin Chrétien[1], Adrien Escande[2], and Abderrahmane Kheddar[2,1]
[1]CNRS-UM LIRMM, France
[2]CNRS-AIST JRL UMI3218/RL, Japan

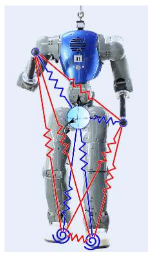
- Handling of contact forces in trajectory optimization
- Specific parametrization to satisfy the Equation of Movement at any instant
- Taylor-based approximation of constraints to tackle semi-infinite programs
- Demonstration of the results in scenarios with the HRP-2 robot

17:35–17:50 WeFT10.4

A General Whole-Body Compliance Framework for Humanoid Robots

Luca Colasanto[1], Nikos G. Tsagarakis[2] and Auke Jan Ijspeert[1]
[1]Biorobotics Laboratory, EPFL, Switzerland
[2]Advanced Robotics Department, IIT, Italy

- A novel compliance framework tailored to control humanoid robots is developed and implemented
- Complex whole-body compliance behaviors are intuitively set using a compact Multi Spring Model (MSM)
- The method is validated both in simulation and on a real robot. A two hand grasping task and a whole-body balancing task are successfully executed

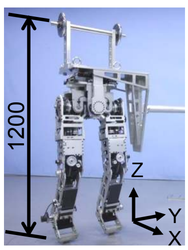


17:50–18:05 WeFT10.5

Running with Lower-Body Robot That Mimics Joint Stiffness of Humans

T. Otani[1], K. Hashimoto[1], M. Yahara[1], S. Miyamae[1], T. Isomichi[1], M. Sakaguchi[2], Y. Kawakami[1], H. O. Lim[3] and A. Takanishi[1]
[1]Waseda University, Japan [2]University of Calgary, Canada [3]Kanagawa University, Japan

- We developed a running control method including pelvis oscillation control for attaining jumping power with the joint stiffness of the leg and running speed control by changing the landing placement of the leg.
- This robot could accomplish the running motion in saggital plane with one leg.

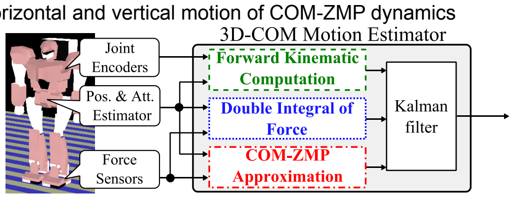


18:05–18:20 WeFT10.6

COM Motion Estimation of a Humanoid Robot Based on a Fusion of Dynamics and Kinematics Information

Ken Masuya[1], Tomomichi Sugihara[1],
[1]Dept. of Adaptive Machine Systems , Osaka University, Japan

- A novel COM motion estimation for a humanoid robot
- Kalman filter combines forward kinematics computation, double-integral of force and COM-ZMP approximation
- Error in vertical direction reduced using interference between horizontal and vertical motion of COM-ZMP dynamics



Optimal Control

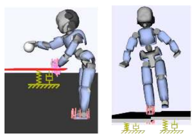
Chair *Vincent Padois, Université Pierre et Marie Curie*
Co-Chair *Michael Mistry, University of Birmingham*

16:50–17:05	WeFT11.1

Reactive whole-body control for humanoid balancing on non-rigid unilateral contacts

Mingxing Liu and Vincent Padois
Pierre and Marie Curie University

- obtain sufficient reaction forces from a compliant environment to support the whole-body motion
- automatically regulate contact forces and whole-body motions based on the motion of contact points
- without the awareness of the rigidity properties of the contact material



17:05–17:20	WeFT11.2

Optimal Control with State and Command Limits for a Simulated Ball Batting Task

Dennis Schüthe, Udo Frese
University of Bremen, Germany

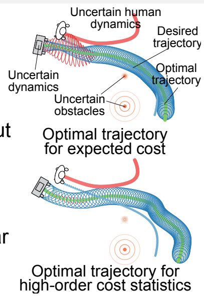
- Task: Rebound a thrown ball
- Finite horizon task level optimal control
- Soft constraints on states and commands
- Task formalization: Be at a given time at a given Cartesian position with a given Cartesian velocity
- No explicit trajectory planning
- Actively exploit redundancy of the robot
- Task and constraints packed into cost functions

17:20–17:35	WeFT11.3

Uncertainty-dependent Optimal Control Considering High-Order Cost Statistics

José Ramón Medina and Sandra Hirche
Technische Universität München, Germany

- Explicit consideration of uncertainty of dynamics and environment in stochastic optimal control
- Considering not only the expected cost but also higher order statistics (cumulants)
- Extension of iLQG algorithm to risk-sensitive and cost-cumulant variants
- Proposed approach evaluated in nonlinear plants with nonlinear costs

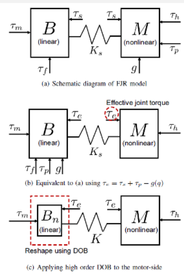


17:35–17:50	WeFT11.4

Carrying Heavy Payload with Limited Sensory Information Using High Order Disturbance Observer

Min Jun Kim[1], Woong Yong Lee[1], Jong-hun Park[1] and Wan Kyun Chung[1]
[1]POSETCH, Korea

- Presents an approach to apply high order DOB for payload carrying applications:
- 1. use flexible joint model (Fig. a)
- 2. estimate effective joint torque (Fig. b)
- 3. apply DOB to the motor-side dynamics (Fig. c)
- High order DOB is applicable without any further special treatments because the motor-side dynamics is linear

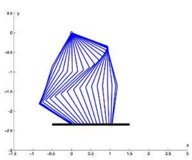


17:50–18:05	WeFT11.5

Projected Inverse Dynamics Control and Optimal Control for Robots in Contact with the Environment: A Comparison

Valerio Ortenzi[1], Rustam Stolkin[1], Jeffrey A. Kuo[2] and Michael Mistry[1]
[1]University of Birmingham, UK [2]NNL, UK

- Comparison of Performances between Optimal Control and Projected Inverse Dynamics Control
- Extension to Force Control (Projected Dynamics)
- Focus on Torque Commands: Projected Dynamics reduces torques w.r.t. classical controllers; Optimal Control based on Projected Dynamics reduces torques w.r.t. Projected Dynamics

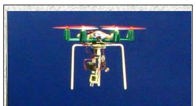


18:05–18:20	WeFT11.6

Nonlinear control of a nano-hexacopter carrying a manipulator arm

J. A. Muñoz[1], N. Marchand[1], J. G. Castellanos[2], A. L. Luna[2], J. T. Guzmán[1], J. C. Vázquez[1], S. Durand[3].
[1]Grenoble Univ., France [2]Puebla Univ., Mexico [3]Marseille Univ., France

This paper proposes a simple solution for stabilization of a nano-hexacopter carrying a manipulator arm in order to increase the type of missions achievable by these types of systems. The present work deals with the stabilization of the whole system - that is hexacopter and arm-.
Experimental results validate the proposed control strategy.



Nano-hexacopter with its arm manipulator in flight

Nonholonomic Motion Planning

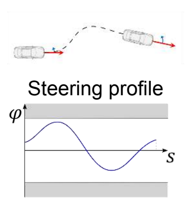
Chair *Benjamin Kuipers, University of Michigan*
Co-Chair *Mikhail Svinin, Kyushu University*

16:50–17:05 WeFT12.1

Novel Steering Profile for Efficient Trajectory Planning

Olexiy Lazarevych[1], Felix Sedlmeier[1], Tillmann Schumm[1]
[1]BMW Car IT GmbH, Germany

- We present an approach to planning motion trajectories that satisfy the initial and target poses as well as the actuator states of the vehicle at the boundaries.
- The approach uses a steering profile inspired by human driving behavior.
- The numerical solver of the trajectory planner relies on the careful parametrization of the steering profile.

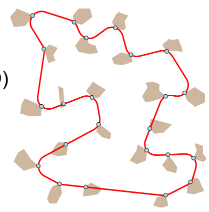


17:05–17:20 WeFT12.2

On the Dubins Traveling Salesman Problem with Neighborhoods

Petr Váňa, Jan Faigl
Czech Technical University in Prague, Czech Republic

- Fast algorithm for the Dubins Traveling Salesman Problem with Neighborhoods (DTSPN)
- Efficient Local Iterative Optimization (LIO) algorithm based on properties of the optimal solution of the DTSPN
- High quality solutions of the DTSPN and the DTSP
- Low computational requirements

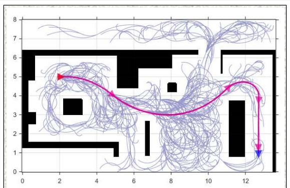


17:20–17:35 WeFT12.3

Feedback Motion Planning via Non-holonomic RRT* for Mobile Robots

Jong Jin Park[1], and Benjamin Kuipers[1]
[1]University of Michigan, USA

- We provide a non-holonomic distance function and exact steering to extend the RRT* to unicycle-type vehicles under differential constraints.
- The critical feature of our distance function is that it is also a control-Lyapunov function, so it better reflects the true cost-to-go between configurations and the constraints.



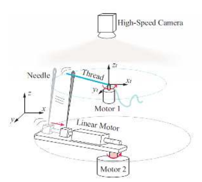
Our algorithm finds smooth and precise paths that exactly reach the goal for unicycle-type vehicles

17:35–17:50 WeFT12.4

Robotic Needle Threading Manipulation Based on High-Speed Motion Strategy Using High-Speed Visual Feedback

Shouren Huang[1], Yuji Yamakawa[1], Taku Senoo[1] and Masatoshi Ishikawa[1]
[1]University of Tokyo, Japan

- Simplifies the needle threading to be peg-insertion based on high-speed motion strategy as well as high-speed visual sensing;
- Complexity of interaction between robot and deformable thread is significantly simplified, rapid manipulation was realized.



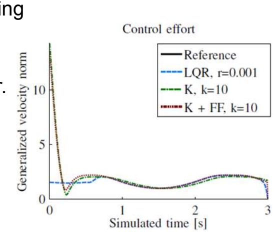
Concept

17:50–18:05 WeFT12.5

A Dual Quaternion Linear-Quadratic Optimal Controller for Trajectory Tracking

Murilo M. Marinho[1], Luis F. C. Figueredo[2] and Bruno V. Adorno[3]
[1]The University of Tokyo, Japan [2]Universidade de Brasilia, Brazil
[3]Federal University of Minas Gerais, Brazil

- We propose a linear-quadratic regulator (LQR) for trajectory tracking using dual quaternion algebra.
- The controller optimally balances control effort and end-effector error.
- Performance is evaluated on a simulated six-DOF robot manipulator and compared to proportional (K) and feed-forward (K+FF) controllers.

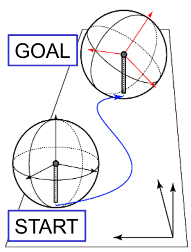


18:05–18:20 WeFT12.6

Motion Planning for a Pendulum-Driven Rolling Robot Tracing Spherical Contact Curves

Yang Bai[1], Mikhail Svinin[1] and Motoji Yamamoto[1]
[1]Kyushu University, Japan

- Motion planning problem (transfer of the robot to a goal state) can be decoupled to kinematic and dynamic levels.
- A reduced dynamic model is derived by imposing virtual constraints restraining the motion of the pendulum to the vertical plane tangential to the contact curve.
- Feedforward control algorithm, generating rest-to-rest motion of the rolling robot, is proposed.



Gesture, Posture, Social Spaces and Facial Expressions

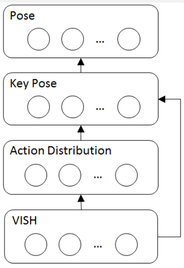
Chair *C. S. George Lee, Purdue University*
Co-Chair *Kostas Kyriakopoulos, National Technical Univ. of Athens*

16:50–17:05 WeFT13.1

Human-Pose Estimation with Neural-Network Realization

Kai-Chi Chan, Cheng-Kok Koh and C. S. George Lee
School of Electrical and Computer Engineering,
Purdue University, U.S.A.

- A probabilistic graphical model (PGM) is realized by a scalable neural network so that factors in a PGM can be designed automatically.
- The realization process allows factors to be adaptive and provides semantic meaning to the nodes and hidden layers in a neural network.
- Experiment results showed that the proposed neural-network realization outperformed some existing works for human-pose estimation using a benchmark dataset.

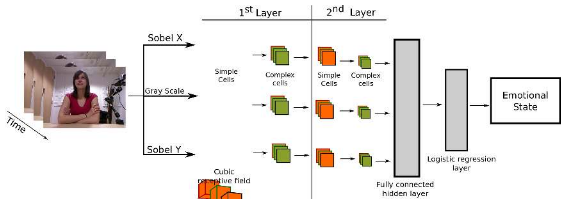


17:05–17:20 WeFT13.2

Recognizing Complex Mental States with Deep Hierarchical Features for Human-Robot Interaction

Pablo Barros[1], Stefan Wermter[1],

[1]University of Hamburg, Germany

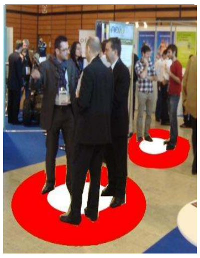


17:20–17:35 WeFT13.3

On equitably approaching and joining a group of interacting humans

Vishnu K. Narayanan[1], Anne Spalanzani[1], Francois Pasteau[2] and Marie Babel[3]
[1]Inria/IRISA Rennes, France [2]UPMF and Inria Grenoble, France
[3]INSA and IRISA Rennes, France

- Approaching and Joining a group while respecting social constraints
- Sensor-based control task in order to reach an optimal meeting point
- Simulation trials demonstrate the convergence and efficiency of the system
- Low-level system for Human-aware navigation



17:35–17:50 WeFT13.4

Determining Natural and Accessible Gestures using Uncontrolled Manifolds and Cybernetics

Hairong Jiang, Chun-Hao Hsu,
Bradley S. Duerstock and Juan P. Wachs
Purdue University, USA

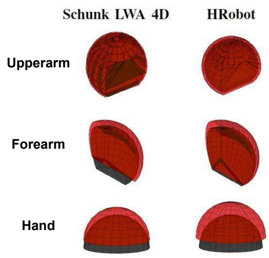
- Apply the Uncontrolled Manifold theory to analyze the variability and stability of gestures
- Simulate gesture trajectories using a WAM™ robotic arm and use *Work* to assess the effort
- An integration is made between Stability indices and *Work* to determine the final accessible gestures

17:50–18:05 WeFT13.5

Quantifying Anthropomorphism of Robot Arms

Christoforos I. Mavrogiannis[1], Minas V. Liarokapis[1], and Kostas J. Kyriakopoulos[3]
[1]Cornell Univ., USA [2]Yale Univ., USA [3]NTUA, USA

- An index for the quantification of anthropomorphism of robot arms.
- The index is defined as the weighted sum of specific metrics which evaluate the similarities between the human and robot arm workspaces.
- The score ranges from 0 (non-anthropomorphic artifacts) to 1 (human-identical artifacts).



Dynamics

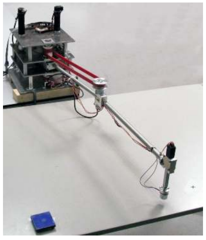
Chair *Neel Doshi, Harvard*
Co-Chair *Fumihiko Asano, Japan Advanced Institute of Science and Technology*

16:50–17:05 WeFT14.1

The effect of the choice of feedforward controllers on the accuracy of low gain controlled robots

Michiel Plooij*, Wouter Wolfslag*, Martijn Wisse
Delft University of Technology, The Netherlands
* These authors contributed equally to this paper

- This paper shows how the choice for a feedforward controller, influences the end-position accuracy of the robot.
- The robot performs pick-and-place tasks, and the feedback control gain is varied.
- Results show that the optimal choice for a trajectory between the pick- and place positions, can lead to an 8-fold increase in the accuracy.



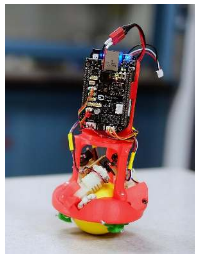
17:05–17:20 WeFT14.2

Design and Control of a Micro Ball-Balancing Robot (MBBR)

Daniel Yang, Eric Sihite, Jeffrey M. Friesen, Thomas Bewley
University of California San Diego, United States

Ball-balancing robots (BBRs) have rich dynamics and exhibit unique motion. The challenges of miniaturizing a BBR are: fast time scales, reduced normal forces, and lower strength. By using novel drive wheel placements, a linearized decoupled system model and successive loop closure control techniques, we successfully built and stabilized a working MBBR.

Height: 22cm, **Mass:** 580g, **Cost:** <$200

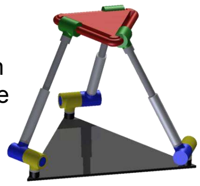


17:20–17:35 WeFT14.3

Dynamic Modeling of the Translational RPC-Manipulator

Isabel Prause[1] and Burkhard Corves[1]
[1]RWTH Aachen University

The performance of the 3-DOF RPC-manipulator with respect to a varying actuator and frame configuration for a given manipulation task is analyzed. For this purpose, the inverse dynamics are presented and the differences between the kinetostatic and dynamic model are highlighted.

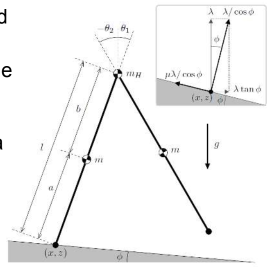


17:35–17:50 WeFT14.4

Passive Dynamic Walking of Compass-like Biped Robot on Slippery Downhill

Fumihiko Asano[1], Toshiaki Saka[1] and Tetsuro Fujimoto[1]
[1]School of Information Science, JAIST, Japan

- A planar 4-DOF compass-like biped robot is introduced for analysis.
- Numerical simulations show that the model can achieve instantaneous stance-leg exchange and generate a stable passive compass gait on a slippery downhill.
- Period-doubling bifurcation according to the sliding friction coefficient is observed.

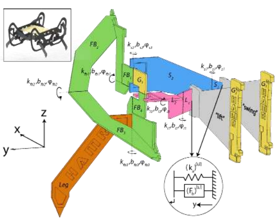


17:50–18:05 WeFT14.5

Model Driven Design for Flexure-Based Microrobots

Neel Doshi, Benjamin Goldberg, Ranjana Sahai, Noah Jafferis, Daniel Aukes, and Robert J. Wood
John A. Paulson School of Engineering and Applied Sciences, Harvard University, Cambridge, MA, USA

- Dynamic model of flexure based transmission
- Empirical model of compliant flexures
- Model informed redesign to improve payload to 2.9g (2x body mass,114% increase)


Model schematic: isometric view

18:05–18:20 WeFT14.6

A General Analytical Procedure for Robot Dynamic Model Reduction

Manuel Beschi[1], Enrico Villagrossi[1,2], Nicola Pedrocchi[1] and Lorenzo Molinari Tosatti[1]
[1]CNR-ITIA, Milan, Italy
[2]University of Brescia, Dep. of Mech. and Ind. Eng, Brescia, Italy

- **Motivation:** the symbolic dynamic model reduction still remains a challenging task, hardly automatable especially for closed-chain kinematics.
- **Method:** exploiting a multi-dimensional Fourier series decomposition of the dynamic equations, an automatic and analytical reduction of the dynamic model is presented.
- **Validation:** a simulated example shows the effectiveness of the proposed algorithm.

Wheeled Robots

Chair *Shugen Ma, Ritsumeikan University*
Co-Chair *Andreas Mueller, Johannes Kepler University*

16:50–17:05 WeFT15.1

Online Path Tracking and Motion Optimization of a 4WS4WD Vehicle

Penglei Dai and Jay Katupitiya
University of New South Wales, Australia

- Online Path Tracking by 7-order Bézier Curves
- Vehicle Dynamic Model Developed for Force Control
- Real-time Vehicle Motion Optimization by PSO
- Simulation Results and Remarks

17:05–17:20 WeFT15.2

Analysis and Path Control of a Mobile Platform with Several Steerable Wheels

Christoph Stöger[1], Andreas Müller[1] and Hubert Gattringer[1]
[1]Institute of Robotics, Johannes Kepler University Linz, Austria

- Control problem suffers from kinematic **singularities** e.g. coaxial wheel orientation
- **Regularization** of this singularities with a:
  - a) regularly parametrized
  - b) second order model of the constraints
- Provides the basis for an **input output linearization** in terms of the path parameter
- With new design option: **choice of path parameter**

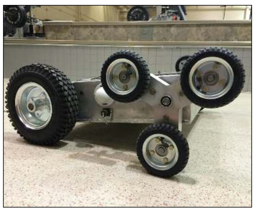
Omnidirectional non-holonomic platform

17:20–17:35 WeFT15.3

The Tri-Wheel: A Novel Wheel-Leg Mobility Concept

Lauren M. Smith[1], R.D.Quinn[3], K.A.Johnson[2], W.R.Tuck[4]
[1]Northrop Grumman, USA [2]NASA Glenn Research Center, USA
[3]Case Western Reserve University, USA [4]Jacobs Technology USA

- The Tri-Wheel is a novel wheel-leg locomotion concept inspired by work with first responders. It utilizes a unique gearing system to enable both a high speed driving mode and a high torque climbing mode.
- This work introduces the Tri-Wheel concept and provides preliminary testing to validate its predicted operating characteristics.

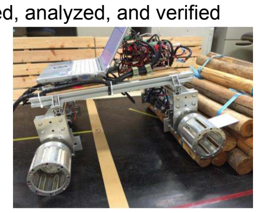


17:35–17:50 WeFT15.4

Modeling Paddle-aided Stair-Climbing for a Mobile Robot based on Eccentric Paddle Mechanism

Yi Sun[1], Yang Yang[1], Shugen Ma[1,2] and Huanyan Pu[2]
[1]Ritsumeikan University, Japan [2]Shanghai University, China

- A mobile robot based on Eccentric Paddle Mechanism (ePaddle) is proposed for accessing rough terrains;
- Paddle-aided stair-climbing is modeled, analyzed, and verified experimentally;
- Critical scenarios are found by analyzing frictional requirements of stair-climbing;
- Paddle's motion improves robot's stair-climbing capacity.

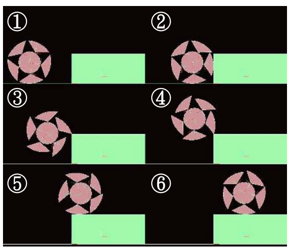


17:50–18:05 WeFT15.5

Study of Swing-Grouser Wheel: A Wheel for Climbing High Steps, even in Low Friction Environment

Hirotaka Komura[1], Hiroya Yamada[2], Shigeo Hirose[2], Gen Endo [1] and Koichi Suzumori[1]
[1]Tokyo Institute of Technology, Japan [2]Hibot corp., Japan

- We propose a new wheel mechanism "swing-grouser wheel", which can climb a higher step than its radius.
- The step climbability and the energy efficiency was confirmed by 2D physics simulation.
- The parameter was improved by full search of parameters.

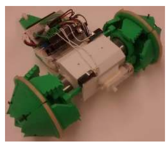


18:05–18:20 WeFT15.6

A Transformable Wheel Robot with A Passive Leg

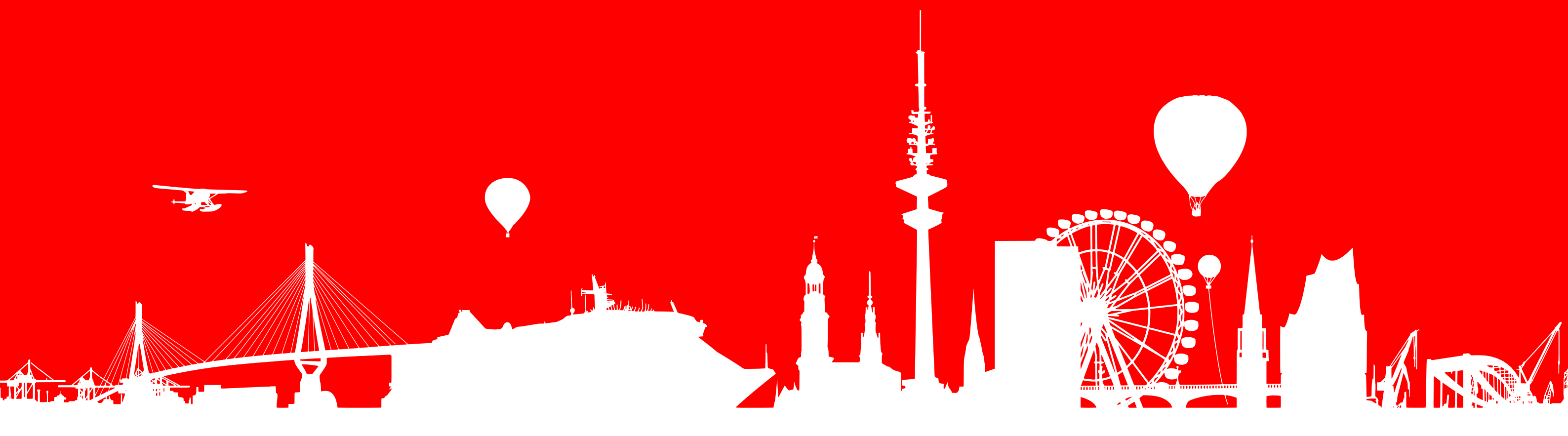
Yu She[1], Carter J. Hurd[1]and Hai-jun Su[1]
[1]The Ohio State University, USA

- A mobile robot with fixed wheel structure might have difficulty satisfying the wild environment with variable terrains;
- Existing transformable mobile robots might be able to change their configuration with a light payload;
- We design such a mobile robot with a passive leg, which can transform under a heavy payload, with the ability of obstacle overcoming and adaptability of dynamic surfaces



Technical Sessions

Thursday
October 1, 2015



Cognitive Human-Robot Interaction

Chair *Jorge Dias, University of Coimbra*
Co-Chair *Tetsuya Ogata, Waseda University*

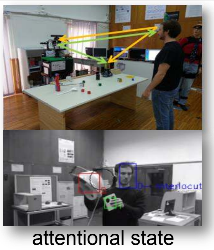
08:30–08:45 ThAT1.1

Designing an Artificial Attention System for Social Robots

Pablo Lanillos[1], João Filipe Ferreira[1], and Jorge Dias[1,2]
[1]Institute of Systems and Robotics, University of Coimbra, Portugal [2]Khalifa University of Science,UAE

Artificial Attention as middleware for sophisticated human-robot interaction

- Bioinspired cognitive functional design
- Hierarchical multisensory perception and goal-dependent action selection
- Closing the action-perception loop and enabling social behaviour



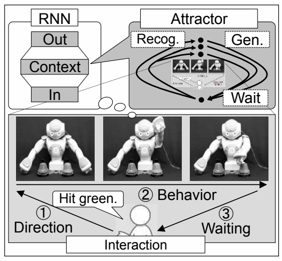
attentional state and intention inference

08:45–09:00 ThAT1.2

Attractor Representations of Language--behavior Structure in a Recurrent Neural Network for Human--robot Interaction

Tatsuro Yamada, Shingo Murata, Hiroaki Arie and Tetsuya Ogata
Waseda University, Japan

- To achieve a robot which can behave corresponding to linguistic directions, we make an RNN self-organize attractors representing interaction series in its dynamics.
- The attractors enable the robot to understand language—behavior relationship, respond to directions immediately and repeatedly, and take turns autonomously.

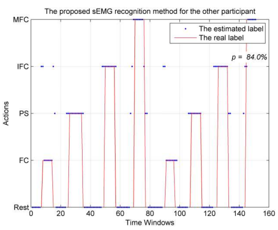


09:00–09:15 ThAT1.3

An User-Independent Gesture Recognition Method Based on sEMG Decomposition

Anbin Xiong[1], Xingang Zhao[1], Jianda Han[1], Guangjun Liu[2] and Qichuan Ding[1]
[1] Shenyang Institute of Automation, Chinese Academy of Sciences
[2] Ryerson University, Canada

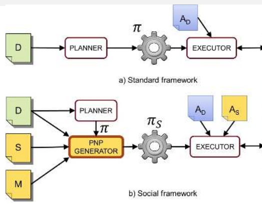
- sEMG recognition has been used extensively in human-robot interface.
- However, the recognition model, trained with one subject's sEMG data, is not applicable to the other subjects.
- An user-independent sEMG recognition method is proposed, which can achieve a mean accuracy of 81.5%.



09:15–09:30 ThAT1.4

Explicit Representation of Social Norms for Social Robots

F. M. Carlucci [1] , L. Nardi [1,2], L. Iocchi [1], D. Nardi [1]
[1] DIAG, Sapienza University of Rome Italy
[2] Inst. for Geodesy and Geoinformation, Univ. of Bonn, Germany



- Automatic generation of social plans from explicit social norms.
- **High variability of social behaviors by only defining social norms.**

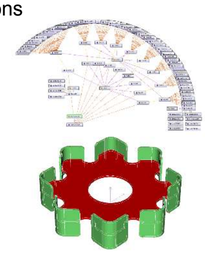
Fully implemented system and several tests performed with users
https://sites.google.com/site/socialrobotplanning/

09:30–09:45 ThAT1.5

An ontology for CAD data and geometric constraints…

Alexander Perzylo[1], Nikhil Somani[1], Markus Rickert[1] and Alois Knoll[2]
[1]fortiss, Germany [2]Technische Universität München, Germany

- Knowledge Representation beyond polygons
- Semantic deep object models (OWL)
  - BREP (Points, edges, faces, …)
  - Geometric constraints (parallel, concentric, coincident, distance, …)
  - Connection to polygons for rendering
- Linking to additional semantic data
  - Parameters for semantic robot tasks
  - Primitives for object recognition



09:45–10:00 ThAT1.6

Procedural Semantics for Autonomous Robots – A Case Study in Locative Language

Michael Spranger
Sony Computer Science Laboratories Inc, Tokyo, Japan

- Application of a procedural semantics framework to autonomous robots.
- We model insights from decades of research in cognitive linguistics to develop a system capable of autonomously producing and interpreting German locative utterances.
- The system is tested in the real world using a population of robots that talk to each other via natural language.

Example of scene used for evaluation

Smart Robotics Application 1

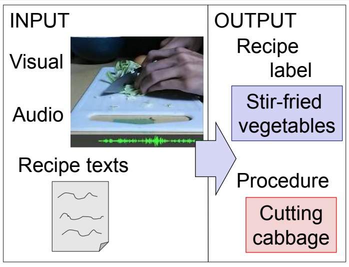
Chair *Kazuhiro Nakadai, Honda Research Inst. Japan Co., Ltd.*
Co-Chair *Cristian Secchi, Univ. of Modena & Reggio Emilia*

08:30–08:45 ThAT2.1

Audio-visual scene understanding utilizing text information for a cooking support robot

Ryosuke Kojima[1], Osamu Sugiyama[1] and Kazuhiro Nakadai[1,2]
[1]Tokyo Institute of Technology, Japan
[2]Honda Research Institute Japan Co., Ltd., Japan

- Proposed a multimodal cooking scene understanding framework consisting of CNN and two-layered HHMM.
- Tackled recipe estimation and cooking procedure extract ion to aim at an interactive cooking support system

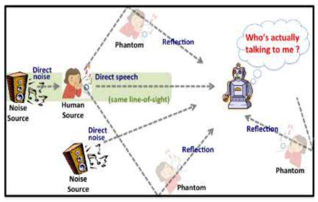


08:45–09:00 ThAT2.2

Utilizing Visual Cues in Robot Audition for Sound Source Discrimination in Speech-based Human-Robot Communication

Randy Gomez, Levko Ivanchuk, Keisuke Nakamura, Takeshi Mizumoto and Kazuhiro Nakadai
Honda Research Institute Japan, Co., Ltd.

- Phantom sources mitigation due to reflections and background noise.
- Improving acoustic based robot attention by using multimodal information
- Robust speech-based communication with robots

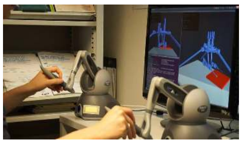


09:00–09:15 ThAT2.3

Bilateral Teleoperation of a Dual Arms Surgical Robot with Passive Virtual Fixtures Generation

Federica Ferraguti[1], Nicola Preda[2], Marcello Bonfè[2] and Cristian Secchi[1]
[1]University of Modena and Reggio Emilia, Italy
[2]University of Ferrara, Italy

- Virtual fixtures embedded in a teleoperation system for assisting and guide the user towards the completion of a task.
- Rotation of the virtual force for improving the efficiency of the system.
- Experimental validation on a dual arms surgical robot.

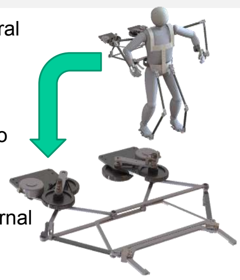


09:15–09:30 ThAT2.4

A Balance Feedback Human Machine Interface for Humanoid Teleoperation in Dynamic Tasks

Joao Ramos[1], Albert Wang[1] and Sangbae Kim[1]
[1]Massachusetts Institute of Technology, USA

- This work explores strategies for bilateral feedback during humanoid full-body teleoperation;
- Robot state of balance is translated into force applied to the operator hips;
- Balancing task is evaluated under external diturbances.

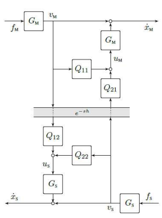


09:30–09:45 ThAT2.5

On the Parameterization of Feasible Admittance Matrices in Delayed Bilateral Teleoperation

Jang Ho Cho[1] and Maxim Kristalny[2]
[1]KIMM, South Korea [2]Technion-IIT, Israel

- Characterizing all **teleoperation system** behaviors that can be achieved with **delayed communication.**
- We obtain a **complete parameterization** of all the admittance matrices feasible under the nominal stability constraint.
- The use of this parameterization for **shaping system behavior** is demonstrated.

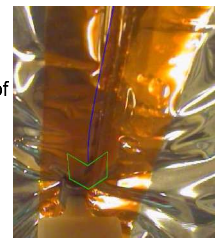


09:45–10:00 ThAT2.6

Preliminary Study of Virtual Nonholonomic Constraints for Time-Delayed Teleoperation

Steve Vozar[1,2], Zihan Chen[1], Peter Kazanzides[1] and Louis L. Whitcomb[1]
[1]Johns Hopkins University, USA [2]University of Michigan, USA

- Motion constraints can assist with time-delayed teleoperation tasks.
- Virtual (software-imposed) nonholonomic constraints (VNHC) can reduce number of input DoF, without reducing output DoF.
- We also introduce a soft virtual fixture subject to nonholonomic constraints.
- Four-subject pilot test shows promise for VNHC for the motivating time-delayed satellite servicing example.



Recognition

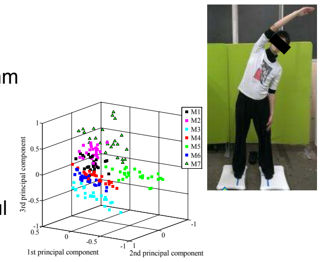
Chair *Rüdiger Dillmann, Karlsruhe Institute of Technology (KIT)*
Co-Chair *Urbano Nunes, Instituto de Sistemas e Robotica*

08:30–08:45	ThAT3.1

Human motion classification and recognition using whole-body contact force

T. Yabuki and G. Venture
Tokyo Univ. of Agri. & Tech., Japan

- Force during exercise
- Segment and classify data
- Propose a recognition algorithm based on feature vector and PCA
- Test on 5 subjects with 7 different motions
- Achieve about 80% successful recognition

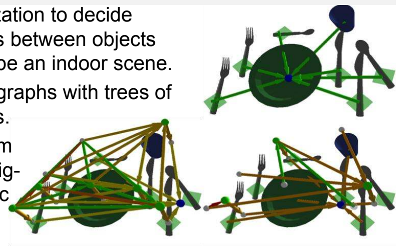


08:45–09:00	ThAT3.2

Automated Selection of Spatial Relations for Modeling & Recognizing Scenes with Hierarchical Implicit Shape Models

Pascal Meißner, Fabian Hanselmann, Rainer Jäkel, Sven R. Schmidt-Rohr and Rüdiger Dillmann
Karlsruhe Institute of Technology, Germany

- Combinatorial optimization to decide which spatial relations between objects are relevant to describe an indoor scene.
- Scenes, modeled as graphs with trees of Implicit Shape Models.
- Models, extracted from perceived object configurations, characteristic for a certain scene.

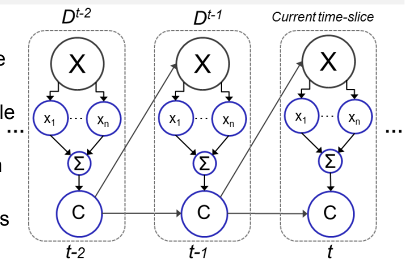


09:00–09:15	ThAT3.3

Applying Probabilistic Mixture Models to Semantic Place Classification in Mobile Robotics

Cristiano Premebida[1], Diego Faria[1], Francisco A. Souza,[2] and Urbano Nunes[1]
[1]ISR, DEEC, Univ. Coimbra, Portugal. [2]DEE, Univ. Ceará, Brazil.

- Dynamic Bayesian Network with Mixture Models (**DBMM**)
- Recursive update rule (smoothing)
- Very good results on benchmark datasets
- Laser-based features

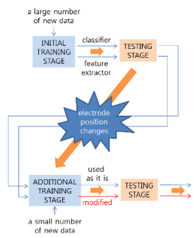


09:15–09:30	ThAT3.4

sEMG-based Decoding of Detailed Human Intentions from Finger-level Hand Motions

Myoung Soo Park, and Sang-Rok Oh
Korea Inst. of Science and Technology (KIST)

- For practical applications, an sEMG (surface electromyography) decoder needs to have a robustness to the changes of electrode positions as well as a high decoding performance
- A new practical decoder is proposed to decode intentions behind continuous, finger-level hand motions, by using a improved supervised feature extractor and a simple classifier.

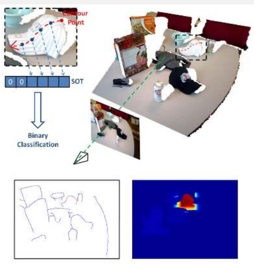


09:30–09:45	ThAT3.5

Surface Oriented Traverse for Robust Instance Detection in RGB-D

Ruizhe Wang[1], Gérard Medioni[1] and Wenyi Zhao[2]
[1]Univ. of Southern California, USA [2]DAQRI, USA

- **Problem:** Detect object of interest in RGB-D image in the presence of noisy data, cluttering, partial occlusion and large pose variation.
- **Method:** Extract Surface Oriented Traverse (SOT) feature for each contour point in the depth image; Classify all contour points to generate a saliency map for object detection.



Localization 4

Chair *Anthony Tzes, University of Patras*
Co-Chair *Niko Sünderhauf, Queensland University of Technology*

08:30–08:45 ThAT4.1

Re-emission and Satellite Aerial Maps Applied to Vehicle Localization on Urban Environments

L. de Paula Veronese[1], E. de Aguiar[1], R. Correia Nascimento[1], J. Guivant[2], F.A. Auat Cheein[3], A.F. De Souza[2] and T. Oliveira-Santos[1]
[1]Universidade Federal do Espírito Santo, Brazil
[2]University of New South Wales, Australia
[3]Universidad Técnica Federico Santa María, Chile

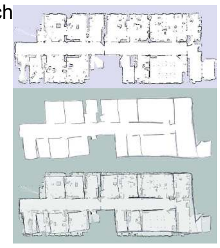
- A Particle Filter Localization improved by Normalized Mutual Information distance to localize a vehicle comparing top view images with different acquisition principles.

08:45–09:00 ThAT4.2

Monte Carlo Localization in Hand-Drawn Maps

B. Behzadian, P. Agarwal, W. Burgard and G. D. Tipaldi
University of Freiburg, Germany

- Localization needs accurate maps, which can be a burden for non expert users
- **Idea**: Localization in hand-drawn maps
- Directly model the deformations of the hand-drawn map
- Extend Monte Carlo localization to estimate the local deformations
- Convergence rate of about 80% in the correct location in real environments

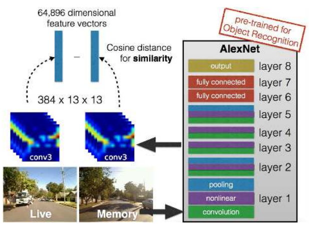


09:00–09:15 ThAT4.3

On the Performance of ConvNet Features for Place Recognition

Niko Sünderhauf, Sareh Shirazi, Feras Dayoub, Ben Upcroft, Michael Milford
Australian Centre for Robotic Vision, Queensland University of Technology (QUT)

- Learnt features have revolutionized object recognition and scene understanding
- We comprehensively evaluate their utility for place recognition
- Features trained on object recognition databases enable state of the art place recognition performance

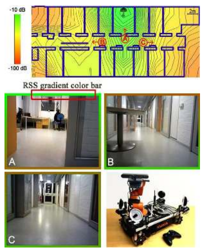


09:15–09:30 ThAT4.4

Extending a UGV Teleoperation FLC Interface with Wireless Network Connectivity Info.

Sergio Caccamo[1], Ramviyas Parasuraman[1], Fredrik Båbarg[1] and Petter Ögren[1]
[1]KTH Royal Institute of Technology, Sweden

Visual teleoperation interface of the Free Look Control (FLC) is extended with Radio Signal Strength (RSS) **Direction of Arrival (DoA)** info around a UGV's camera view.
This enhances Situational Awareness and assists operator in **avoiding loss of connectivity** with the UGV.
Experimental results show **high accuracy and reliability** in presenting the DoA information to the operator.

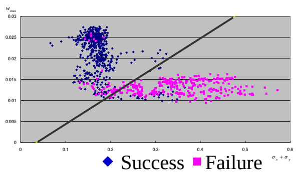


09:30–09:45 ThAT4.5

Detection of Localization Failure using Logistic Regression

Akinobu Fujii[1], Minoru Tanaka[1], Hidenori Yabushita[2] , Takemitsu Mori[2] and Tadashi Odashima[2]
[1]Toyota Central R&D Labs., Inc., Japan
[2]Toyota Motor Corporation, Japan

- Detection of localization failure in Monte Carlo Localization using logistic regression with high reliability.
- Hybrid localization scheme with the probability of localization failure is proposed to reduce pose error in cluttered environments.



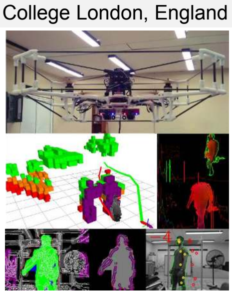
Classification result by logistic regression

09:45–10:00 ThAT4.6

Aerial Robotic Tracking of a Generalized Mobile Target employing Visual and Spatio-Temporal Dynamic Subject Perception

Christos Papachristos[1], Dimos Tzoumanikas[2] and Anthony Tzes[3]
[1,3]University of Patras, Greece [2]Imperial College London, England

- **Fully-onboard** 3D visual perception
- **Identification & Segmentation** of a *generalized* dynamic subject
- **Real-time Tracking** employing 3D *spatial* & *temporal* perception along with *visual* cues & features
- **Autonomous Aerial Robotic Mobile Tracking** & *relocalization* of a free-roaming subject with *collision-free* navigation in a cluttered environment



Mechanism Design 2

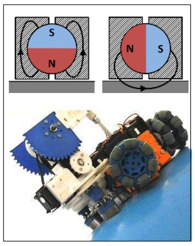
Chair *Mahmoud Tavakoli, University of Coimbra*
Co-Chair *Jean-Pierre Merlet, INRIA*

08:30–08:45	ThAT5.1

Switchable magnets for robotics applications

Mahmoud Tavakoli[1], Carlos Viegas[1], José C. Romão[1]
Pedro Neto[2] and Aníbal T. de Almeida[1]
[1]Institute for Systems and Robotics, University of Coimbra, Portugal [2]CEMUC, University of Coimbra, Portugal

- Switchable magnet is a device which uses moving permanent magnets to change the magnetic flux path and switch on or off the magnetic attraction force.
- Developed a novel device in a smaller scale with the best holding force/mass ratio, for using in climbing robot applications.

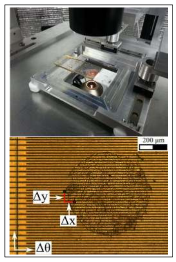


08:45–09:00	ThAT5.2

Design and Analysis of an Under-actuated XYθ Stage for Automated Tissue Indentation

Carolyn M. Davis, Kihan Park, and Jaydev P. Desai
University of Maryland, College Park, Maryland, USA

- Micro-manipulation stage design
  - Compatible with the microscope
  - Large range of motion
- A novel under-actuated planar mechanism
  - Geometric constraints
  - Kinematic analysis
  - Controllability and observability
- Micro-manipulation for tissue indentation



09:00–09:15	ThAT5.3

A Passive Mechanism for Relocating Payloads with a Quadrotor

Joseph DeGol, David Hanley,
Navid Aghasadeghi, and Tim Bretl
University of Illinois Urbana-Champaign, USA

- Our mechanism is actuated by thrust and enables a quadrotor to relocate small payloads.
- We choose design parameters systematically and experimentally find the probability of success.
- We demonstrate our mechanism being used to relocate cameras.
- Our mechanism is open source and can be 3D printed.

09:15–09:30	ThAT5.4

R-Mo: a new mobile robotic platform to reduce height and pitch angle variations

Dongkyu Choi[1], Youngsoo Kim[1],
Seungmin Jung[1], Hwa Soo Kim[2] and Jongwon Kim[1]
[1]Seoul Nat'l Univ., South Korea [2]Kyonggi Univ., South Korea

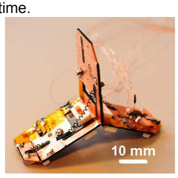
- Smooth movement is important for mobile robots on rough terrains
- Height and pitch angle variations are chosen as the measures for smooth movement
- Rocker-Bogie combined with Inverse four bar linkage mechanism is used
- Height and pitch angle variations are considerably reduced compared to the Rocker-Bogie mechanism

09:30–09:45	ThAT5.5

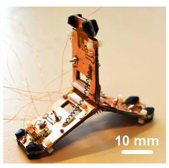
The Design and Control of The Multi-Modal Locomotion Origami Robot, *Tribot*

Zhenishbek Zhakypov, Mohsen Falahi,
Manan Shah and Jamie Paik
Reconfigurable Robotics Lab, EPFL, Switzerland

Presentation of the first origami robot that has a bi-modal locomotion
-We illustrate two fabrication methods for the robogami architecture using monolithic additive manufacturing and multi-material 3D printer.
-We applied a closed-loop control to the robogamis with the embedded curvature sensors.
-We developed a GUI platform for optimizing robogami design iteration and controlling the robot in real time.



Multi-layer integrated prototype



Multi-material 3D printed prototype

09:45–10:00	ThAT5.6

On the inverse kinematics of cable-driven parallel robots with up to 6 sagging cables

Jean-Pierre Merlet
INRIA, France

- Robot with catenary sagging cables
- Find all inverse kinematics solutions
- Require to solve complex, non-linear and non algebraic equations
- Interval analysis is used: all solutions are guaranteed to be found
- Result 1: inverse kinematics may have no solution even for a "reasonable" pose
- Result 2: up to 3 IK solutions

Medical Robots and Systems 4

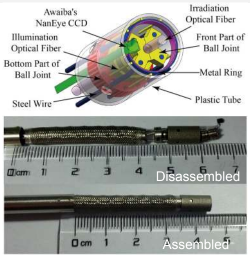
Chair *Jose Luis Pons, Spanish Research Council, CSIC*
Co-Chair *Jungwon Yoon, Gyeongsang National University*

08:30–08:45	ThAT6.1

Automatic Laser Ablation Control Algorithm for an Novel Endoscopic Laser Ablation End Effector for Precision Neurosurgery

Baiquan Su[1], Jie Tang[2], Hongen liao[1]
[1] Department of Biomedical Engineering, Tsinghua University, China
[2]Beijing Tiantan Hospital, Capital Medical University, China

- ◆ A laser ablation end effector system for minimally invasive surgery is designed and built.
- ◆ An ablation algorithm for planar lesion case, and we explain the overall method and procedure of laser ablation.
- ◆ The experimental results demonstrates the performance of the laser ablation system.



Prototype of laser ablation distal module

08:45–09:00	ThAT6.2

A Flexible Architecture to Enhance Wearable Robots: Integration of EMG-informed Models

E. Ceseracciu[1], A. Mantoan[1], M. Bassa[1], J. Moreno[2], J. Pons[2], G. Asin[2], A. del Ama[3], E. Marquez[3], A. Gil[3], C. Pizzolato[4], D. Lloyd[4], M. Reggiani[1]
[1]U Padova,Italy [2]CSIC,Spain [3]HospSCI,Spain [4]Griffith U, Australia

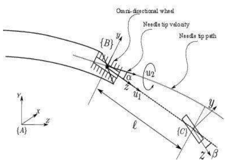
- Need to monitor and engage the **user** that is wearing an exoskeleton
- **ROS**-based architecture to include different sensors and diverse software tools
- Proof of concept: use of electromyographic signals to drive **neuromusculoskeletal** models and estimate users' muscle forces online
- Results are reported for two healthy subjects and compared with unassisted walking condition

09:00–09:15	ThAT6.3

Extended Bicycle Model for Needle Steering in Soft Tissue

B. Fallahi[1], M. Khadem[1], C. Rossa[1]
R. Sloboda[2], N. Usmani[2] and M. Tavakoli[1]
[1]University of Alberta, Canada, [2]Cross Cancer Institute, Canada

- We propose a model for needle deflection in soft tissue
- The needle is modelled as a bicycle model with omni-directional wheels to account for needle tip deflection with- non constant curvatures
- Needle tip deflection can be estimated with the maximum error of 0.66 mm, compared to 3.79 mm error obtained from original bicycle model

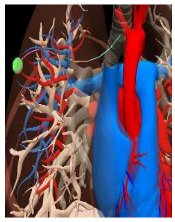


09:15–09:30	ThAT6.4

Optimizing Sets of Concentric Tube Robot Designs using Motion Planning

C. Baykal, L. G. Torres, and R. Alterovitz
University of North Carolina at Chapel Hill

- Novel design optimization algorithm for generating patient- and application-specific sets of concentric tube robot designs
- Method generates sets of designs that can maximize reachability to clinical targets
- Algorithm interleaves global optimization algorithm and motion planning to generate robot designs with high reachable goal coverage in a practical amount of time

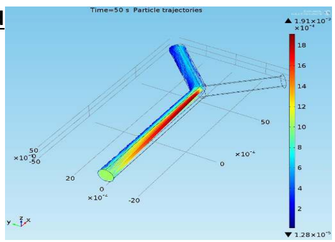


09:30–09:45	ThAT6.5

An Optimized Field Function Scheme for Nanoparticle Guidance in MDT systems

Ton Duc Do[1], Yeongil Noh[1],
Myeong Ok Kim[1] and Jungwon Yoon[1]
[1]Gyeongsang National University, Republic of Korea

- An **optimized and modified field function scheme** are proposed for maximized the particles guidance performance and reduce energy consumption
- **Guidelines** are also explained in details to achieved the highest performance



Perception for Grasping and Manipulation 1

Chair *Peter Allen, Columbia University*
Co-Chair *Manolis Lourakis, Institute of Computer Science - FOundation for Research andTechnology - Hellas*

08:30–08:45 ThAT7.1

Responsive Fingers – Capacitive Sensing During Object Manipulation

S. Mühlbacher-Karrer[1], A. Gaschler[2] and H. Zangl[1]
[1]Alpen-Adria-Universität Klagenfurt, Austria
[2]fortiss GmbH, Germany

- **Active** object categorization
  - Iterative Bayesian approach
  - Confidence level about result
- Combined **sensing** and **object manipulation**
- **Capacitive sensor** in one finger

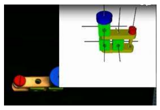
Demonstration:
- Robot bartender JAMES

08:45–09:00 ThAT7.2

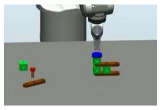
Probabilistic graph based spatial assembly relation inference for programming of assembly task by demonstration

Yue Wang, Jie Cai, Yabiao Wang, Youzhong Hu,
Rong Xiong, Yong Liu, Jiafan Zhang, Liwei Qi
State Key Laboratory of Industrial Control Technology, Zhejiang University, P. R. China

- Assembly graph is proposed as the representation of assembly tasks, which can represent the **poses of parts**, **relations between parts**, **prior domain knowledge** as well as the **observations** in a **unified** model.
- An alternative algorithm is proposed to infer a **global consistent** configuration of **poses and relations** from the assembly graph, which can be utilized to drive the robot **without programming**.



Infer the assembly task



Drive the robot to execute

09:00–09:15 ThAT7.3

Multi-Contour Initial Pose Estimation for 3D Registration

Ernest C.H. Cheung, Chao Cao, Jia Pan
The University of Hong Kong

- Effectively guess an object pose by leveraging the fact that many household objects can only keep stable on a planar surface under a small set of poses
- Reduce the 6-D pose estimation problem into a set of 3-D pose estimation problems
- Each 3-D problem is solved by detect extreme responses on the convolution result between cross-section contours of the point-cloud observation and the geometric model of the object

The limited number of object stable poses on a plane is used for fast and accurate pose estimation

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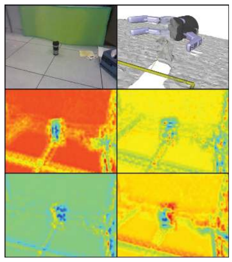
09:15–09:30 ThAT7.4

Generating Multi-Fingered Robotic Grasps via Deep Learning

Jacob Varley, Jonathan Weisz,
Jared Weiss and Peter Allen
Columbia University, USA

- A deep learning architecture for detecting palm and fingertip positions for stable grasps from partial object views
- A framework for utilizing experience gained from grasps computed on complete object models to generate grasps given partial views of potentially novel objects.

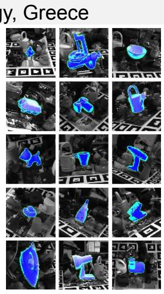


09:30–09:45 ThAT7.5

Detection and Fine 3D Pose Estimation of Texture-less Objects in RGB-D Images

Tomáš Hodaň[1], Xenophon Zabulis[2], Manolis Lourakis[2],
Štěpán Obdržálek[1], Jiří Matas[1]
[1]Czech Technical University in Prague, Czech Republic
[2]Foundation for Research and Technology, Greece

- Sliding window with a cascaded evaluation
- Most locations rejected by a simple pre-filtering
- Sub-linearity in the number of templates achieved by a hashing-based voting generating a small set of candidates per location
- Candidate templates verified by matching feature points in different modalities
- Accurate 3D pose estimated by a stochastic optimization procedure

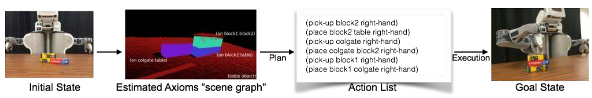


09:45–10:00 ThAT7.6

Axiomatic Particle Filtering for Goal-directed Robotic Manipulation

Zhiqiang Sui[1],
Odest Chadwicke Jenkins[1] and Karthik Desingh[1]
[1]Brown University, USA

- Perform sequential manipulation task successfully given occluded physically-touching objects
- Develop Axiomatic Particle Filter system
- Estimate scene graph of the cluttered environment
- Generative Model(Particle Filter)
- Employ OpenGL rendering engine to generate particles



Mapping 1

Chair *Francesco Amigoni, Politecnico di Milano*
Co-Chair *Matteo Luperto, Politecnico di Milano*

08:30–08:45 ThAT8.1

Automatic Planning of Laser Measurements for a Large-scale Environment using CPS-SLAM System

Souichiro Oshima[1], Shingo Nagakura[1], Jeong Yongjin[1], Akihiro Kawamura[1], Yumi Iwashita[1], Ryo Kurazume[1],
[1]Kyushu University, Japan

- CPS-VIII: a highly precise open-loop SLAM system utilizing cooperative localization by multiple robots
- Automatic planning of laser measurements for large-scale architecture
- 3D model consisting of 6.13 billion points is captured within an error of 23.1 mm after robots traveled 270.1m.

08:45–09:00 ThAT8.2

Landmark-Based Navigation in Large-Scale Outdoor Environments

Dennis Fassbender, Michael Kusenbach, and Hans-Joachim Wuensche[1]
[1]University of the Bundeswehr Munich, Germany

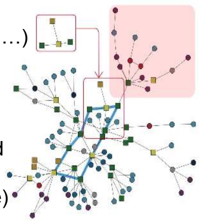
- Goal: autonomous navigation along a prerecorded route without the need for satellite data (e.g., GPS)
- Approach: build highly compact metric-topological map of the route in real-time
- Landmarks: road segments, intersections and salient structures in 3D point clouds
- Landmarks are transmitted via low-bandwidth radio connection, receiver builds identical map and navigates in it

09:00–09:15 ThAT8.3

A Generative Spectral Model for Semantic Mapping of Buildings

Matteo Luperto, Leone D'Emilio, and Francesco Amigoni
Politecnico di Milano, Italy

- We propose a generative model of the topological structure and semantic labeling schema of buildings (e.g., schools, offices, …)
- Buildings are represented as graphs
- The model clusters subgraphs obtained by segmenting an initial set of buildings
- A prediction of the topological structure and sematic labeling schema of unexplored portions of a building (a school in the figure) is obtained by sampling from the model

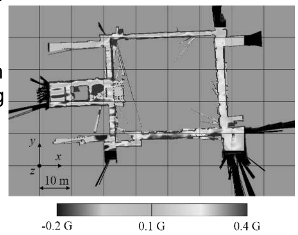


09:15–09:30 ThAT8.4

Gaussian Processes for Magnetic Map-Based Localization in Large-Scale Indoor Environments

Naoki Akai[1] and Koichi Ozaki[1]
[1]Utsunomiya University, Japan

- Applying Gaussian processes for learning and mapping magnetic distribution
- Efficient magnetic data collection by a mobile robot for the learning
- Building a magnetic map in large scale indoor environments and realizing magnetic map-based localization in the environment



09:30–09:45 ThAT8.5

Real-Time and Scalable Incremental Segmentation on Dense SLAM

Keisuke Tateno[13],Federico Tombari[12] and Nassir Navab[1]
[1]TU Munich, Germany [2]Univ. Bologna, Italy [3]Canon Inc., Japan

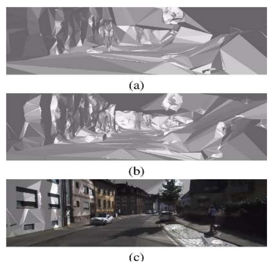
- A real-time segmentation method for 3D point clouds obtained via SLAM.
- Incrementally merge segments obtained on each input depth image within a unified global model.
- It runs in constant time regardless of the size of the GSM and the number of merged depth maps in the global 3D model.

09:45–10:00 ThAT8.6

Incremental Reconstruction of Urban Environments by Edge-Points Delaunay Triangulation

Andrea Romanoni1 and Matteo Matteucci1
1Politecnico di Milano, Italy

- **Incremental** 3D reconstruction of a **manifold surface**
- **Edge-Points** (b) induce better triangulation fit to the scene than classical features (a)
- Novel **preemptive** artifact removal heuristic
- Final reconstruction (c) suitable for **photometric refinement**



Legged Robots 1

Chair *Zhibin Li, Istituto Italiano di Tecnologia*
Co-Chair *Darwin G. Caldwell, Istituto Italiano di Tecnologia*

08:30–08:45 ThAT9.1

A bi-level nonlinear predictive control scheme for hopping robots with hip and tail actuation

Knut Graichen, Sebastian Hentzelt
University of Ulm, Institute of Measurement, Control, and Microtechnology, Germany

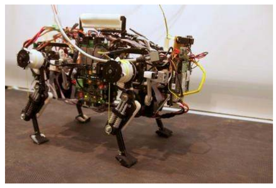
A control concept is presented for hopping robots with hip and tail actuation. The nonlinear flight phase controller accounts for state and input contraints. An additional nonlinear model predictive control (MPC) scheme is superposed to coordinate the hopping cycles and to maximize the hopping speed. The MPC can be designed with a simple nonlinear optimization algorithm, as the constraints are already accounted for by the cascaded controller. Simulation results for a nonlinear dynamical model of the Festo BionicKangaroo show the working principle of the bi-level predictive control scheme.

08:45–09:00 ThAT9.2

Developing an Embodied Gait on a Compliant Quadrupedal Robot

Jonas Degrave[1], Ken Caluwaerts[2], Joni Dambre[1] and Francis wyffels[1]
[1]Ghent University, Belgium
[2]NASA Ames Research Center, United States

- Incorporating the body dynamics in the computation
- explore the extra minimal requirements in terms of
  - memory
  - nonlinear complexity.
- A controller for a dynamically balanced trot gait is learned in a couple of steps.

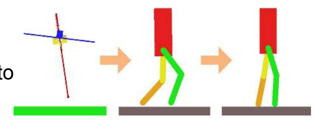


09:00–09:15 ThAT9.3

From One-legged Hopping to Bipedal Running and Walking: A Unified Foot Placement Control Based On Regression Analysis

Yangwei You[1], Zhibin Li[1], Darwin G. Caldwell[1] and Nikos G. Tsagarakis[1]
[1]Istituto Italiano di Tecnologia, Italy

- Body attitude is controlled at stance by the hip actuator, and height is controlled by the motion of stance leg.
- Forward velocity is controlled based on online linear regression analysis of its relationship with foot placement.
- Hopping, bipedal running and walking are achieved with accurate forward velocity tracking. And good adaptation to unknown mass offset is also demonstrated in hopping.

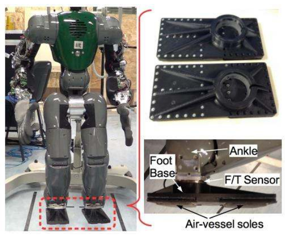


09:15–09:30 ThAT9.4

A New Foot Sole Design for Humanoids Robots based on Viscous Air Damping Mechanism

Wooseok Choi, Chengxu Zhou, Gustavo A. Medrano-Cerda, Darwin G. Caldwell and Nikos G. Tsagarakis
Instituto Italino di Tecnologia, Italy

- Reducing foot impact forces.
- Decreasing oscillation between foot sole and the ground.
- Compensating unpredictable reaction forces by foot sole instead of actively controlled ankle joint.
- Modeling of viscous air damping mechanism.



09:30–09:45 ThAT9.5

Experience-Based Adaptation of Locomotion Behaviors for Kinematically Complex Robots in Unstructured Terrain

Alexander Dettmann[1], Anna Born[1], Sebastian Bartsch[2] and Frank Kirchner[1,2]
[1]University of Bremen, Germany [2]DFKI RIC, Germany

- Storing of experiences in behavior libraries
  - Estimation of environmental features (context)
  - Evaluation of behaviors regarding action performance, efficiency, and stability
- Adaptation of locomotion behavior based on desired action with performance prioritization, current context, and stored experiences

Cloud Robotics

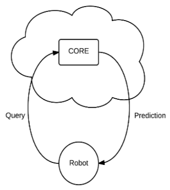
Chair *Nikos Papanikolopoulos, University of Minnesota*
Co-Chair *Cristian Secchi, Univ. of Modena & Reggio Emilia*

08:30–08:45 ThAT10.1

CORE: A Cloud-based Object Recognition Engine for Robotics

William J. Beksi, John Spruth, and Nikolaos Papanikolopoulos
University of Minnesota, USA

- Distributed and scalable architecture for performing object recognition in a cloud computing infrastructure
- Capable of training on large-scale datasets, performing classification of 3D point cloud data, and efficiently transferring data in a robotic network

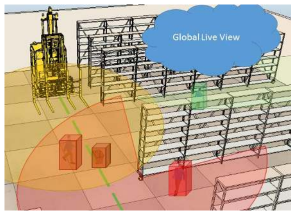


08:45–09:00 ThAT10.2

Cloud Robotics Paradigm for Enhanced Navigation of Autonomous Vehicles in Real World Industrial Applications

Elena Cardarelli[1], Lorenzo Sabattini[1], Cristian Secchi[1] and Cesare Fantuzzi[1]
[1]University of Modena and Reggio Emilia, Italy

- Hierarchical data fusion for industrial applications
- Sensing data acquired by different sensors are fused in a centralized cloud service, for the implementation of advanced navigation strategies
- Experimental validation in a real industrial warehouse

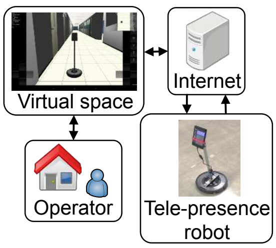


09:00–09:15 ThAT10.3

A Remote Navigation System for a Simple Tele-Presence Robot with Virtual Reality

Yuka Kato[1]
[1]Tokyo Woman's Christian University, Japan

- Navigation of a tele-presence robot by mean of an Internet-based server and a virtual space
- **Point 1**: The movement of a real robot is synchronized with the virtual robot
- **Point 2**: Almost all navigation functions are implemented on the server to reduce power consumption on robots

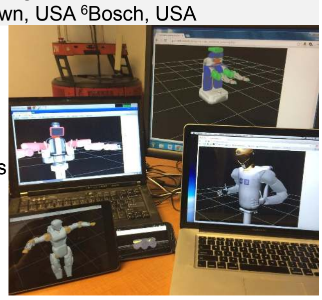


09:15–09:30 ThAT10.4

Robot Web Tools: Efficient Messaging for Cloud Robotics

R. Toris[1], J. Kammerl[2], DV Lu[3], J. Lee[4], Chad Jenkins[5], S. Osentoski[6], M. Wills[1] and S. Chernova[1]
[1]WPI, USA [2]Willow Garage, USA [3]WUSTL, USA
[4]Yujin, Korea [5]Brown, USA [6]Bosch, USA

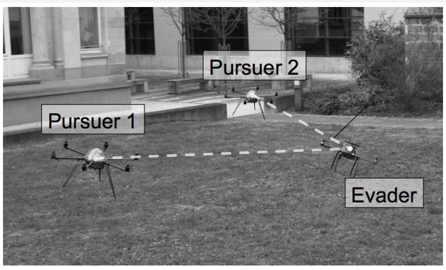
- Advances communication protocols for cloud robotics
- Enables HRI through clean front-end interfaces
- Power of ROS on new devices platforms and interfaces
- Works with all modern web browsers via HTTP



09:30–09:45 ThAT10.5

Cooperative Pursue in Pursuit-Evasion Games with Unmanned Aerial Vehicles

Alexander Alexopoulos[1], Tobias Schmidt[1] and Essamedin Badreddin[1]
[1]Heidelberg University, Germany



09:45–10:00 ThAT10.6

Optimizing Survivability of Multi-Robot Formation in Adversarial Environments

Yaniv Shapira and Noa Agmon
Computer Science Department
Bar-Ilan University, Israel
agmon@cs.biu.ac.il

- Presenting a new problem: *Safe Robotic Adversarial Formation*
- A team of robots travels in a connected formation through an adversarial environment
  - Contains threats that may harm them
- Goal: Maximize survivability of robots
  - Optimize chances of reaching endpoint unharmed
- Solved under several formation constraints
- Examined continuous vs. discrete representation
  - In theory and simulation

Telerobotics 1

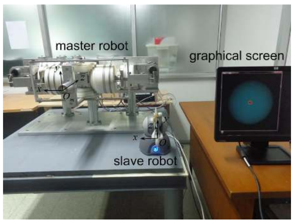
Chair *Björn Hein, Karlsruhe Institute of Technology (KIT)*
Co-Chair *Long Cheng, Chinese Academy of Sciences*

08:30–08:45	ThAT11.1

Control of Time-Varying Delayed Teleoperation System Using Corrective Wave Variables

Phongsaen Pitakwatchara
Chulalongkorn University, THAILAND

- Corrective waves are introduced to compensate for the wave distortion caused by time delayed variation.
- The correction is based on the difference between the desired and fictitious position.
- This can be applied to any local motion or force controllers.

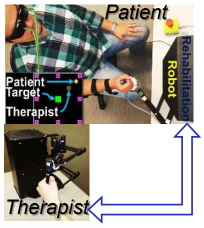


08:45–09:00	ThAT11.2

A New Passivity-Based Control Technique for Safe Patient-Robot Interaction in Haptics-Enabled Rehabilitation Systems

S. Farokh Atashzar[1,3], Mahya Shahbazi[1,3], Mahdi Tavakoli[2] and Rajni V. Patel[1,3]
[1]Western University, [2]University of Alberta, [3]Canadian Surgical Technologies & Advanced Robotics, Canada

- Stability analysis of patient-robot interaction in haptics-enabled robotic/telerobotic rehabilitation Systems
- Eliminating fixed conservative caps for therapeutic forces
- New passivity-based stabilizing controller for non-passive therapeutic environment and communication network.
- Experimental Validation



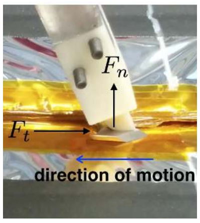
Experimental Setup

09:00–09:15	ThAT11.3

Parameter Estimation and Anomaly Detection while Cutting Insulation during Telerobotic Satellite Servicing

Xiao Li and Peter Kazanzides
Johns Hopkins University, USA

- We previously developed a model of the forces encountered during cutting of satellite multi-layer insulation (MLI).
- A Task Monitor uses the model to stop the remote robot when cutting fails.
- This work presents an on-line estimator to update the model parameters while cutting, thereby adapting to MLI in space.
- Results show reliable detection of failures, with few false positives and negatives.

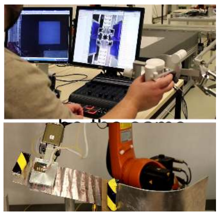


09:15–09:30	ThAT11.4

Telemanipulation with Force-based Display of Proximity Fields

S. Escaida Navarro[1], F. Heger[1], F. Putze[2], T. Beyl[1], T. Schultz[2] and B. Hein[1]
[1]IAR-IPR, Karlsruhe Institute of Technology, Germany
[2]IAR-CSL, Karlsruhe Institute of Technology, Germany

- A novel system for Telemanipulation, mapping proximity values from inside the gripper to a haptic input device
- Intuitive control over system parameters (available DoFs, feedback gain, etc.) using MIDI-devices
- Evaluated in a user study comprising grasping and exploration scenarios that considers intuitiveness and workload in different operation modes

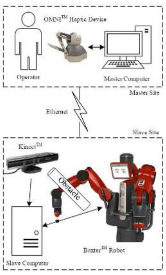


09:30–09:45	ThAT11.5

Shared Control for Teleoperation Enhanced by Autonomous Obstacle Avoidance of Robot Manipulator

Xinyu Wang[1,2], Chenguang Yang[*,2,3], Hongbin Ma[1] and Long Cheng[4]
[1]Beijing Institute of Technology, China [2]Plymouth University, UK [3]South China University of Technology, China [4]Chinese Academy of Science, China

- A human robot shared control strategy is developed and tested on a Baxter robot.
- An improved obstacle avoidance strategy based on the joint space redundancy of the manipulator is designed.
- By employment of an artificial parallel system, the robot can restore the commanded pose when the obstacle is removed.
- By implementing the dimension reduction method, the trajectory of each joint of the manipulator can be controlled at the same time to achieve the restoring task.



Robot Learning 1

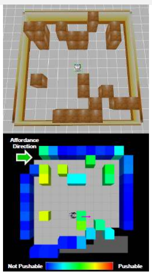
Chair *Mohammad Khansari, Stanford University*
Co-Chair

08:30–08:45 ThAT12.1

Interactive Affordance Map Building for a Robotic Task

David Inkyu Kim[1], Gaurav S. Sukhatme[1]
[1]University of Southern California, U.S.A

- Goal: Affordance map building via interactive manipulation for a rearrangement task.
- Object affordance (= how to manipulate) is predicted using geometric features along with pairwise relation between objects.
- Interactive manipulation confirms the affordance of the object.
- Information gaining manipulation planning using Markov Random Field model is applied to build the affordance map.

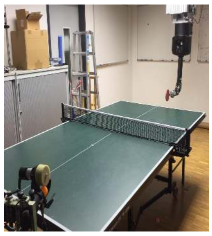


08:45–09:00 ThAT12.2

Learning Optimal Striking Points for A Ping-Pong Playing Robot

Yanlong Huang[1], Bernhard Schölkopf[1] and Jan Peters[1,2]
[1]Max-Planck Institute for Intelligent Systems
[2]Technische Universität Darmstadt

- **Robot table tennis:** visual estimation, trajectory prediction, inverse kinematics, robot trajectory generation, and inverse dynamics.
- **Spatio-temporal similarity**: measure the coincidence between ball trajectory and racket trajectory.
- **Non-parametric learning:** learn optimal striking points using stochastic policies.

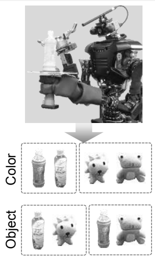


09:00–09:15 ThAT12.3

Concept Formation by Robots Using an Infinite Mixture of Models

Tomoaki Nakamura, Yoshiki Ando, Takayuki Nagai and Masahide Kaneko
University of Electro-Communications, Japan

- We propose a model that enables robots to form various concepts autonomously
- Concept classes are found based on Dirichlet process from observed information
- Each concept is formed by classifying observed information based on multimodal hierarchical Dirichlet process
- We demonstrate that a robot can find two concept classes and form the concepts in an unsupervised way

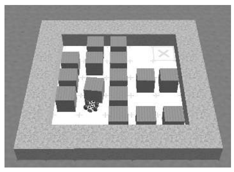


09:15–09:30 ThAT12.4

Simultaneously Learning at Different Levels of Abstraction

Benjamin Quack[1], Florentin Wörgötter[1] and Alejandro Agostini[1]
[1]University of Göttingen, Germany

- Architecture for solving human-like tasks learning on two levels of abstraction.
- High-level: logic-based planner and an online planning operator learner.
- Low-level: online reinforcement learning units learn for the grounding of the symbolic high-level actions.



Solving a task in a physically realistic simulation of the Sokoban game.

09:30–09:45 ThAT12.5

Learning Multiple Behaviours using Hierarchical Clustering of Rewards

Javier Almingol[1,2], Luis Montesano[1,2]
[1]Universidad de Zaragoza, Spain [2] I3a, Spain

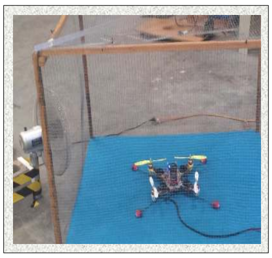
- We address the problem of learning an unknown number of behaviours from **unlabelled datasets** in **continuous** action-state **spaces**
- Behaviours are encoded as **reward/cost functions** which are linear combination of features
- A **hierarchical clustering** algorithm **simultaneously groups trajectories** that share a common reward function and **learns** the **parameters** of the reward functions
- Similarity metric is based on the distribution of **maximum entropy** over trajectories computed using **path integrals**

09:45–10:00 ThAT12.6

A Platform for the Direct Hardware Evolution of Quadcopter Controllers

David Howard and Torsten Merz
Autonomous Systems, CSIRO, Australia

- Quadcopter flies a waypoint path, fan creates disturbances & excites PID gains.
- Differential Evolution algorithm used simultaneously optimise 18 PID gains based on desired behaviour.
- Results show high-quality control evolved in under 12 hours.



Path Planning for Mobile Robots or Agents

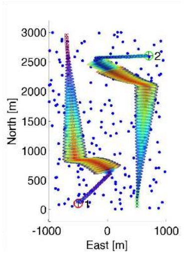
Chair *Javier Alonso-Mora, MIT*
Co-Chair *Aparajit Narayan, Aberystwyth University*

08:30–08:45	ThAT13.1

Towards Multi-Robot Active Collaborative State Estimation via Belief Space Planning

Vadim Indelman[1]
[1]Technion – Israel Institute of Technology

- Approach for active collaborative state estimation in unknown environments
- Robots' belief represents the uncertainty in robot poses and in the environment
- Incorporate within the belief multi-robot constraints; model observation of mutual scenes, possibly at different future times
- Robots do not have to coordinate rendezvous with each other

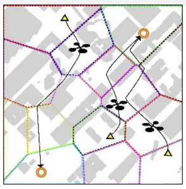


08:45–09:00	ThAT13.2

Learning to Trick Cost-Based Planners into Cooperative Behavior

Carrie Rebhuhn[1], Ryan Skeele[1],
Jen Jen Chung[1], Geoffrey Hollinger[1] and Kagan Tumer[1]
[1]Oregon State University, USA

- We route autonomous robots that use cost-based planners through an obstacle-filled map by manipulating the cost space
- A cooperative coevolutionary algorithm evolves policies for handling directional traffic to minimize conflicted trajectories
- We demonstrate 16.4% conflict reduction

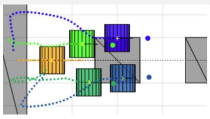


09:00–09:15	ThAT13.3

Multi-robot navigation in formation via sequential convex programming

Javier Alonso-Mora, Stuart Baker, Daniela Rus
Massachusetts Institute of Technology, USA

- Navigate a team of robots in **formation** in **2D and 3D dynamic environments**
- Formation is locally optimized via **Sequential Convex Programming**
- Static and **moving obstacles** are avoided by computing the largest convex volume in free-space
- Simulations with quadrotors
- Experiments with mobile manipulators

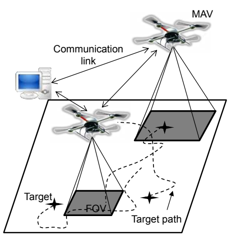


09:15–09:30	ThAT13.4

Multiscale Observation of Multiple Moving Targets using Micro Aerial Vehicles (MAVs)

Asif Khan[1,2], Bernhard Rinner[1],
Andrea Cavallaro[2]
[1]Alpen-Adria-Universität Klagenfurt, Austria
[2]Queen Mary University of London, UK

- Maximizing *duration* and *quality* of observation for each target
- Larger number of targets than that of MAVs
- Variable field of view
- Quad-tree data structure to model the movement of MAV
- Centralized and greedy assignment of way-points

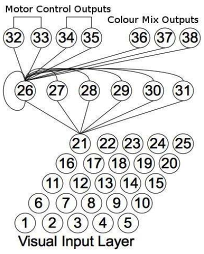


09:30–09:45	ThAT13.5

An Active Vision Approach to the Road Following Problem

Aparajit Narayan[1], Elio Tuci[1],
Frédéric Labrosse[1]
[1]Aberystwyth University, United Kingdom

- Continuous time recurrent neural network processing low resolution visual inputs used to control a Pioneer 3-AT robot.
- Network developed using artificial evolution in a simulated environment.
- Learns to extract contrast between the road and it's surroundings by dynamically mixing the Red, Green and Blue colour channels.

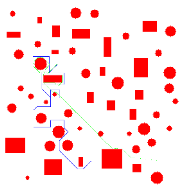


09:45–10:00	ThAT13.6

Path Planning for a Tethered Mobile Robot using Multi-Heuristic A* with Topology-based Heuristics

Soonkyum Kim[1] and Maxim Likhachev[1]
[1]Carnegie Mellon University, USA

- Find suboptimal path of a tethered mobile robot with fixed cable length and fixed anchor point.
- Guarantee suboptimality bound by adapting Multi-Heuristic A*
- Add proper heuristic function considering the topology class of the path to escape from local minimum
- Present experimental analysis comparing TbMHA* with weight A*



Example with 53 obstacles

Robot Safety

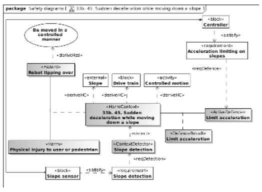
Chair *Bong Keun Kim, National Institute of Advanced Industrial Science and Technology*
Co-Chair *Geoffrey Biggs, National Institute of AIST*

08:30–08:45	ThAT14.1

Modelling the safety of a semi-autonomous wheelchair

Geoffrey Biggs, Takuya Ogure, Kiyoshi Fujiwara, Yoshihiro Nakabo and Tetsuo Kotoku
AIST, Japan

- Applied a modelling language for safety to a semi-autonomous wheelchair
- Modelled results of a real safety analysis
- Compare modelled information with existing methods of storage and presentation to show advantages of the model-based approach

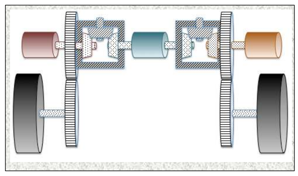


08:45–09:00	ThAT14.2

Seizing Failure-tolerant Differential Redundant Drive Mechanism and Control Technique for Two-wheeled, Self-balancing Vehicle

Kiyoshi Fujiwara[1], Takuya Ogure[1] and Geoffrey Biggs[1]
[1]Advanced Industrial Science and Technology (AIST), Japan

- Continuous motion control in the case of seizing failure of the motor is a critical problem to keep balancing.
- A seizing failure-tolerant system using differential mechanisms.
- Redundancy using fewer actuators by sharing.
- N outputs requires only N+1 number of actuators, not 2N.
- Continuous compensation by modeless control system

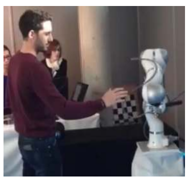


09:00–09:15	ThAT14.3

Control of robots sharing their workspace with humans: an energetic approach to safety

Anis Meguenani[1], Vincent Padois[1], Philippe Bidaud[1,2]
[1]ISIR-UPMC [2]ONERA

- Safe control of robots
- Sensing the human operator
- Sharing the same workspace
- Kinetic energy modulation
- Enabling/disabling physical contact
- Stopping the robot at a desired distance

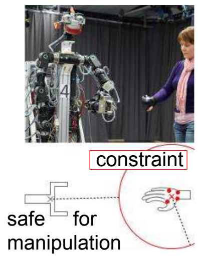


09:15–09:30	ThAT14.4

Active Safety Control for Dynamic Human-Robot Interaction

Melanie Kimmel[1] and Sandra Hirche[1]
[1]Technische Universität München, Germany

- Systematic control approach for guaranteed constraint satisfaction
- Stability preserving extension of Invariance Control to dynamic constraints
- Compliant nominal robot control for additional safety
- Experimental evaluation on a 7-DoF manipulator in a scenario involving interaction with a human



09:30–09:45	ThAT14.5

Visibility Reduction Based Performance Evaluation of Vision-Based Safety Sensors

Bong Keun Kim[1], Yasushi Sumi[1], Ryusuke Sagawa[1]
Kenji Kosugi[2] and Shigeto Mochizuki[2]
[1]AIST, Japan [2]NIED, Japan

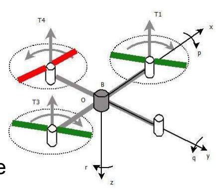
- The snowfall simulation chamber for realizing visibility reduction using EPB has been described with the spectral transmission measurement experiments.
- The object detection performance of the vision based safety sensors have been evaluated based on the preliminary experiments carried out in the proposed snowfall simulation chamber and the artificial snowfall facility.

09:45–10:00	ThAT14.6

Active fault-tolerant control for quadrotors subjected to a complete rotor failure

Peng Lu[1], Erik-Jan van Kampen[1],
[1]Delft University of Technology, The Netherlands

- A complete **Active Fault-Tolerant Control** System is proposed for one total rotor failure case.
- A novel **Fault Detection and Isolation** algorithm is proposed to detect the fault.
- The **Incremental Nonlinear Dynamic Inversion** is used to control the vehicle after the detection of the total rotor failure



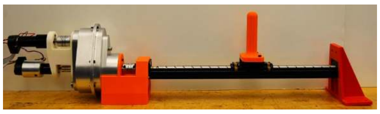
New Actuators 1

Chair *Alexandre Girard, MIT*
Co-Chair *Jun Sheng, University of Maryland, College Park*

08:30–08:45	ThAT15.1

A Two-Speed Actuator for Robotics with Fast Seamless Gear Shifting

Alexandre Girard[1], H. Harry Asada[1],
[1]Massachusetts Inst. of Technology, USA



- Actuator with two distinctively different gear reduction ratios;
- Power available over a wide range of output speed;
- Large variations of the intrinsic impedance;
- Nullspace control scheme for fast seamless transitions even when interacting with unknown environments.

08:45–09:00	ThAT15.2

A novel piezohydraulic actuator as artificial muscle in robotic applications

Wolfgang Zoels[1], Iason Vittorias[1],
Georg Bachmaier[1]
[1]Siemens AG

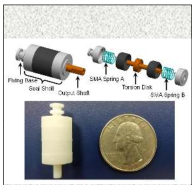
- **Efficient novel piezohydraulic actuator** for low power range
- **Variable impedance** by the duty cycle of the piezo voltage signal
- **Passive safety** by hydraulic design
- High robustness by hydraulic design and
- **Low reflected inertia**
- Suited for **harsh environment** by complete metal encapsulation

09:00–09:15	ThAT15.3

A Novel Meso-Scale SMA-Actuated Torsion Actuator

Jun Sheng and Jaydev P. Desai
University of Maryland, College Park, USA

- This paper presents our work on design, modeling, and control of a meso-scale shape memory alloy (SMA) actuated torsion actuator.
- This torsion actuator is bi-directionally activated by a pair of antagonistic SMA torsion springs through alternate Joule heating.



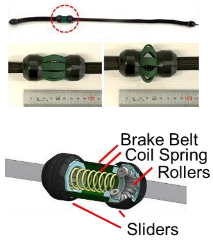
SMA-actuated torsion actuator

09:15–09:30	ThAT15.4

A High-speed Locomotion Mechanism Using Pneumatic Hollow-shaft Actuators for In-pipe Robots

Tomonari Yamamoto[1], Masashi Konyo[1]
and Satoshi Tadokoro[1]
[1]Tohoku University, Japan

- Proposed new mechanism realize unifying both holding and impelling force generation within same actuator
- Advantageous features for pipe inspection: high-speed locomotion, small diameter, flexibility, and low weight.
- Prototype robot can be propelled inside a 53-mm-diameter pipe at a maximum speed of 250 mm/s.



Collision Detection and Avoidance

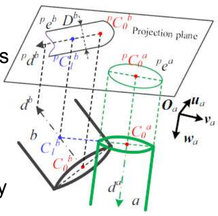
Chair *Dengpeng Xing, Chinese Academy of Sciences*
Co-Chair *Dinesh Manocha, University of North Carolina at Chapel Hill*

11:20–11:35 ThCT1.1

Collision Detection for Blocking Cylindrical Objects

Dengpeng Xing, De Xu, and Fangfang Liu
Institute of Automation, Chinese Academy of Sciences

- This paper proposes two methods for collision detection between cylindrical components when mutual blocking occurs
- An optimization method to compute 3D reconstruction
- projection method to convert two planar views to contours on a projection plane and to detect high dimension collisions by studying the projection's relationships in low dimension

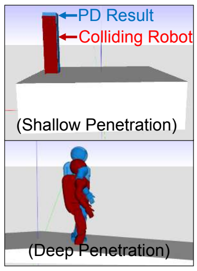


11:35–11:50 ThCT1.2

Hybrid Penetration Depth Computation Using Local Projection and Machine Learning

Yeojin Kim[1], Dinesh Manocha[2] and Young J. Kim[1]
[1]Ewha Womans University, Korea
[2]The University of North Carolina at Chapel Hill, USA

- Real-time algorithm to compute accurate and fast penetration depth (PD) for general polygonal models in 3D
- Applicable to motion planning, contact dynamics, and haptic rendering
- Hybrid of global (machine learning) and local methods (local projection)
- Error-bounded results for both deep and shallow penetrations

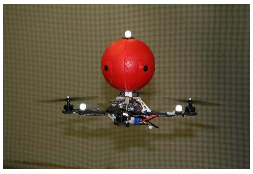


11:50–12:05 ThCT1.3

Reciprocal Collision Avoidance For Quadrotors Using On-board Visual Detection

Steven Roelofsen, Denis Gillet, Alcherio Martinoli
École Polytechnique Fédérale de Lausanne, Switzerland

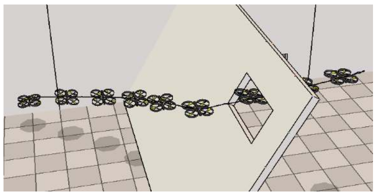
- Collision avoidance system for un-manned aerial vehicle using vision
- Designed to work with limited field of view and without inter-vehicle communication
- Besides self-localization, all onboard
- Over 200 experiments performed with no collision



12:05–12:20 ThCT1.4

Stochastic Automatic Collision Avoidance for Tele-Operated Unmanned Aerial Vehicles

Daman Bareiss[1], Jur van den Berg[2], and Kam K. Leang[1]
[1]Department of Mechanical Engineering, [2]School of Computing, University of Utah, USA



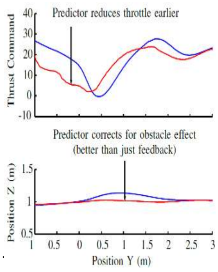
A 3-dimensional example is shown where the quadrotor is steered towards a goal point through a window on a slanted wall.

12:20–12:35 ThCT1.5

Improving MAV Control by Predicting Aerodynamic Effects of Obstacles

John Bartholomew, Andrew Calway and Walterio Mayol
Department of Computer Science, University of Bristol, UK

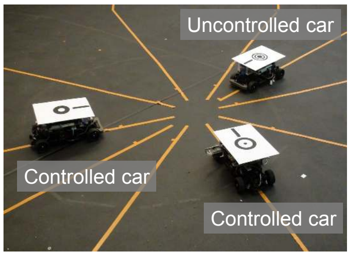
- We use a regression model to *learn* and then *predict* the aerodynamic effect of obstacles on a Micro Air Vehicle.
- We then compensate disturbances via a control loop to maintain level flight.
- We use low resolution depth images to make the prediction from a distance.
- Results show statistically significant improvement vs control without prediction.



12:35–12:50 ThCT1.6

Experimental Testing of Multi-vehicle Control for Intersection Collision Avoidance

Heejin Ahn[1], Andrea Rizzi[2], Alessandro Colombo[3] and Domitilla Del Vecchio[1]
[1]MIT, USA [2]Cornell University, USA [3]Politecnico di Milano, Italy



The supervisor overrides the **controlled cars** only when necessary to avoid a collision.

From the experiments, we demonstrate that intersection collisions are averted.

Smart Robotics Application 2

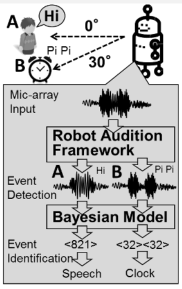
Chair *Abril Torres, CINVESTAV Campus Saltillo*
Co-Chair *Kazuhiro Nakadai, Honda Research Inst. Japan Co., Ltd.*

11:20–11:35	ThCT2.1

Robot Audition Based Acoustic Event Identification Using a Bayesian Model Considering Spectral and Temporal Uncertainties

Keisuke Nakamura[1] and Kazuhiro Nakadai[1]
[1]Honda Research Institute Japan Co., Ltd.

- Acoustic event identification for robots featuring:
  1. Event localization and detection using a robot audition framework
  2. Two Bayesian models to extract noise-robust sound-units and words considering probabilistic spectral and temporal uncertainties

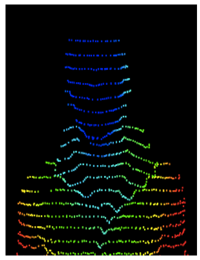


11:35–11:50	ThCT2.2

Audio Augmented Point Clouds for Applications in Robotics

Jani Even[1,2], Florent ferreri[1,2], Atsushi Watanabe[1]
Yoichi Morales[1], Carlos Ishi[1,2] and Norihiro Hagita[1]
[1]IRC, ATR, Japan [2]Ishiguro Symbiotic Human-Robot Interaction Project, ERATO, JST, Japan

- Combine point cloud and acoustic information
- Sound from microphone array
- Point cloud from LRF or RGB-D camera
- Use multiple coordinate frames
- Well suited for mobile robotic applications
- Multiple coordinate frames

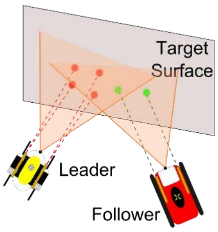


11:50–12:05	ThCT2.3

Towards Cooperation of Underwater Vehicles: A Leader-Follower Scheme Using Vision-based Implicit Communications

G. K. Karavas[1], G. C. Karras[2] and K. J. Kyriakopoulos[2]
[1]Arizona State University, USA [2]National Technical University of Athens, Greece

- We present an implicit communications scheme for a Leader - Follower underwater inspection task using a vision-based approach that includes cameras and laser pointers.
- We also present a motion controller for the Follower that guarantees the cooperation of the vehicles and it has guaranteed convergence and stability properties.

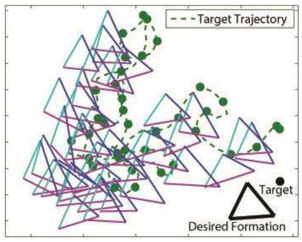


12:05–12:20	ThCT2.4

Decentralized Multi-Vehicle Dynamic Pursuit using Acoustic TDOA Measurements

Mei Yi Cheung[1], Joshua Leighton[1], and Franz Hover[1]
[1]Massachusetts Institute of Technology, USA

- Decentralized control and communication scheme for dynamic target pursuit with time-difference-of-arrival measurements
- Field experiments with three pursuers using autonomous surface vehicles and WHOI Micro-modems

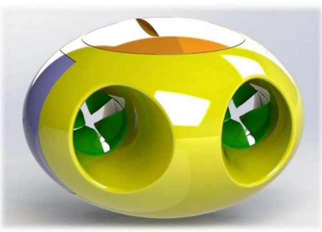


12:20–12:35	ThCT2.5

Design of A Maneuverable Swimming Robot for In-pipe Missions

You Wu[1], Antoine Noel[1], David Donghyun Kim[1], Kamal Youcef-Toumi[1] and Rached Ben-Mansour[2]
[1]Massachusetts Institute of Technology, USA
[2]King Fahd University of Petroleum and Minerals, Saudi Arabia

- Integrated, untethered robot
- Capable of carrying sensors and maneuver into water pipe networks
- Optimal shape design for maneuverability
- RIM driven propulsion
- Prototype for Ø10cm pipes

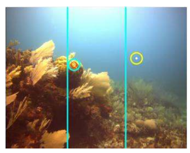


12:35–12:50	ThCT2.6

Ethologically inspired Reactive Exploration of Coral Reefs with Collision Avoidance

Alejandro Maldonado-Ramírez, L. Abril Torres-Méndez, Francisco Rodríguez-Telles
CINVESTAV Campus Saltillo, Mexico

- A vision-based reactive exploration of coral reefs with collision avoidance is presented which considers human understanding of the underwater world.
- Region of interest (RoI) (left circle) is detec- and robustly tracked by using an adapted visual attention algorithm.
- If the water/non-water classifier returns a direction of escape (right circle) falling outside the vertical lines, an evasion maneuver is carried out. After this, a new RoI is detected.



Human Detection and Tracking

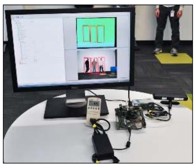
Chair *Fulvio Mastrogiovanni, University of Genoa*
Co-Chair *Masaki Takahashi, Keio University*

11:20–11:35	ThCT3.1

Depth-Augmented Deformable Parts Models for RGBD Person Detection on Embedded GPUs

Stefan Zickler
iRobot Corp, USA

- High accuracy person detection runs on embedded GPU at 5Hz and <10 Watt
- Uses a Deformable Parts Model (DPM) with a joint RGBD HOG-based feature descriptor (DHOG)
- We provide a detailed GPU algorithm description
- We apply Principal Component Analysis (PCA) to the feature space for increased performance
- We evaluate on indoor dataset, showing how our DPM-RGBD approach outperforms RGB-only DPM, depth-only DPM and traditional HOG cascades.

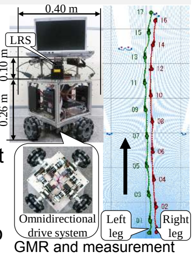


11:35–11:50	ThCT3.2

Development of Gait Measurement Robot Using Laser Range Sensor for Evaluating Long-distance Walking Ability in the Elderly

Ayanori Yorozu and Masaki Takahashi
Keio University, Japan

- Gait measurement robot (**GMR**) **leads the participant** and **measures both legs trajectory and walking parameters**
- Measurement accuracy with young people compared with the VICON system is verified
- For the advance verification of measurement in the elderly, seven-meter straight walk tests using a stationary LRS are carried out
- Gait measurement method can be applied to **participants with various walking ability**



GMR and measurement result of the elderly

11:50–12:05	ThCT3.3

Classification of Motor Stereotypies in Video

Joshua Fasching, Nicholas Walczak, Vassilios Morellas and Nikolaos Papanikolopoulos
University of Minnesota, U. S. A.

- Early intervention is a key aspect of treating developmental disorders.
- Motor stereotypic behaviors are associated with certain developmental disorders.

- This work explores characterizing videos of novel motor stereotypic activities in the context of an activity classification problem using different descriptors and classification techniques.

12:05–12:20	ThCT3.4

Indoor Trajectory Identification: Snapping with Uncertainty

Richard Wang[2], Ravi Shroff[1], Yilong Zha[1], Srinivasan Seshan[2] and Manuela Veloso[2]
[1]New York University, USA [2]Carnegie Mellon University, USA

- Indoor human trajectory identification using odometry data from smartphone sensors
- Apply traditional outdoor GPS map matching to indoor motion trajectories
  1. Extract steps and heading
  2. Identify trajectory segments
  3. Snap trajectory to identify path traversed
- As new segments are added, number of possibilities for earlier segments decreases monotonically

12:20–12:35	ThCT3.5

HOOD: a Real Environment Human Odometry Dataset for Wearable Sensor Placement Analysis

Barbara Bruno[1], Fulvio Mastrogiovanni[1], and Antonio Sgorbissa[1]
[1]University of Genoa, Italy

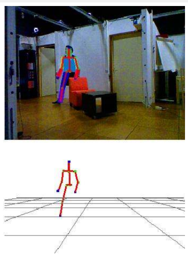
- HOOD: public dataset of labelled IMU data recordings
- 4 sensor placements (foot, waist, wrist, chest)
- 6 motions (slow walk, normal walk, run, slow crawl, fast crawl, slither)
- 6 outdoor environments (grass field, uphill road, staircase, *river bed*, woods, snow)
- Analysis of the step counting accuracy w.r.t. to placement, motion and environment

12:35–12:50	ThCT3.6

Pose Estimation For A Partially Observable Human Body From RGB-D Cameras

Abdallah Dib[1], François Charpillet[1],
[1]Inria, Université de Lorraine, CNRS, LORIA, France,

- Propose a scalable framework for human pose estimation in real world conditions.
- Background is continuously updated and learned and moving subjects are extracted without any initialization process.
- Robustness against occlusions: Detect and eliminate hidden body parts from the pose estimation process.
- Provide a benchmark for a person perfoming activities in scene with occlusions.



Motion and Trajectory Generation

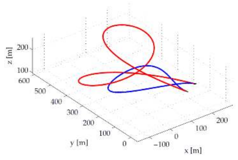
Chair *Daniel Sidobre, University of Toulouse*
Co-Chair *Yantao Shen, University of Nevada, Reno*

11:20–11:35	ThCT4.1

3D Path Planning with Continuous Bounded Curvature and Pitch Angle Profiles Using 7th Order Curves

Armando Neto[1], Douglas Macharet[2] and Mario Campos[2]
[1]UFSJ, Brazil [2]UFMG, Brazil

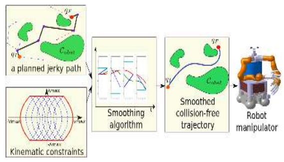
- It presents a path planning method for vehicles in $\mathbb{R}^3$ with curvature and climb (or dive) angle constraints.
- C^∞ (continuous) curves are provided, preventing abrupt direction changes during the robot navigation.
- The presented paths are shorter than those in the *state-of-the-art* literature and are comparable in length to optimal discontinuous paths.



11:35–11:50	ThCT4.2

Trajectory Smoothing Using Jerk Bounded Shortcuts for Service Manipulator Robots

Ran Zhao and Daniel Sidobre
LAAS-CNRS, University de Toulouse, France



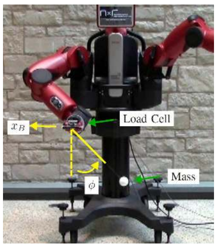
- Using series of 3rd degree polynomials to represent trajectories.
- Building a smooth motion trajectory from way points using shortcuts.
- Operating in the configuration/velocity/acceleration state space.
- Using an exact collision checking method for third-order polynomial trajectories.
- Building a smooth trajectory that respects the collision and kinematic constraints for a service manipulator robot.

11:50–12:05	ThCT4.3

Real-time Trajectory Synthesis for Information Maximization using Sequential Action Control and Least-Squares Estimation

Andrew D. Wilson[1], Jarvis A. Schultz[1], Alex R. Ansari[1], and Todd D. Murphey[1]
[1]Northwestern University, USA

- Trajectory generation based on the maximization of Fisher information in real-time and closed-loop.
- On-line estimation is performed with a least-squares estimator employing a nonlinear state observer model.
- Mean estimate error is ~1% of the actual string length from 9 trials with varying initial estimates for 6s trials.

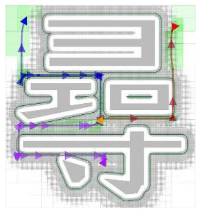


12:05–12:20	ThCT4.4

Metric cells: towards complete search for optimal trajectories

Devin Balkcom, Ajay Kannan, Yu-Han Lyu, Weifu Wang and Yinan Zhang
Dartmouth College, Hanover NH, US

- We give a definition of convexity useful for describing local optimality in configuration spaces.
- We present an algorithm for approximating the free configuration space using a set of such convex regions.
- Experiments non-holonomic systems.



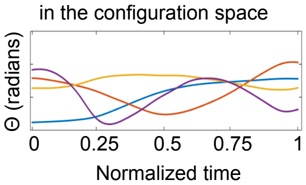
12:20–12:35	ThCT4.5

Generating Manipulation Trajectories Using Motion Harmonics

Yongqiang Huang, Yu Sun,
University of South Florida, USA

The proposed approach first learns motion harmonics from demonstrated motions. Then, given task constraints, and by using the motion harmonics, the approach generates trajectories that optimally balance between meeting the constraints and resembling the demonstrated motions.

Extracted motion harmonics in the configuration space

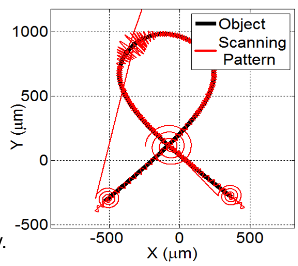


12:35–12:50	ThCT4.6

Adaptive Local Scanning: A Comprehensive and Intelligent Method for Fast Scanning of Indiscrete Objects

Mehdi Rahimi*, Yantao Shen*
* University of Nevada-Reno, USA

- Developed a comprehensive and intelligent method to fast scan indiscrete micro objects.
- The scanning covers every possible situation of the scanned object (loops, intersections or bifurcations).
- The results validate it can greatly reduce scanning time while maintaining high accuracy.



Reactive and Sensor-Based Planning

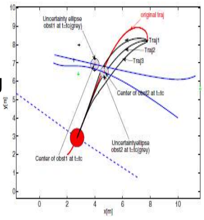
Chair *Mårten Björkman, KTH*
Co-Chair *Dylan Hadfield-Menell, UC Berkeley*

11:20–11:35 ThCT5.1

Closed Form Characterization of Collision Free Velocities and Confidence Bounds

B.Gopalakrishnan*, A.K Singh*,K.M Krishna
RRC, IIIT Hyderabad, India

- We compute closed form characterization of collision free velocities and confidence bounds for non-holonomic robots in dynamic environments.
- The crux of the framework lies in replacing probabilistic constraints through a deterministic surrogate with a particular confidence bounds.
- The deterministic surrogates are solved in closed form through time scaling transformations.



11:35–11:50 ThCT5.2

A sensorimotor approach for self-learning of hand-eye coordination

Ali Ghadirzadeh, Atsuto Maki, Mårten Björkman

Computer Vision and Active Perception Lab (CVAP)
Royal Institute of Technology (KTH), Sweden

Can we learn sensorimotor coupling to autonomously achieve hand-eye coordination on a robot without calibrations and any knowledge of the kinematic model? Yes, we did it by:

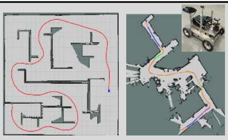
- Devising an online rule to train forward models based on GPs.
- Using delta rule to search through the forward models to find the optimum actions; no implicit inverse model.
- Encoding 3D spatial position of an object in terms of the corresponding joint positions while gazing on it.

11:50–12:05 ThCT5.3

Information-Theoretic Occupancy Grid Compression for High-Speed Information-Based Exploration

Erik Nelson and Nathan Michael
Robotics Institute, Carnegie Mellon University, PA, USA

- We develop map compression strategies to reduce the computational expenses of autonomous exploration.
- Resulting compression algorithms are simple and cause minimal distortion.
- Compressing occupancy grid maps causes order-of-magnitude increase in planning frequency for information-theoretic exploration strategies.



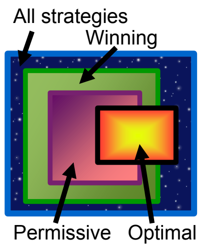
(left) Fast autonomous maze exploration, and (right) exploration with adaptive map resolution

12:05–12:20 ThCT5.4

Correct-by-synthesis reinforcement learning with temporal logic constraints

Min Wen[1],
Ruediger Ehlers[2] and Ufuk Topcu[3]
[1]University of Pennsylvania, USA [2]University of Bremen, Germany [3]University of Pennsylvania, USA

- Synthesis of optimal reactive controllers with
  - a given temporal logic specification
  - some a priori unknown performance criterion
- Combining the ideas of permissive strategies (for correctness) and reinforcement learning (for optimality)

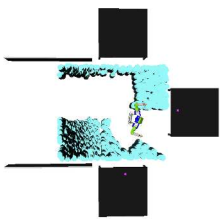


12:20–12:35 ThCT5.5

Modular Task and Motion Planning in Belief Space

Dylan Hadfield-Menell[1], Edward Groshev[1], Rohan Chitnis[1] and Pieter Abbeel[1]
[1]University of California at Berkeley, USA

- We apply maximum likelihood observation determinizations in a a determinize-replan approach to solve large POMDPs
- Task independent interface leverages off-the-shelf motion planning, task planning, and state estimation
- Our approach works with a wide variety of state estimation methods with little to no change



12:35–12:50 ThCT5.6

Augmented Reality on Robot Navigation using Non-Central Catadioptric Cameras

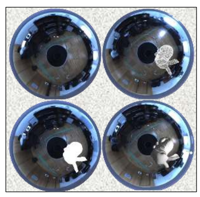
T. Dias[1], P. Miraldo[2], N. Gonçalves[1], and P. U. Lima[2]
[1]ISR, U. Coimbra, [2]ISR/IST, U. Lisboa

Motivation:

- Unexplored study;
- Useful for medical and robot navigation applications.

Our solution:

- Projection onto the image plane;
- Solve the occlusions problem;
- Application of illumination/shading;
- Online robot pose estimation.



Rehabilitation Robotics 1

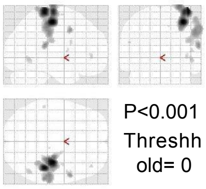
Chair *Kyung-Soo Kim, KAIST(Korea Advanced Institute of Science and Technology)*
Co-Chair *Yoshihiro Kai, Tokai University*

11:20–11:35	ThCT6.1

Development and Evaluation of an MRI Compatible Finger Rehabilitation Device for Stroke Patients

Zhenjin Tang, Shigeki Sugano and Hiroyasu Iwata
Waseda University, Japan

- Design, development and magnetic resonance imaging compatibility evaluation of a finger rehabilitation device.
- A novel six-link mechanism is adopted to drive two joints in each finger to do extension and flexion motion.
- A stable brain activation was observed when the subject performs rehabilitation exercise inside the MRI scanner.



The statistical maps in the SPM software

11:35–11:50	ThCT6.2

Automatically characterizing driving activities onboard smart wheelchairs

HiuKim Yuen[1],
Joelle Pineau[2] and Philippe Archambault[3]
McGill University, Canada

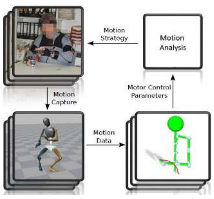
- **Activities Classification**
  - features extraction
  - supervised learning
- **Hidden Patterns Discovery**
  - topic modeling
  - unsupervised learning

11:50–12:05	ThCT6.3

Learning Motor Control Parameters for Motion Strategy Analysis of Parkinson's Disease Patients

F. Burget[1], C. Maurer[2], W. Burgard[1], M. Bennewitz[3]
[1]Univ. of Freiburg, Germany [2]Univ. Medical Center, Germany
[3]Univ. of Bonn, Germany

- Novel approach to analyze motor control parameters affected by the Parkinson's disease
- Recorded human motions reproduced using a Jacobian controller with adaptive joint weights
- Joint weights of the controller are iteratively learned using the human joint trajectories as reference input
- Results: Healthy subjects follow a *proximal* motion strategy, whereas PD patients adopt a *distributed* motion strategy



12:05–12:20	ThCT6.4

A Walking Support Robot with Velocity, Torque, and Contact Force-based Mechanical Safety Devices

Yoshihiro Kai and Kai Arihara
Tokai University, Japan

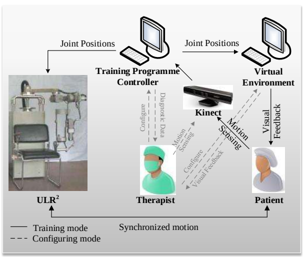
- The safety devices stop the robot after detecting an unexpected movement from the robot.
- The safety devices work even after the robot's computer has broken down, because they consist of only passive mechanical components without actuators, controllers, or batteries.

12:20–12:35	ThCT6.5

Intention Detection in Upper Limb Kinematics Rehabilitation Using a GP-based Control Strategy

Yongzhuo Gao[1], Yanyu Su[1], Wei Dong [1],
Zhijiang Du [1] and Yan Wu [2]
[1]Harbin Institute Of Technology, China
[2]A*STAR Institute for Infocomm Research, Singapore

- Intention detecting strategy applied to a rehabilitation robot with VE and a Kinect.
- Programmed motion sequence
- Use the unaffected arm to estimate the affected arm
- Adopted in Mirror Therapy
- Experiments for 10 healthy subjects.

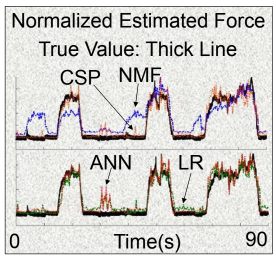


12:35–12:50	ThCT6.6

Using CSP for Unsupervised Real-Time Estimation of Fingertip Forces from sEMG

Pyungkang Kim[1], Kyung-Soo Kim[1], and Soohyun Kim[1]
[1]Korea Advanced Institute of Science and Technology, Korea

- We suggests CSP-based model that estimates proportional and simultaneous fingertip forces of the index and middle fingers.
- The model can be obtained in unsupervised manner, thus, only sEMG data is sufficient.
- The result was compared with conventional unsupervised(NMF) and supervised(LR, ANN) models.



Perception for Grasping and Manipulation 2

Chair *Ren Luo, National Taiwan University*
Co-Chair *Tucker Hermans, University of Utah*

11:20–11:35	ThCT7.1

Transparent Object Recognition and Retrieval for Robotic Bio-Laboratory Automation Applications

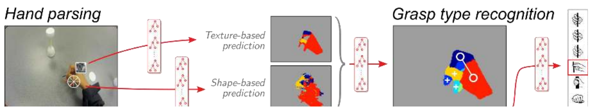
Ren C. Luo, Po-Jen Lai, Vincent Wei Sen Ee
International Center of Excellence on Intelligent Robotics and Automation Research(iCeiRA), National Taiwan University, Taiwan

- A transparent object recognition algorithm which can integrate with visual cues of transparent objects to enhance the retrieval result.
- This algorithm can be integrated with pose estimation methods on robotic bio-laboratory automation applications.

11:35–11:50	ThCT7.2

Hand Parsing for Fine-Grained Recognition of Human Grasps in Monocular Images

Akanksha Saran, Damien Teney and Kris M. Kitani
Carnegie Mellon University, USA

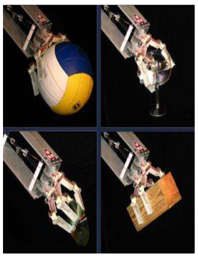


- Recognize challenging grasp categories to better understand human hand use
- Two stage approach: hand parsing (hand part segmentation) followed by grasp recognition
- 30% improvement over a state-of-the-art grasp recognition technique.

11:50–12:05	ThCT7.3

A Comparative Study of Contact Models for Contact-Aware State Estimation

Shuai Li[1], Siwei Lyu[2],
Jeff Trinkle[1] and Wolfram Burgard[3]
[1]Rensselaer Polytechnic Institute, USA [2]Univeristy at Albany SUNY, USA [3]University of Freiburg, Germany

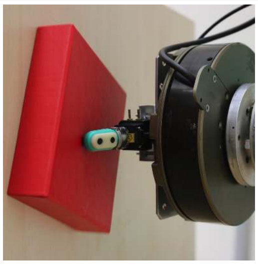


- We evalutated four particle filters based upon four probabilistic state transition models generated from a deterministic multibody dynamics models with rigid or compliant contacts.
- Comparisons of these particle filters are carried out gthrough the analysis of real and simulated experiments, the resutls of which, provide guidance ot the fitler designers.

12:05–12:20	ThCT7.4

Stabilizing Novel Objects by Learning to Predict Tactile Slip

Filipe Veiga[1], Herke van Hoof[1],
Jan Peters[1] and Tucker Hermans[1]
[1]Technische Universitaet Darmstadt, Germany

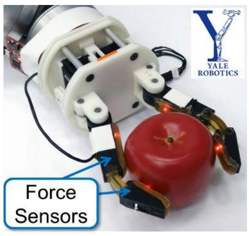


- Supervised learning for creating generalizable slip predictors.
- Predictors provide feedback for object stabilization control.
- Controller can successfully stabilize previously unknown objects by predicting and counteracting slip events.

12:20–12:35	ThCT7.5

Unplanned, Model-Free, Single Grasp Object Classification with Underactuated Hands and Force Sensors

Minas V. Liarokapis, Berk Calli,
Adam J. Spiers and Aaron M. Dollar
Yale University, USA



- Objects classified during a single grasp of an underacted robot hand equipped with force sensors.
- Feature space consists of actuator positions and force sensor values at two time instances.
- Process uses open loop control and no model of the hand or object.

12:35–12:50	ThCT7.6

On the Development of a Tactile Sensor for Fabric Manipulation and Classification for Industrial Applications

Simone Denei, Perla Maiolino, Emanuele Baglini and Giorgio Cannata
University of Genova

- A novel multi-modal tactile sensor featuring a matrix of capacitive pressure sensors, a microphone for acoustic measurements and proximity and ambient light sensor.
- The sensor is fully embedded and can be easily integrated at mechanical and electrical levels with industrial grippers.
- Experiments assess the capabilities of the sensor for implementing tactile based industrial gripper control and tactile based fabric classification.

Mapping 2

Chair *Christian Häne, ETH Zurich*
Co-Chair *Patrick Rives, INRIA*

11:20–11:35	ThCT8.1

Real-time Point Cloud Compression

Tim Golla[1] and Reinhard Klein[1]
[1]University of Bonn, Germany

- Compression approach much faster than previous ones
- Compression rates comparable or better
- Easy to implement
- Based on reparameterization and image compression techniques

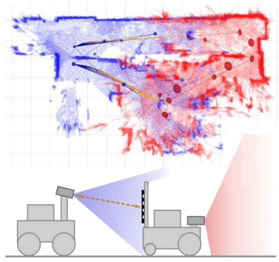
Original Compressed

11:35–11:50	ThCT8.2

Multi-Robot 6D Graph SLAM Connecting Decoupled Local Reference Filters

Martin J. Schuster[1], Christoph Brand[1], Heiko Hirschmüller[1], Michael Suppa[1] and Michael Beetz[2]
[1]German Aerospace Center (DLR), [2]University Bremen, Germany

- **Local reference filters** on each robot for real-time state estimation
- **Incremental graph SLAM:** Novel graph topology to combine the filter estimates for online multi-robot global localization and mapping
- **Multi-robot experiments** with loop closures through visual robot detections and map matching



11:50–12:05	ThCT8.3

Obstacle Detection for Self-Driving Cars Using Only Monocular Cameras and Wheel Odometry

Christian Häne, Torsten Sattler and Marc Pollefeys
Department of Computer Science
ETH Zürich, Switzerland

- Self-driving car equipped with monocular fisheye cameras
- 3D reconstruction from multiple images of a single camera while the car moves
- Extraction of obstacles as objects sticking out of the ground plane
- Fusion into joint 2D obstacle map
- Real-time processing on the car

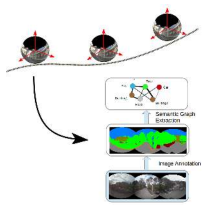
(Figure: *white* free space, *gray* obstacles)

12:05–12:20	ThCT8.4

Hybrid Metric-Topological-Semantic Mapping in Dynamic Environments

R., Drouilly[1,2], P., Rives[1],And B., Morisset[2]
[1]Lagadic-INRIA Méditerranée Team, France,
[2]ECA Robotics, France

- Efficient representation for large scale dynamics environments.
- Scene understanding is used to detect dynamic objects and to recover the labels of the occluded parts of the scene through an inference process.
- Evaluation on a large dynamic outdoor database acquired at two times with an interval of three years.



Map Structure

12:20–12:35	ThCT8.5

Information-Theoretic Dialog to Improve Spatial Semantic Representations

Sachithra Hemachandra[1] & Matthew R. Walter[2]
[1]MIT [2]TTI-Chicago

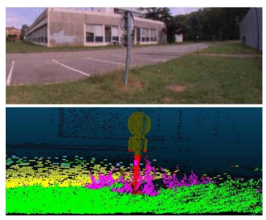
- Learn spatial-semantic world models from natural language descriptions
- Engage the user in dialog to reduce uncertainty in learned semantic map
- Decision process balances information gain with cost of asking questions
- Experimental results demonstrate reduced entropy and improved accuracy over previous methods

12:35–12:50	ThCT8.6

Improving LiDAR Point Cloud Classification using Intensities and Multiple Echoes

Christophe Reymann[1,2] and Simon Lacroix[2],
[1]Université de Toulouse, France [2]LAAS-CNRS, France

- Qualitative assessment of multi-echo and intensity features of a small LiDAR
- Potential improvement of multi-label classification using these features
- Hierarchical classification scheme
- Results on complex outdoor scenes



Legged Robots 2

Chair *Koichi Osuka, Osaka University*
Co-Chair *Ioannis Poulakakis, University of Delaware*

11:20–11:35 ThCT9.1

Dynamic Trotting on Slopes for Quadrupedal Robots

C. Gehring[1], C. D. Bellicoso[1], S. Coros[2], M. Bloesch[1], P. Fankhauser[1], M. Hutter[1] and R. Siegwart[1]
[1]ETH Zurich, Switzerland, [2]Carnegie Mellon University, USA

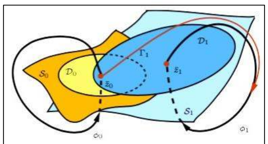
- Terrain estimation technique for dynamic gaits
- Control method for trotting on slopes
  - Body adaptation
  - Foot placement strategies
- Experimental results with quadruped StarlETH

11:35–11:50 ThCT9.2

On the Control of Gait Transitions in Quadrupedal Running

Qu Cao[1], Anthom T. van Rijn[2] and Ioannis Poulakakis[1]
[1]University of Delaware, USA
[2]Eidhoven University of Technology, The Netherlands

- Periodic motions of pronking and bounding are generated passively using a reduced-order model
- A hybrid controller is developed to stabilize the periodic motions
- Gait transitions between pronking and bounding are realized through estimates of the domain of attraction



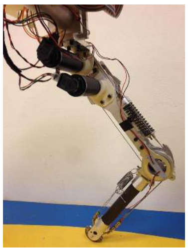
$\bar{z}_0$ is within the domain of attraction of $\bar{z}_1$ and can transit to $\bar{z}_1$ through the stabilizing controller Γ_1

11:50–12:05 ThCT9.3

SPEAR: A Monopedal Robot with Switchable Parallel Elastic Actuation

Xin Liu, Anthony Rossi and Ioannis Poulakakis
University of Delaware, USA

- A Switchable Parallel Elastic Actuator (S-PEA) is employed to drive the knee of the monopod SPEAR
- The switch in S-PEA engages the spring during stance allowing energy storage; the spring is turned off during flight allowing precise motion control of the joints
- Experimental results demonstrate the effectiveness of the S-PEA design in dynamic locomotion gaits

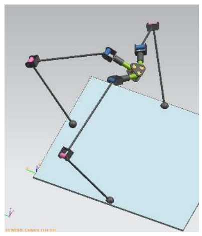


12:05–12:20 ThCT9.4

Gait Design and Gain-Scheduled Balance Controller of an Under-Actuated Robotic Platform

Jacob Webb, Alexander Leonessa, Dennis Hong
Virginia Tech, United States

This work presents a method for deriving a gain scheduled balance controller to stabilize the gate of a three legged under-actuated robotic platform called THALeR (Tri-Pedal Hyper Altitudinal Legged Robot). The scheduler adapts the controller gains in real time based upon the system's instantaneous potential energy in order to create a smooth, stable gait.

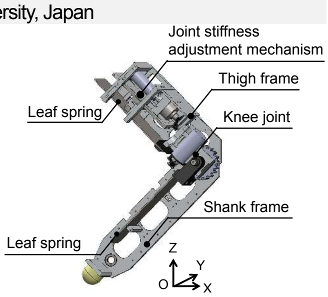


12:20–12:35 ThCT9.5

Knee Joint Mechanism That Mimics Elastic Characteristics and Bending in Human Running

T. Otani[1], K. Hashimoto[1], S. Hamamoto[1], S. Miyamae[1], M. Sakaguchi[2], Y. Kawakami[1], H. O. Lim[3] and A. Takanishi[1]
[1]Waseda University, Japan [2] University of Calgary, Canada [3]Kanagawa University, Japan

- The knee was equipped with a mechanism comprising two leaf springs and a worm gear for adjusting the joint stiffness and high-speed bending knee.
- We were able to achieve joint stiffness within the range of human knee joints.

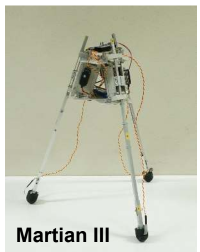


12:35–12:50 ThCT9.6

Tripedal Walking Robot with Fixed Coxa driven by Radially Stretchable Legs

Kentaro Oki[1], Masato Ishikawa[1], Yu Li[1] , Naoto Yasutani[1] and Koichi Osuka[1,2]
[1]Osaka University, Japan [2]JST CREST, Japan

- **Tripedal Walking Robot**, hip joints are all fixed, legs can only shrink/stretch
- Locomotion (forwarding/rotation) is realized by periodic control signals, with proper frequency ratio and phase gaps
- Background theory stems from differential geometric principle of rolling hemisphere
- Successor of the Matian II, where the legs are completely fixed and driven by



Autonomous Agents

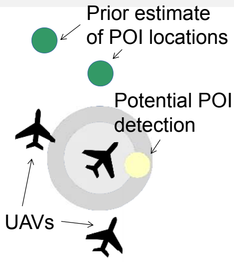
Chair *Michael Beetz, University of Bremen*
Co-Chair *Kagan Tumer, Oregon State University*

11:20–11:35	ThCT10.1

Implicit Adaptive Multi-robot Coordination in Dynamic Environments

Mitchell Colby, Jen Jen Chung, and Kagan Tumer
Oregon State University, USA

- Multi-robot teams can improve performance in exploration missions.
- Ensuring coordination between robots is critical for mission success.
- We develop robot control policies using cooperative coevolutionary algorithms.
- By shaping fitness functions with difference evaluation functions, we can ensure coordination.

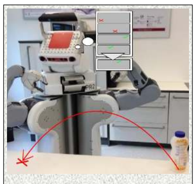


11:35–11:50	ThCT10.2

Robot Action Plans that Form and Maintain Expectations

Jan Winkler, Michael Beetz
University of Bremen, Germany

- Robots Forming Intuition from Experience
- Two way Prediction: What will happen and what does a robot need to do to make it happen?
- Plan Language Features – no extra coding
- Unsupervised Learning: Robot judges good from bad choices
- Performance Improvement: Avoid known problems autonomously

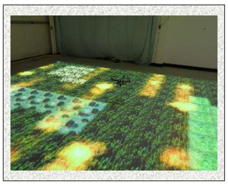

Action Effect Prediction

11:50–12:05	ThCT10.3

Online Heterogeneous Multiagent Learning Under Limited Communication

N. K. Ure[1], S. Omidshafiei[1], B. T. Lopez[1], A. Agha-Mohammadi[1] , J. P. How[1] and J. Vian[2]
[1]MIT, USA [2]Boeing Research &Technology, USA

- Multiagent learning where agents estimate different models from their measured data, but they can share information by communicating model parameters.
- hardware flight tests on a forest fire management scenario for which agents must learn the transition model of the fire spread depending on external factors such as wind and vegetation.



12:05–12:20	ThCT10.4

Tight Analysis of A Collisionless Robot Gathering Algorithm

Gokarna Sharma[1], Costas Busch[2], Supratik Mukhopadhyay[2] and Charles Malveaux[2]
[1]Kent State University, USA [2]Louisiana State University, USA

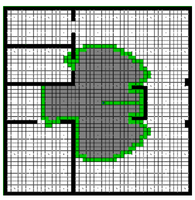
- Fundamental problem of gathering n fat robots around a predetermined point T in the Euclidean plane avoiding collisions.
- A runtime upper bound of $O(R+n)$ rounds for the algorithm of Cord-Landwehr *et al.* in a synchronous setting, where R is the longest distance to a robot from T in the initial configuration
- A runtime lower bound of $R+(n-1)/2$ rounds for a class of greedy algorithms.
- A runtime lower bound of $R+(n-1)$ rounds for the algorithm of Cord-Landwehr *et al.* showing the tightness of the analysis.

12:20–12:35	ThCT10.5

Multi-robot taboo-list exploration of unknown structured environments

Mihai Andries[1], François Charpillet[1]
[1]Inria, Université de Lorraine, CNRS, LORIA, France

- Taboo-list graph exploration;
- Distributed identification of exploration completion;
- Marking multiple cells at once;
- Gathering agents at a pre-defined spot after exploration is complete.



12:35–12:50	ThCT10.6

Towards robots conducting chemical experiments

Gheorghe Lisca[1], Daniel Nyga[1], F. Bálint-Benczédi[1], H. Langer[1] and M. Beetz[1]
[1]Universität Bremen, Germany

- Understanding Chemistry Protocols
- Symbolicaly Describing Actions
- Parametrizable Plan Schemata
- Manipulation Plan Library
- Symbolicaly Parametrizable Perception System
- Performing pipetting and centrifuging

Telerobotics 2

Chair *Stefano Stramigioli, University of Twente*
Co-Chair *Jee-Hwan Ryu, Korea Univ. of Tech. and Education*

11:20–11:35	ThCT11.1

Higher Order Sliding Mode based Impedance Control for Dual User Bilateral Teleoperation

H. Santacruz-Reyes[1], L.G. Garcia-Valdovinos[1],
T. Salgado-Jimenez[1] and L.A. Garcia-Zarco[2]
[1]CIDESI, Mexico [2]ITLAC, Mexico

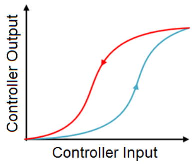
A dual-user teleoperation scheme to perform a collaborative task using n-DOF nonlinear manipulators as masters and slave is presented. Impedance controllers for the manipulators are implemented in order to achieve a desired dynamic behavior depending on the user's necessities. Furthermore, a sliding mode controller is introduced to cope with the time delay in the communication channels and the uncertainty in the slave.

11:35–11:50	ThCT11.2

Stable Bilateral Teleoperation with Input-to-State Stable Approach

Aghil Jafari, Muhammad Nabeel, Jee-Hwan Ryu
Korea University of Technology and Education
Cheonan, Rep. Of Korea

- Passivity approaches has been suffering from their **intrinsic conservatism** which leads **low transparency**.
- **Input-to-State Stable Approach as a Less conservative** control approach is extended for bilateral teleoperation.
- Inspired from the analogy between bilateral controllers and systems with hysteresis nonlinearity.
- Providing higher transparent teleoperation.

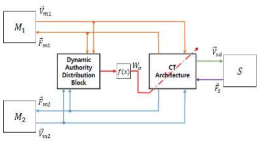


11:50–12:05	ThCT11.3

Dynamic Authority Distribution for Cooperative Teleoperation

Naveed Ahmed Usmani, Tae-Hwan Kim
and Jee-Hwan Ryu
Korea University of Technology and Education, Rep. of Korea

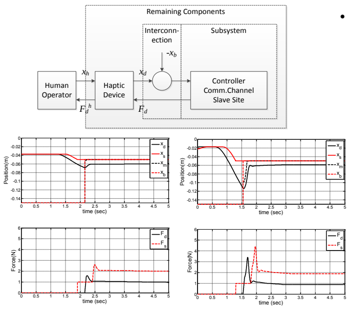
- This paper presents **dynamic authority distribution** method for dual master single slave cooperative teleoperation systems
- Concept of energy flow is utilized to identify operators' intentions and behaviors to classify into leader/follower characteristic
- Authorities are dynamically updated in real-time in each DOF separately



12:05–12:20	ThCT11.4

Position and Stiffness Bounding Approach for Geometry Transparency in Time-delayed Teleoperations

Sungjun Park, Riaz Uddin, Sungchul Kang and Jeha Ryu
Gwangju Institute of Science and Technology
Korea Institute of Science and Technology



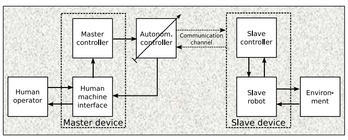
- The current investigation presented a position and stiffness bounding approach for solving the abrupt model jump problem that may cause instability by a sudden contact location change. The stability also is rigorously proved. The proposed method, therefore, significantly improved so called "geometry transparency" in time-delayed teleoperations. Experimental results showed the rapid and stable update for the remote environment location.

12:20–12:35	ThCT11.5

Bilateral Human-Robot Control for Semi-Autonomous UAV Navigation

Han. W. Wopereis, Matteo Fumagalli,
Stefano Stramigioli and Raffaella Carloni
University of Twente, The Netherlands

- The controller combines the stability and precision of an UAV autonomous control with the cognitive abilities of a human operator.



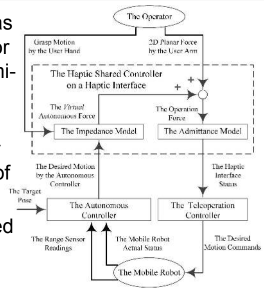
- The human operator is allowed to assist the autonomous controller by actively changing its navigation parameters to assist in critical situations.

12:35–12:50	ThCT11.6

A haptic shared control algorithm for flexible human assistance to semi-autonomous robots

Ningbo Yu*, Kui Wang, Yuan Li, Chang Xu, Jingtai Liu
Institute of Robotics and Automatic Information Systems
Nankai University, Tianjin 300071, China

- A haptic shared control algorithm has been proposed for a human operator to provide flexible assistance to semi-autonomous mobile robots.
- The motion control authority can smoothly shift between the operator and the robot autonomy, at the will of the human operator.
- The algorithm has been implemented and validated by experiments.



Robot Learning 2

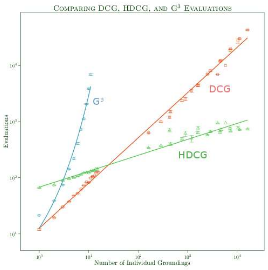
Chair *Ales Ude, Jozef Stefan Institute*
Co-Chair *Baris Akgun, Georgia Institute of Technology*

11:20–11:35	ThCT12.1

On the Performance of Hierarchical Distributed Correspondence Graphs for Efficient Symbol Grounding of Robot Instructions

Istvan Chung[1], Oron Propp[1], Matthew Walter[2], Thomas Howard[3]
[1]MIT [2]TTI-Chicago [3]University of Rochester

- Hierarchical Distributed Correspondence Graphs (HDCG) learn a reduction of the symbol space for real-time natural language understanding or robot instructions
- Experimental evaluation of HDCG computational complexity in the context of other approaches based on probabilistic graphical models

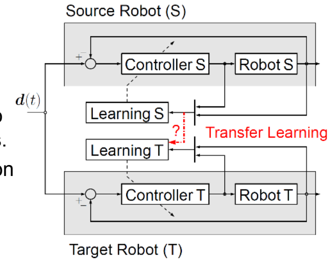


11:35–11:50	ThCT12.2

An Upper Bound on the Error of Alignment-Based Transfer Learning Between Two Linear, Time-Invariant, Scalar Systems

Kaizad V. Raimalwala[1], Bruce A. Francis[1], and Angela P. Schoellig[1]
[1]University of Toronto, Canada

- Question: Can a robot use another robot's data for model learning?
- We study a simple scenario with two LTI, SISO systems.
- We derive analytic results on when transfer learning is beneficial.

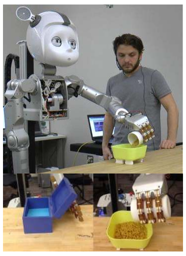


11:50–12:05	ThCT12.3

Self-Improvement of Learned Action Models with Learned Goal Models

Baris Akgun[1] and Andrea Thomaz[1],
[1]Georgia Institute of Technology, USA

- Action models - to execute the skill - and goal models - to monitor this execution - are learned from demonstrations
- Self-improvement: skills are executed by sampling from the action model and the goal model is used to label these executions
- Successful samples are used to update the action model
- Successful action models are reached starting from the failed action models

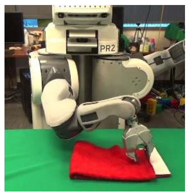


12:05–12:20	ThCT12.4

Learning from Multiple Demonstrations using Trajectory-Aware Non-Rigid Registration

Alex X. Lee, Abhishek Gupta, Henry Lu, Sergey Levine, Pieter Abbeel
University of California, Berkeley

- Non-rigid registration based trajectory transfer predicts gripper motions for a new scene by first finding a registration between training scene and new scene, and then extrapolating this registration to transfer training scene gripper motion to new scene.
- Challenge addressed: a trajectory-aware non-rigid registration that uses multiple demonstrations to focus the registration on the points that are relevant to the task.

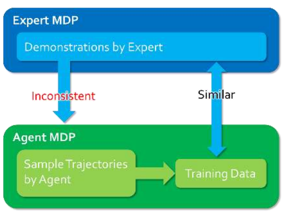


12:20–12:35	ThCT12.5

Apprenticeship Learning Based on Inconsistent Demonstrations

Gakuto Masuyama[1], Kazunori Umeda[1],
[1]Chuo University, Japan

- Inconsistency of demonstrations
  - Differences in dynamics, environments
- Picking out demonstrations from sample trajectories obtained by exploration
  - Abstraction of trajectories; importance estimation



Planning, Scheduling and Coordination

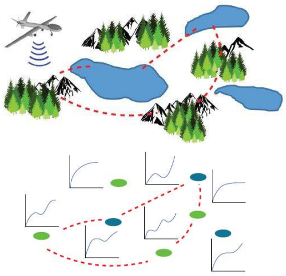
Chair *Jingjin Yu, Rutgers University*
Co-Chair *Jean Oh, Carnegie Mellon University*

11:20–11:35 ThCT13.1

Anytime Planning of Optimal Schedules for a Mobile Sensing Robot

Jingjin Yu*, Javed Aslam, Sertac Karaman*, and Daniela Rus***
*** Massachusetts Institute of Technology **Northeastern University**

- We introduce the **Optimal Tourist Problem (OTP)** for modeling a constrained mobile sensor optimization problem
- We propose two dual formulations
  - Reward Maximizing Tourist (RMT)
  - Budget Minimizing Tourist (BMT)
- We derive integer linear programming (ILP) models for optimally solving RMT and BMT, along with faster anytime algorithms that find near optimal solutions faster



11:35–11:50 ThCT13.2

A decision-theoretic planning approach for multi-robot exploration and event search

Jennifer Renoux[1], Abdel-Illah Mouaddib[1] and Simon Le Gloannec[2]
[1]University of Caen Normandy, France [2]Airbus Defence and Space, France

- Event search: **detecting** and **tracking** changes in a dynamic environment
- Each robot computes **communication** and **exploration** policies by assessing the **relevance** of the observations
- Agents gradually reduce the importance of old observations in their belief state
- Targetted applications: intrusion detection, industrial maintenance, search and rescue

11:50–12:05 ThCT13.3

POMDP to the Rescue: Boosting Performance for Robocup Rescue

Kegui Wu[1], Wee Sun Lee[1], and David Hsu[1]
[1]National University of Singapore, Singapore

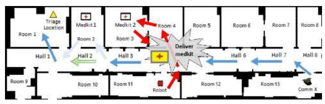
- Boost the performance on Robocup Rescue given several policies from the competition
- Online POMDP algorithm with macro-actions
- Plan in a macro-action space suggested by the competition policies
- Use Structured SVM to approximate and extrapolate the competition policies

12:05–12:20 ThCT13.4

Planning for Serendipity

T. Chakraborti[1], G. Briggs[2], K. Talamadupula[3], Y. Zhang[1], M. Scheutz[2], D. Smith[4], S. Kambhampati[1]
[1]Arizona State University, USA [2]Tufts University, USA
[3]IBM Research, USA [4]NASA ARC, USA

- Stigmergic collaboration among robots and humans in cohabitation.
- How can a robot provide assistance to a human without any commitments or expectations to help?
- Modeling plan interruptibility and plan preservation.
- Producing external positive interventions on plans under execution – forming impromptu "teams".
- Results show significant opportunities for such interventions.

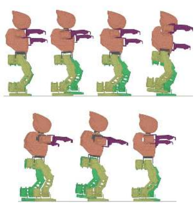


12:20–12:35 ThCT13.5

Ensemble-CIO: Full Body Dynamic Motion that Transfers to Physical Humanoids

Igor Mordatch[1], Kendall Lowrey[1], and Emanuel Todorov[2]
[1]University of Washington, USA

- Trajectory Optimization transfers poorly to the real world due to model errors, noise
- Ensemble-CIO applies contact invariant optimization to multiple models with perturbed parameters
- Resulting trajectory is more robust to sources of errors
- Ensemble method tested on Darwin-OP robot with and without optimization derived feedback

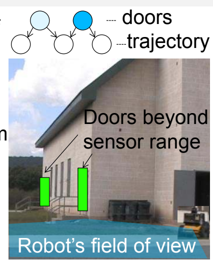


12:35–12:50 ThCT13.6

Inferring door locations from a teammate's trajectory in stealth human-robot operations

Jean Oh, Luis Navarro-Serment, Arne Suppé, Anthony Stentz and Martial Hebert
Carnegie Mellon University, USA.

- Inferred perception: probabilistic model of environment beyond hardware sensor ranges
- **Teammate is a remote sensor**
- Noisy-OR model to infer environment from noisy observations of human teammates
- Motivating example: detecting doors (threats) with high accuracy by exploiting teammate's trajectory and inter-visibility



Wearable Robots

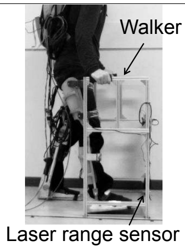
Chair *Chang-Soo Han, Hanyang University*
Co-Chair *Yoji Uno, Nagoya University*

11:20–11:35	ThCT14.1

On-line control of continuous walking of wearable robot coordinating with user's voluntary motion

Takahiro Kagawa, Takayuki Kato, Yoji Uno
Nagoya University, Japan

- This system consists of sensing of user's motion and on-line motion planning.
- Distance between the user and walker is measured by a laser range sensor.
- Motion of the robot is planned on the basis of optimization so that the stride length is equal to the movement distance of the walker.
- On-line motion planning algorithm enables fast and continuous walking.

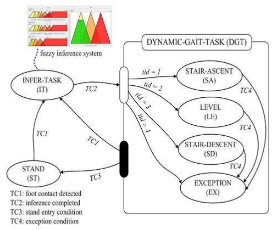


11:35–11:50	ThCT14.2

Online Gait Task Recognition Algorithm for Hip Exoskeleton

Junwon Jang[1], Kyungrock Kim[1], Jusuk Lee[1], Bokman Lim[1], and Youngbo Shim[1]
[1]Samsung Advanced Institute of Technology, South Korea

- Online gait task recognition is achieved by the relations of both hip joint angles at the moment of foot contact.
- No sensors measuring foot force or pressure in direct are used.
- Foot contact is estimated by processing the vertical acceleration at the lower back in hip exoskeleton.



11:50–12:05	ThCT14.3

EMY : a dual arm exoskeleton dedicated to the evaluation of BMI in clinical trials

Boris Morinière[1], Alexandre Verney[1], Neil Abroug[1], Philippe Garrec[1], and Yann Perrot[1]
[1]CEA-LIST, France

- Two actuated arms (4 DoF each)
- Experimental platform for BMI evaluation
- Usable in Clinical Trial with disabled people
- Design under medical standards in order to reduce:
  - Mechanical harm
  - Electrical hazard

12:05–12:20	ThCT14.4

Development and experimental testing of a portable hand exoskeleton

Benedetto Allotta[1], Roberto Conti[1], Lapo Governi[1], Enrico Meli[1], Alessandro Ridolfi[1] , Yary Volpe[1]
[1]University of Florence, Italy

Objective: development of a low cost, portable and wearable Hand Exoskeleton System (HES) for hand opening disabilities.

- Motion capture of the fingers' trajectories;
- Development of 3D multibody model of the hand and the exoskeleton;
- Design of a real prototype of the HES to perform preliminary tests;
- Testing phase of the HES.

HES prototype worn by the TH1 patient

12:20–12:35	ThCT14.5

Development of a Lower Extremity Exoskeleton Robot with a Quasi-anthropomorphic Design Approach for Load Carriage

Donghwan Lim [1], Wansoo Kim[1], Heedon Lee[1], Hojun Kim[1], Kyoosik Shin[1], Taejoon Park[1], JiYeong Lee[1] and Changsoo Han[1*]
[1]Hanyang Univeristy, Korea

- This study developed the Hanyang Exo-skeleton Assistive Robot (HEXAR)-CR50 aimed at improving muscle strength of the wearer while transporting a load.
- The developed exoskeleton robot HEXAR -CR50 has 7 DOF for one foot, 3-DOF for the hip joints, 1-DOF for the knee joints, and 3-DOF for the ankle joints.

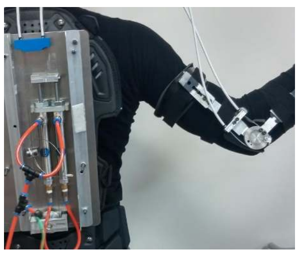
< HEXAR CR-50>

12:35–12:50	ThCT14.6

Introduction and Initial Exploration of an Active/Passive Exoskeleton Framework

Robert P Matthew[1], Eric J Mica[2], Joel A Loeza[2], Waiman Meinhold[2], Masayoshi Tomizuka[2] and Ruzena Bajcsy
[1]UC Berkeley EECS [2]UC Berkeley Mechanical Engineering

- Novel actuation strategy for assisting an individual.
- Active mode sets dynamic response of arm.
- Passive mode maintains the dynamic response without requiring additional energy.
- Initial prototype passively increases the hammer curl count between 65-92%.



Animation and Simulation

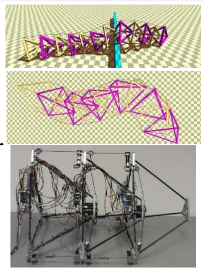
Chair *Evan Drumwright, George Washington University*
Co-Chair *Brian T. Mirletz, Case Western Reserve University*

11:20–11:35	ThCT15.1

Towards bridging the reality gap between tensegrity simulation and robotic hardware

Brian T. Mirletz[1], Roger D. Quinn[1], In Won Park[2] and Vytas SunSpiral[2]
[1]Case Western Reserve University, USA [2]NASA Ames Research Center, USA

- Using Bullet Physics Engine via NASA Tensegrity Robotics Toolkit to model compliant tensegrity robots
- Verified simulator sufficient for future robotic design: maximum actuator forces within 8% of those predicted by simulator
- New version of Tetraspine hardware with accurate force sensing
- Machine learned gait successfully transferred to hardware

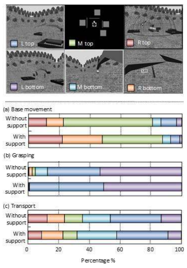


11:35–11:50	ThCT15.2

Inducement of Visual Attention Using Augmented Reality for Multi-Display Systems in Advanced Tele-operation

Junjie Yang, Mitsuhiro Kamezaki, Ryuya Sato, Hiroyasu Iwata, and Shigeki Sugano
Waseda University, Japan

- We have introduced the Augmented Reality (AR) items to advanced tele-operation.
- Performance is improved after using AR visual support.
- How AR items support operators' performance is discussed
- Visual attention habit is changed after using AR visual support

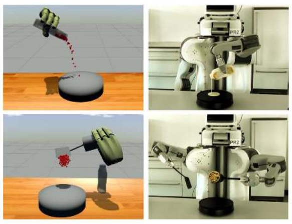


11:50–12:05	ThCT15.3

Learning Action Failure Models from Interactive Physics-based Simulations

Andrei Haidu[1], Daniel Kohlsdorf[2] and Michael Beetz[1]
[1]Universität Bremen [2]GATECH

- Learning an action failure detection model from Physics-based interactive simulations
- Storing and querying large amounts of simulation data

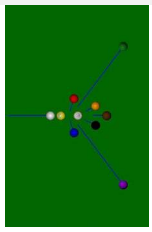


12:05–12:20	ThCT15.4

Computational Modeling of N-body Collisions

Feifei Wang, Huan Lin, And Yan-Bin Jia
Iowa State University, USA

- Frictionless case: impulses are initialized from a non-linear system and tracked through numerical integration.
- Frictional case: checking for contact modes to be in consistence with Coulomb's friction law.
- Simulation: implement frictional model by nine-ball break shots.
- Experiment: verify frictionless model by Newton's cradle.

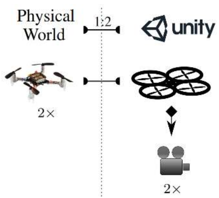

stop shot

12:20–12:35	ThCT15.5

Mixed Reality in Robotics

Wolfgang Hönig[1], Christina Milanes[1], Lisa Scaria[1], Thai Phan[1], Mark Bolas[1] and Nora Ayanian[1]
[1]University of Southern California, USA

- Spatial Flexibility
- Remote Collaboration
- Elimination of Safety Risks
- Debugging Simplification
- Unconstrained Additions to Robots
- Scaling up Swarms
- Cheaper or fewer robots for experiments
- Free choice of virtual vs. physical objects

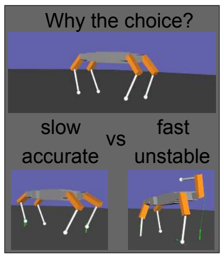


12:35–12:50	ThCT15.6

Adaptive Integration for Controlling Speed vs. Accuracy in Multi-Rigid Body Simulation

Samuel Zapolsky[1], Evan Drumwright[1],
[1]George Washington University, USA

- How can we know when a robotic simulation is sufficiently accurate?
- What type of integration scheme should be selected to maximize performance (accuracy and stability vs. speed)?
- Can dissipation be used to increase simulation stability, and at what cost?



Motion Control

Chair *Lorenzo Moriello, University of Bologna*
Co-Chair *Andreas Zell, University of Tübingen*

14:00–14:15	ThDT1.1

Perosonal Robot Assisting Transportation to Support Active Human Life

Noriaki Hirose[1], Ryosuke Tajima[1], and Kazutoshi Sukigara[1]
[1]Toyota Central R&D Labs., INC.

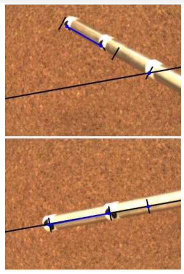
- New Prototype Personal Robot (approx. **10 kg**)
- Following User Automatically and Bringing Baggages
- **Model Predictive Control with Multiple Future Prediction** for Adjacent Following w/o Collision

14:15–14:30	ThDT1.2

Adaptive Image-based Positioning of RCM Mechanisms Using Angle and Distance Features

D Navarro-Alarcon, HM Yip, Z Wang, YH Liu, W Lin, P Li
The Chinese University of Hong Kong, HKSAR

- We present a method to position RCM mechanisms with a single camera
- The 3-DOF configuration is characterized with image features
- A visual servo controller with adaptive Jacobian estimation is proposed



14:30–14:45	ThDT1.3

A Robust Nonlinear Controller for Nontrivial Quadrotor Maneuvers: Approach and Verification

Y. Liu[1,3], J. M. Montenbruck[2], P. Stegagno[3], F. Allgöwer[2] and A. Zell[1]
[1]Univ. of Tübingen, Germany [2]Univ. of Stuttgart, Germany
[3]Max Planck Inst. for Biological Cybernetics, Germany

- A nonlinear control approach for quadrotor Micro Aerial Vehicles (MAVs) combining a global output regulator for attitude and a robust controller for translational motions.
- An online trajectory generator using a model predictive control method.
- Waypoint tracking and aggressive maneuver tests on a high-payload-capable quadrotor with disturbances.

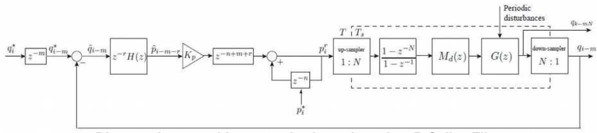
"Aggressive quadrotor Maneuvers" experiment

14:45–15:00	ThDT1.4

A Repetitive Control Scheme for Industrial Robots Based on B-Spline Trajectories

Luigi Biagiotti*, Lorenzo Moriello**, Claudio Melchiorri**
*DIEF – University of Modena and Reggio Emilia - Italy
**DEI – University of Bologna - Italy

- A novel Repetitive Control scheme based on B-Spline trajectory modification is presented.
- B-spline filters for online trajectory generation are illustrated and the scheme stability is analyzed.
- Conditions for asymptotic convergence of the error to zero are given.
- Experimental results on an industrial manipulator proved the enhancement of the factory position controller performances.



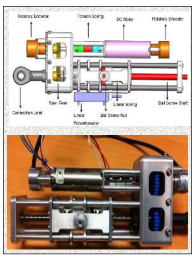
Discrete-time repetitive control scheme based on B-Spline Filter

15:00–15:15	ThDT1.5

Robust Position Control of a Novel Series Elastic Actuator via Disturbance Observer

Emre Sariyildiz, Gong Chen, Hoayong Yu
National University of Singapore, Singapore

- A novel Series Elastic Actuator (SEA) design
- Variable impedance via soft and stiff springs in series
- Multiple resonant modes
- Robust position control of the novel SEA via Disturbance Observer (DOb)
- Vibration suppression via resonance ratio control



15:15–15:30	ThDT1.6

An On-line Gravity Estimation Method using Inverse Gravity Regressor for Robot Manipulator Control

Joonhee Jo[1,2], DongHyun Lee[1], Duc Trong Tran[3], Yonghwan Oh[1] and Sang-Rok Oh[1]
[1]Korea Institue of Science and Technology(KIST), Korea
[2]University of Science and Technology(UST), Korea [3]Global Technology Center, Samsung Electronicsns, Korea

- Prerequisite:
  - Model parameters are estimated under quasi-static state
  - CoM of link is located along the axial line at some distance.
- Update rule:

$$\hat{s}(q, m, p, p_c)(t) = \hat{s}_0(q, m, p, p_c) + \int_0^t QZ^{\dagger}(q)(K_p(q_d(\tau) - q(\tau)) - K_d\dot{q})d\tau$$

Space Robotics and Automation

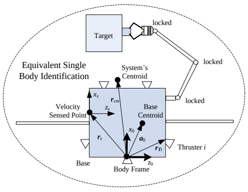
Chair *Sven Mikael Persson, McGill University*
Co-Chair *Wenfu Xu, Harbin Institute of Technology*

14:00–14:15	ThDT2.1

A Practical and Effective Method for Identifying the Complete Inertia Parameters of Space Robots

Wenfu Xu[1], Zhonghua Hu[1], Yu Zhang[1], Zhiying Wang[1], and Xinyu Wu[2]
[1]Harbin Institute of Technology, China [2]Shenzhen Institute of Advanced Technology, China

- Modeling of Space Robotic System
- Equivalent Single Body System Identification
- Equivalent Two-body System Identification
- Parameters Resolving Based on PSO Algorithm

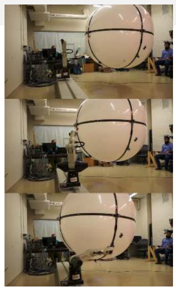


14:15–14:30	ThDT2.2

Ground Experiments towards the Interception of Non-Coop. Space Debris w\ Robotic Manip.

Sven Mikael Persson[1] and Inna Sharf[1]
[1]McGill University, Canada

- **Neutrally-buoyant Airship** as Non-cooperative Free-floating Target
- **Mobile Robotic Manipulator** as Analog for Space Manipulator
- Fully-integrated Online **Estimation**, **Prediction** and **Motion-planning** System
- Discussion of Experimental Issues with using an **Airship as a Satellite Emulator**
- Presents First Ever Live Experiments of **Close-range Interception Maneuvers**

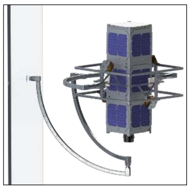


14:30–14:45	ThDT2.3

Robotic Test Bench for CubeSat: Concept and Satellite Dynamic Parameter Identification

Irina Gavrilovich[1], Sébastien Krut[1], Marc Gouttefarde[1], François Pierrot[1] and Laurent Dusseau[2]
[1]LIRMM, [2]University of Montpellier, France

- A novel concept of an air bearing test bench for CubeSats ground testing involving a 4-DoF redundant robotic wrist for 3-DoF unlimited rotation
- Dynamic parameter identification method based on the sampling of CubeSat free oscillating motions with no external actuation required

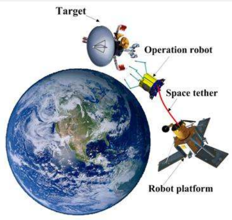


14:45–15:00	ThDT2.4

Segmented Control for Retrieval of Space Debris after Captured by Tethered Space Robot

Fan Zhang[1,2], Panfeng Huang[1,2]
[1]Research Center for Intelligent Roboics, School of Astronautics, Northwestern Polytechnical University
[2]National Key Laboratory of Aerospace Flight Dynamics, Northwestern Polytechnical University

In this paper, we propose a new control scheme for the retrieval of passive space debris after captured by a Tethered Space Robot (TSR)

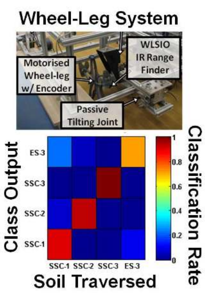


15:00–15:15	ThDT2.5

Soil Classification based on the Analysis of the Interaction with a Wheel-Legged Robot

Francisco Comin[1] and Chakravarthini Saaj[1]
[1]Surrey Space Centre, University of Surrey, United Kingdom

- Identifying in-situ the **physical, non-geometric response** of traversed terrain while minimizing risks
- Features related to **wheel-leg slip and sinkage** for terrain classification
- Approach experimentally tested with a **Single Wheel-Leg Test Bed** on dry sands with a range of physical characteristics
- Performance comparison of **different classifier algorithms** and parameters

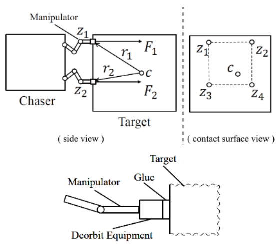


15:15–15:30	ThDT2.6

Multipoint-Contact Attitude Control of Non-Cooperative Spacecraft with Parameter Estimation

Tomohiro Narumi[1], Naohiro Uyama[2], and Shinichi Kimura[3]
[1]Tokyo University of Science, Japan [2]Shimizu Institute of Technology, Shimizu Corporation, Japan

- Estimation method of the dynamic parameters using an unscented Kalman filter based on multipoint contact information, and attitude stabilization control method using push-only (without pull operation) control based on feedback linearization and receding horizon with input constraints



Visual Servoing

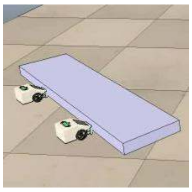
Chair *Luigi Villani, Università di Napoli Federico II*
Co-Chair *Kostas Kyriakopoulos, National Technical Univ. of Athens*

14:00–14:15 ThDT3.1

Image-Based Control of Two Mobile Robots for Object Pushing

Gonzalo López-Nicolás[1], Erol Özgür[2] and Youcef Mezouar[3]
[1]Universidad de Zaragoza, Spain [2]Universite d'Auvergne, France
[3]Institut Pascal, France

- Problem: how to push an object to a target pose with two cooperating mobile robots
- Non-holonomic velocity constraint is imposed on the object motion producing smooth and efficient trajectories.
- Pushing manipulation is performed with a new uncalibrated image-based control
- Stability of the control law is demonstrated



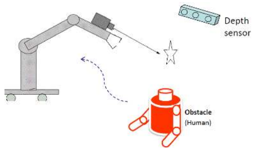
Two mobile robots pushing an object

14:15–14:30 ThDT3.2

Visual Servoing with Safe Interaction using Image Moments

Hamid Sadeghian[1], Luigi Villani[2], *et al.*
[1]University of Isfahan, Iran [2]University of Naples, Italy

- The problem of IBVS for robots working in a cluttered dynamic environment is addressed.
- The main idea is to control suitable image moments and to relax a certain number of robot's degrees of freedom during the interaction phase.

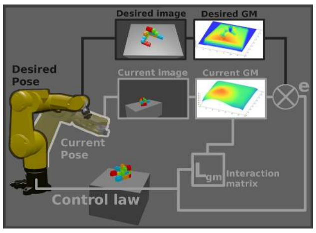


14:30–14:45 ThDT3.3

Photometric Gaussian Mixture Based Visual Servoing

Nathan Crombez[1], Guillaume Caron[1], El Mustapha Mouaddib[1]
[1]University of Picardie Jules Verne, Amiens, France
MIS laboratory

- **Gaussian** representation gives to each **pixel** a **power of attraction**
- Gaussian **extension** (variance) is optimized during the **visual servoing**
- **Enlargement** of the **convergence** domain

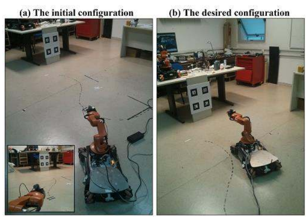


14:45–15:00 ThDT3.4

A Robust Self Triggered Image Based Visual Servoing Model Predictive Control Scheme for Small Autonomous Robots

Shahab Heshmati-alamdari, George C. Karras, Alina Eqtami and Kostas J. Kyriakopoulos
National Technical Universityof Athens

- A novel Image Based Visual Servoing-Model Predictive Control scheme which is combined with a mechanism that decides when the system needs to track visual information and when no, while the whole system does not lose the required performance.
- Satisfying the Visibility and inputs constraints.
- Robust with respect to the external disturbances.
- Results in the reduction of the computational effort, energy consumption and increases the autonomy of the system.
- Can be used effectively in small autonomous robotic systems which perform long lasting inspection tasks, where low energy consumption and high system autonomy are required.



15:00–15:15 ThDT3.5

Vision-Based High-Speed Manipulation For Robotic Ultra-Precise Weed Control

Andreas Michaels[1], Sebastian Haug[2], and Amos Albert[1]
[1]Deepfield Robotics, Germany [2]Robert Bosch GmbH, Germany

- Robotic mechanical weed control for organic farming
- High speed image processing pipeline for closed loop positioning of a weeding tool (Visual Servoing)

BoniRob® equipped with delta robot for mechanical weed control

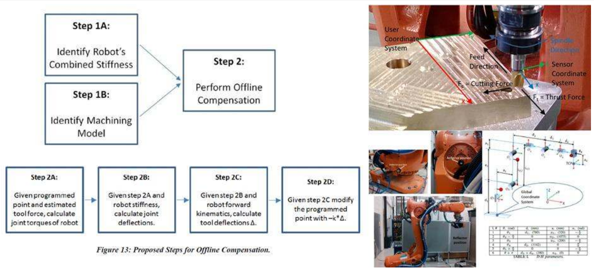
Motion Planning for Manipulators

Chair *Alessandro De Luca, Sapienza University of Rome*
Co-Chair *Petar Kormushev, Istituto Italiano di Tecnologia*

14:00–14:15	ThDT4.1

Off-line Path Correction of Robotic Face Milling Using Static Tool Force and Robot Stiffness

Ilya Tyapin, Knut Berg Kaldestad, Geir Hovland
Faculty of Engineering and Science, University of Agder, Norway

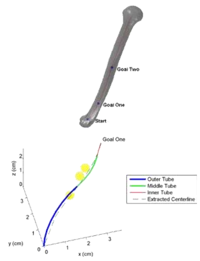


14:15–14:30	ThDT4.2

Motion Planning of Continuum Tubular Robots based on Centerlines Extracted from Statistical Atlas

Keyu Wu, Liao Wu, and Hongliang Ren
National University of Singapore, Singapore

- Propose a sampling-based motion planning algorithm with shape constraints for continuum tubular robots
- Utilize the centerline of a statistical atlas to determine the desired shape of the robot's shaft
- Deploy the continuum tubular robot in an approximate follow-the-leader manner during the motion process

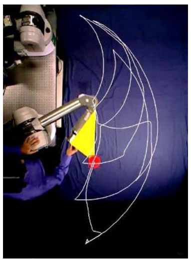


14:30–14:45	ThDT4.3

Kinematic-free Position Control of a 2-DOF Planar Robot Arm

Petar Kormushev[1,2], Yiannis Demiris[1]
and Darwin G. Caldwell[2]
[1]Imperial College London, UK [2]Italian Inst. of Technology, Italy

- New robot control concept: **Kinematic-free** and **encoderless** control of robot arms
- Does not need any prior kinematic knowledge; Does not measure joint angles
- **Learns** on-line to control the end-effector position using visual feedback only
- **Adapts** to changes in the robot kinematics (e.g. joint offsets, link lengths)
- **Proof-of-concept** experiments with a 2-DOF planar robot arm

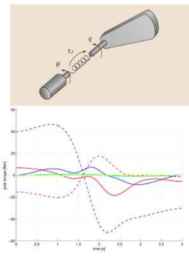


14:45–15:00	ThDT4.4

A recursive Newton-Euler algorithm for robots with elastic joints and its application to control

Gabriele Buondonno Alessandro De Luca
Sapienza Università di Roma, Italy

- recursive numerical inverse dynamics for serial robots with *N* elastic joints, having linear complexity *O(N)*
- generalized version of Newton-Euler algorithm with recursions involving higher order derivatives of motion/force variables
- basic algorithm + numerical factorization of link inertia matrix for real-time evaluation of feedback linearization control in $O(N^3)$

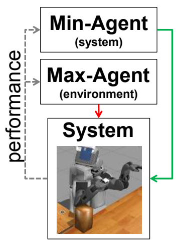


15:00–15:15	ThDT4.5

Automatic Testing and MiniMax Optimization of System Parameters

Kim Peter Wabersich[1], Marc Toussaint[1],
[1]University of Stuttgart, Germany

- Find best worst-case performance parameters:
- Evaluate system parameters by adversarially optimizing over environment parameters
- Use 'evil' environments in a game-theoretic optimization setting
- Bayesian global optimization is used for both optimization levels in a novel nested minimax optimization approach

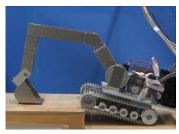


15:15–15:30	ThDT4.6

Obstacle Surmounting by Arm Maneuver for Unmanned Power Shovel

Peshala G. Jayasekara[1]and Hitoshi Arisumi[1]
[1]AIST, Japan

- To speed up access to inner parts of disaster stricken areas, obstacles can be surmounted with the assistance of maneuvered power shovel arm.
- Autonomous obstacle surmounting method that optimizes the total energy consumption is proposed for an unmanned power shovel to surmount a step-like obstacle.
- Simulation and experiment results show the effectiveness of the proposed method.



Robot Audition 1

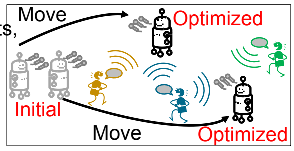
Chair *Jani Even, ATR*
Co-Chair *Hiroshi G. Okuno, Waseda University*

14:00–14:15 ThDT5.1

Optimizing the Layout of Multiple Mobile Robots for Cooperative Sound Source Separation

Kouhei Sekiguchi[1], Yoshiaki Bando[1], Katsutoshi Itoyama[1] and Kazuyoshi Yoshii[1]
[1] Kyoto University, Japan

- Our purpose is to find the optimal layout of multiple mobile robots for sound source separation
- The proposed method **estimates the performance of source separation** by **simulating delay-and-sum beamforming**
- We regard multiple mobile rsobots, each of which is equipped with a microphone array, as one big microphone array

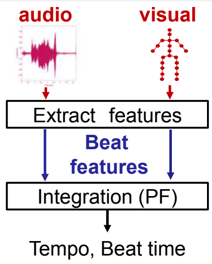


14:15–14:30 ThDT5.2

Audio-Visual Beat Tracking Based on a State-Space Model for a Music Robot Dancing with Humans

Misato Ohkita, Yoshiaki Bando, Yukara Ikemiya, Katsutoshi Itoyama, and Kazuyoshi Yoshii
The Graduate School of Informatics, Kyoto University

- Our purpose is beat tracking for a music robot dancing with humans.
- Our method extracts and integrates beat information of both **audio and visual signals** with **a particle filter**.
- Experimental results showed thes performance improvement of our audio-visual beat tracking method over mono-modal method.



14:30–14:45 ThDT5.3

Simultaneous asynchronous microphone array calibration and sound source localisation

Daobilige Su, Teresa Vidal-Calleja and Jaime Valls Miro
Centre for Autonomous System (CAS), University of Technology Sydney (UTS), Australia

- Asynchronous microphone array calibration
- Jointly estimates microphone locations, starting time offsets, clock differences and sound source positions

14:45–15:00 ThDT5.4

Sound-based control with two microphones

Aly Magassouba[1], Nancy Bertin[2], and François Chaumette[3]
[1]Université Rennes I, France [2]CNRS-IRISA, France [3]Inria-IRISA, France

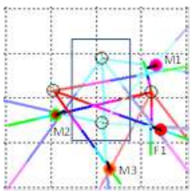
- We propose a modelling utilizing a sensor-based framework based on aural information.
- No explicit sound source localization is performed.
- Auditory cues are modelled using the time difference of arrival (TDOA).
- Positionning tasks of a robot can be achieved with respect to the sound source(s).

15:00–15:15 ThDT5.5

Speech activity detection and face orientation estimation using multiple microphone arrays and human position information

Carlos Ishi, Jani Even and Norihiro Hagita
Social Media Research Lab., ATR, Japan

- Estimation of speech activity and face orientation of multiple speakers, by integrating sound directions by multiple microphone arrays and human position information.
- More than 90% accuracies for speech activity detection, and standard deviations within 30 degrees for face orientation estimation.



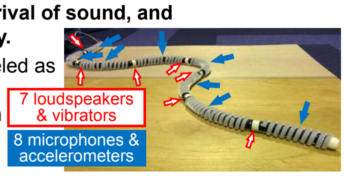
Estimated sound directions for four people talking simultaneously

15:15–15:30 ThDT5.6

Microphone-Accelerometer Based 3D Posture Estimation for a Hose-shaped Rescue Robot

Y. Bando[1], K. Itoyama[1], M. Konyo[2], S. Tadokoro[2], K. Nakadai[3], K. Yoshii[1], H. G. Okuno[4]
[1]Kyoto Univ. [2]Tohoku Univ. [3]Titech, Honda RI-JP [4]Waseda Univ.

- Our purpose is to estimate the 3D posture of a hose-shaped rescue robot in a **GPS- & magnetometer-denied** environment.
- The proposed method uses following two information:
  1) time differences of arrival of sound, and
  2) the direction of gravity.
- The robot posture is modeled as a **state-space model**, s and estimated by using an **unscented Kalman filter**.



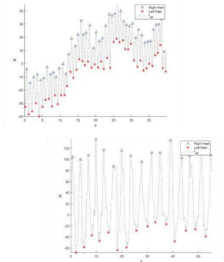
Rehabilitation Robotics 2

Chair *Junho Choi, Korea Institute of Science and Technology*
Co-Chair *Joaquin Ballesteros, University of Malaga*

14:00–14:15 ThDT6.1

Gait analysis for challenged users based on a rollator equipped with force sensors

Joaquin Ballesteros[1], Cristina Urdiales[1],
Antonio B. Martinez[2] and Marina Tirado[3]
[1]University of Malaga, Spain [2]Technical University of Cataluña, Spain [3]UGC Rehabilitación, Hospital Regional de Málaga, Spain

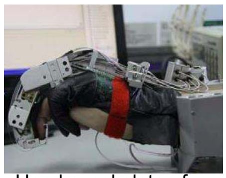


14:15–14:30 ThDT6.2

A Human-robot Interaction Modeling Approach for Hand Rehabilitation Exoskeleton Using Biomechanical Technique

Fuhai Zhang[1], Xiangyu Wang[1],
Yili Fu[1] and Sunil Agrawal[2]
[1]Harbin Institute of Technology, China [2]Columbia University, USA

- A method based on PCSA is adopted to get the optimized solution of muscle force.
- In order to obtain the parameters of Hill model, an optimization method based on TME is presented.
- The approach proposed can get the quantifiable muscle parameters to study the statistical analysis of muscle motion and rehabilitation state.



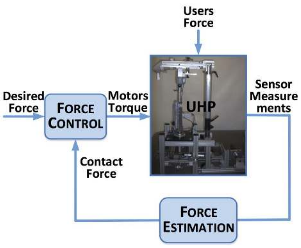
Hand exoskeleton for rehabilitation by HIT

14:30–14:45 ThDT6.3

Enhanced force control using force estimation and nonlinearity compensation for the Universal Haptic Pantograph

A. Mancisidor[1], A. Zubizarreta[1], I. Cabanes[1], P. Bengoa[1], M. Marcos[1] and J. H. Jung[2]
[1]University of the Basque Country, Spain [2]Tecnalia, Spain

- The design of a stable and robust enhanced force controller of the Universal Haptic Pantograph (UHP) was presented.
- The controller uses the robot model to estimate the contact force and to compensate nonlinearities in the actuators.
- Several tests are realized and the results reveal that mean of tracking errors is of 0.1N (2.5 N in previous work).

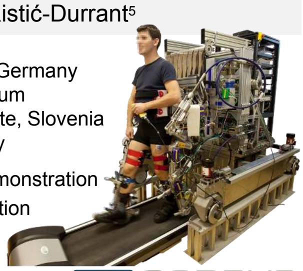


14:45–15:00 ThDT6.4

Learning gait by therapist demonstration

C. Glackin[1], C. Salge[1], D. Polani[1], M. Tüttemann[2], C. Vogel[2], C. Rodriguez Guerrero[3], V. Grosu[3], S. Grosu[3], A. Olenšek[4], M. Zadravec[4], I.Cikajlo[4], Z.Matjačić[4], A.Leu[5], D. Ristić-Durrant[5]
[1] University of Hertfordshire, UK
[2] Otto Bock HealthCare GmbH, Germany
[3] Vrije Universiteit Brussel, Belgium
[4] University Rehabilitation Institute, Slovenia
[5] University of Bremen, Germany

- Learning Gait by Therapist Demonstration
- Natural-like Walking Rehabilitation
- 16 DoF Powered Orthosis



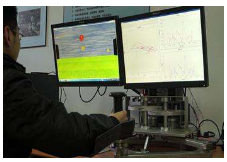
CORBYS
Cognitive Control Framework for Robotic Systems

15:00–15:15 ThDT6.5

Design of CASIA-ARM: a Novel Rehabilitation Robot for Upper Limbs

Liang Peng[1], Zeng-Guang Hou[1],
Long Peng[1] and Weiqun Wang[1]
[1]Institute of Automation, Chinese Academy of Sciences, China

- **Introduction:** design of an upper-limb rehabilitation robot named CASIA-ARM
- **Properties:** five-bar closed-chain structure, hybrid actuation, cable transmission
- **Control:** PID position control and impedance control
- **Training modes:** passive tracking and active assistance



Training Demonstration

15:15–15:30 ThDT6.6

A Methodology to Control Walking Speed of Robotic Gait Rehabilitation System using Feasibility-Guaranteed Trajectories

Chan-Yul Jung[1], Junho Choi[2],
Shinsuk Park[3] and Seung-Jong Kim[2]
[1]Korea Univ. & KIST [2]KIST [3]Korea Univ.

- Interaction torques are measured using force sensors
- User's intention to change speed is estimated using interaction torque
- Select trajectories from database to produce the desired walking speed
- Trajectories in database are guaranteed to be admissible for gait

Dexterous Manipulation 1

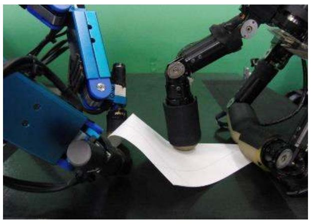
Chair *Tadayoshi Aoyama, Hiroshima University*
Co-Chair *Raul Suarez, Universitat Politecnica de Catalunya (UPC)*

14:00–14:15 ThDT7.1

Robotic Origami Folding with Dynamic Motion Primitives

Akio NAMIKI[1], Shuichi YOKOSAWA[1]
[1]Chiba University, Japan

- Dexterous paper folding by extracting some dynamic motion primitives.
- Physical model of a sheet of paper for analyzing its deformation.
- Machine learning method for predicting its future state.
- Valley folds in a sheet of paper twice in a row.

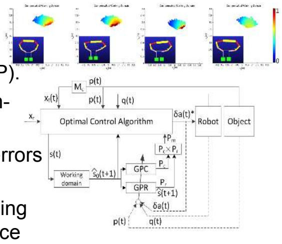


14:15–14:30 ThDT7.2

An Under-actuated Manipulation Controller Based on Workspace Analysis and Gaussian Processes

Fan Zhang, Yanyu Su, Xiang Zhang,
Wei Dong and Zhijiang Du
Harbin Institute of Technology, China

- Gaussian Processes enhanced Workspace Analysis (GP-WA) is integrated of Workspace Analysis (WA) and Gaussian Processes (GP).
- GP Classification models condition-violated grasping.
- GP Regression compensates for errors of WA .
- Simulations show our controller using GP-WA achieves better performance than other controllers.

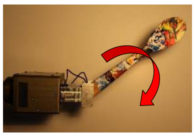


14:30–14:45 ThDT7.3

In-hand manipulation using gravity and controlled slip

Francisco E. Viña B.[1], Y. Karayiannidis[1], K. Pauwels[1]
C. Smith[1] and Danica Kragic[1]
[1]KTH Royal Institute of Technology, Stockholm, Sweden

- In-hand manipulation by **pivoting.** The object rotates around a fixed axis
- Control objective is to allow the object to slip to a desired orientation due to gravity
- Slippage (friction) is controlled with the gripper's **grasping force**
- **Sliding mode control** used to account for friction modeling uncertainties



14:45–15:00 ThDT7.4

Unknown Object Manipulation Based on Tactile Information

Andrés Montaño and Raúl Suárez
Institute of Industrial and Control Engineering (IOC)
Universitat Politècnica de Catalunya (UPC), Spain

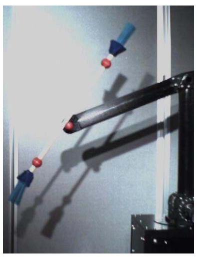
- Proposal of motion strategies to move the fingers in order to optimize the:
  - *hand configuration,*
  - *grasp quality,*
  - *object orientation.*
- Real experimentation was performed using rigid objects and the Schunck Dexterous Hand - SDH2.

15:00–15:15 ThDT7.5

Realization of Flower Stick Rotation Using Robotic Arm

Tadayoshi Aoyama[1], Takeshi Takaki[1],
Takumi Miura[1], Qingyi Gu[1] and Idaku Ishii[1]
[1]Hiroshima University, Japan

- This work focuses on flower stick juggling and proposes a feedback control strategy for a flower stick juggling task called "propeller" as one of the robotic dexterous manipulations.
- The proposed control strategy was verified and the desired flower stick propeller motion is realized using an actual robotic system.

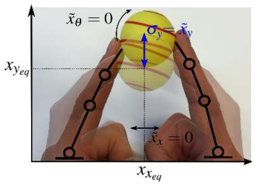


15:15–15:30 ThDT7.6

On Task-decoupling by Robust Eigenstructure Assignment for Dexterous Manipulation

A. Caldas[1], A. Micaelli[1], M. Grossard[1],
M. Makarov[2], P. Rodriguez-Ayerbe[2], D. Dumur[3]
[1]CEA LIST [2]Supélec

- The new control scheme for **dexterous manipulation** of an object with **multifingered hand** ensures stability of the object motion and a **decoupling** of the system according to **task specifications**
- New **eigenstructure assignment** algorithm is presented
- **Robustness to uncertainties** on the contact points can be specified



Mapping 3

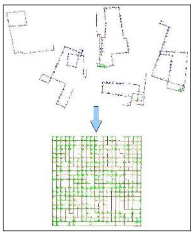
Chair *Masahiro Tomono, Chiba Institute of Technology*
Co-Chair *Fiora Pirri, La Sapienza University of Rome*

14:00–14:15	ThDT8.1

Map Merging Using Cycle Consistency Check and RANSAC-based Spanning Tree Selection

Masahiro Tomono[1] and Takeaki Uno[2]
[1]Chiba Institute of Technology, Japan
[2]National Institute of Informatics, Japan

- Map merging from pose graphs with many outlier pose constraints
- Iterative cycle consistency check for outlier reduction avoiding the explosion of cycles
- Spanning tree selection by RANSAC to transform sub-maps to a global frame
- Experiments using pubic dataset to show the effectiveness

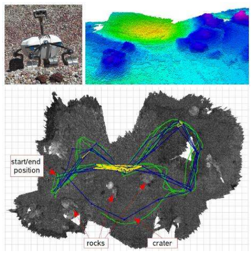


14:15–14:30	ThDT8.2

Submap Matching for Stereo-Vision Based Indoor/Outdoor SLAM

Christoph Brand, Martin J. Schuster, Heiko Hirschmüller, Michael Suppa
German Aerospace Center (DLR)

- **Submap-based dense on-board 3D map creation**
- **Submap matching** based on geometric 3D features to generate **loop-closure** constraints
- **Graph SLAM** for 6D pose estimation
- **3D global mapping experiments** in indoor, unstructured outdoor and mixed environments

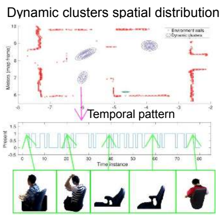


14:30–14:45	ThDT8.3

Unsupervised learning of spatial-temporal models of objects in a longterm autonomy scenario

Rares Ambrus[1], Johan Ekekrantz[1], John Folkesson[1] and Patric Jensfelt[1]
[1]KTH Royal Institute of Technology, Sweden

- Dynamic object segmentation through change detection
- Initial clustering using visual features
- Refined clustering using spatial distributions and temporal patterns



14:45–15:00	ThDT8.4

DPPTAM: Dense Piecewise Planar Tracking and Mapping from a Monocular Sequence

Alejo Concha[1], Javier Civera[1],
[1]University of Zaragoza, Spain

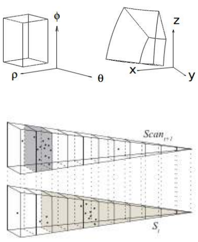
- We estimate a dense monocular map in real-time on a CPU.
- Highly textured areas are mapped with standard direct mapping.
- Low textured areas are mapped assuming piecewise planarity, from a superpixel segmentation and a semidense map.

15:00–15:15	ThDT8.5

Dynamic obstacles detection and 3D map updating

Federico Ferri[1], Mario Gianni[1], Matteo Menna[1] and Fiora Pirri[1]
[1]Sapienza University of Rome, Italy

- Real-time 3D map updating in presence of dynamic obstacles
- Spherical voxel space partitioning for fast ray-casting
- Detects and removes points belonging to moved dynamic obstacles by performing fast comparisons between columns of voxels (wedges)
- Application to robot path-planning and navigation in real dynamic environments

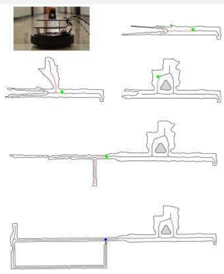


15:15–15:30	ThDT8.6

Robust Environment Mapping Using Flux Skeletons

M. Rezanejad[1], B. Samari[1], I. Rekleitis[2], K. Siddiqi and G. Dudek[3]
[1]McGill University, Canada, [2]University of South Carolina, USA

- Online construction of a topological map.
- Flux-based skeletonization algorithm on the latest occupancy grid map.
- A navigation strategy to guide the robot to the nearest unexplored area.



Legged Robots 3

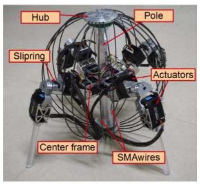
Chair *Claudio Semini, Istituto Italiano di Tecnologia*
Co-Chair *Gavin Kenneally, University of Pennsylvania*

14:00–14:15	ThDT9.1

Development of Quadruped Walking Robot with Spherical Shell -Mechanical Design for rotational locomotion-

Takeshi Aoki[1], Satoshi Ito[1], and Yosuke Sei[1]
[1]Chiba Institute of Technology, Japan

- Proposal of a new concept quadruped walking robot with a spherical shell, named "QRoSS".
- QRoSS is a transformable robot that can store legs in the shell to absorb external force from all directions.
- Analyses of rising motions and a rotational locomotion of QRoSS-II.

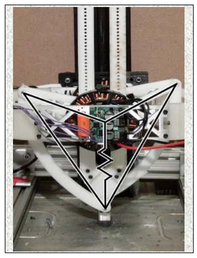


14:15–14:30	ThDT9.2

Leg Design for Energy Management in an Electromechanical Robot

Gavin Kenneally[1] and Daniel Koditschek[1]
[1]University of Pennsylvania, USA

- Analysis leading to unconventional leg design whose "knee" rides above the "hip"
- Experiments demonstrate that the resulting mechanism can deliver more than half again as much kinetic energy to the body (or more than double the kinetic energy if the full workspace is used), and offers a five-fold increase in energy storage and collision efficiency relative to the conventional design

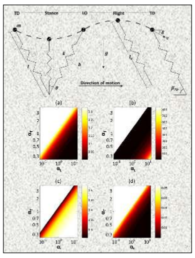


14:30–14:45	ThDT9.3

Dynamic similarity and scaling for the design of dynamical legged robots

Bruce D. Miller and Jonathan E. Clark
Florida State University, USA

- A dynamic scaling approach is presented to scale platforms to any arbitrary size without redesign or optimization
- Validation is simulation demonstrates the preservation of fundamental behaviors and predictable changes in performance
- Case study of RHex family suggests efficiency improvements decreased limb stiffness

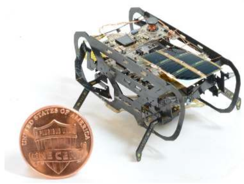


14:45–15:00	ThDT9.4

Feedback Control of a Legged Microrobot with On-Board Sensing

Remo Brühwiler, Benjamin Goldberg, Neel Doshi, Onur Ozcan, Noah Jafferis, Mike Karpelson, and R. J. Wood
John A. Paulson School of Engineering and Applied Sciences, Harvard University, Cambridge, MA, USA

- 2.3 g autonomous legged microrobot
- Solar or battery powered
- On-board sensing and feedback control with optical mouse sensor and gyroscope



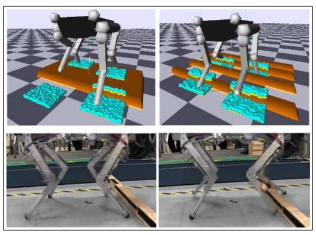
HAMR-VP modified for on-board power, sensing, and control

15:00–15:15	ThDT9.5

Reactive Trotting with Foot Placement Corrections thro. Visual Pattern Classification

Victor Barasuol, Marco Camurri, Stephane Bazeille, Darwin G. Caldwell and Claudio Semini
Istituto Italiano di Tecnologia (IIT), Italy

- Visual-based reactions for foot placement corrections
- Avoidance of frontal leg and shin collisions
- Heightmaps from online 3D mapping, autonomously classified to avoid collisions
- Simulated and experimental results on our robot HyQ

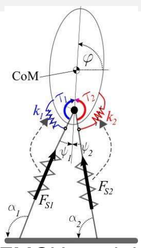


15:15–15:30	ThDT9.6

FMCH: a new model for human-like postural control in walking

Maziar A. Sharbafi and Andre Seyfarth
Lauflabor Locomotion Lab, TU Darmstadt

- **Approach:**
  - ✓ BSLIP + trunk with compliant hip
  - ✓ Using leg force feedback for modulating hip compliance
- **Achievements:**
  - ✓ Robust walking in simulation
  - ✓ Mimicking human hip torque
  - ✓ Physical implementation of VPP



FMCH model

Human Centered Robotics

Chair *Atsushi Watanabe, ATR*
Co-Chair *Filippo Cavallo, Scuola Superiore Sant'Anna - Pisa*

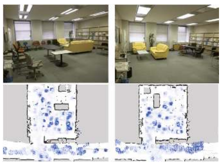
14:00–14:15	ThDT10.1

Long-Term Human Affordance Maps

R. Limosani[1], L. Y.Morales[2], J. Even[2], F. Ferreri[2], A. Watanabe[2], F. Cavallo[1], P. Dario[1] and N.Hagita[2]
[1]Scuola Superiore Sant'Anna, Italy [2]Advanced Telecommunications Research Institute International, Japan

This paper presents a work on mapping the use of space by humans in long periods of time.

The contribution of the paper is two-fold: an approach to detect geometric changes to cluster them in similar geometric configurations and the building of geometric and affordance composite maps on each cluster.

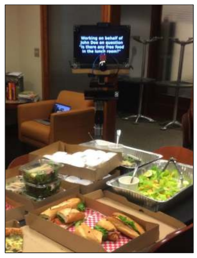


14:15–14:30	ThDT10.2

Paper Title in One or Two Lines

Michael Jae-yoon Chung[1], Andrzej Pronobis[1], Maya Cakmak[1], Dieter Fox[1] and Rajesh P. N. Rao[1]
[1]University of Washington, USA

- We propose categorization of information gathering task types in human-populated environments
- We propose a framework for information checking robots (InfoBots)
- We report survey findings on people's expected usage of InfoBots
- We present empirical findings of people's actual usage of InfoBots



14:30–14:45	ThDT10.3

Communicating Robotic Navigational Intentions

Atsushi Watanabe[1], Tetsushi Ikeda[1], Yoichi Morales[1], Kazuhiko Shinozawa[2,1], Takahiro Miyashita[1], Norihiro Hagita[1]
[1] ATR, Japan [2] Osaka Kyoiku University, Japan

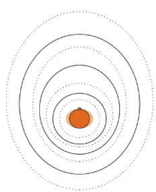
- **Task:** comfortable autonomous robotic wheelchair navigation
- **Comparison:** with and without intention communication projecting its future path
- **Hypothesis:** intention communication makes both passengers and pedestrians comfortable
- **Result:** comfortability and intelligibility of motion are significantly improved

14:45–15:00	ThDT10.4

A Conceptual Model of Personal Space for Human-Aware Robot Activity Placement

Felix Lindner
University of Hamburg, Germany

- A symbolic model of personal space: Personal spaces are constituted by the possibilities to interact with humans.
- Formalization of two principles of using personal space based on the distinction between focused and unfocused interactions.
- Demonstration: Robot can solve the problem of adequately placing its interactions plus it can communicate the pros and cons of its choices to humans.



15:00–15:15	ThDT10.5

Improving Human-In-The-Loop Decision Making In Multi-Mode DASs Using Hidden Mode Stochastic Hybrid System

Chi-Pang Lam, Allen Yang, Katherine Driggs-Campbell, Ruzena Bajcsy and Shankar Sastry
University of California, Berkeley, United States

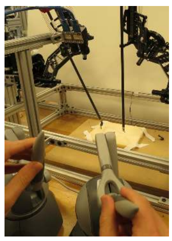
- Include human in the decision making process for multi-mode driver assistance systems.
- Joint estimating human state and solving safety input in real time using hidden mode stochastic hybrid systems.

15:15–15:30	ThDT10.6

Models of Human-Centered Automation in a Debridement Task

Kirk Nichols[1], Adithyavairavan Murali[2], Siddarth Sen[2], Ken Goldberg[2], and Allison M. Okamura[1]
[1]Stanford University, USA,
[2]University of California at Berkeley, USA

- Adapted a multilateral manipulation framework to a debridement task on the RAVEN-II surgical robot
- Developed and tested four different collaboration models: teleoperation, full robot autonomy, supervised control, and shared control
- Results indicate tradeoffs in procedure time, tissue disturbance, and safety implications



Integrated Planning and Control

Chair *Rowland O'Flaherty, Georgia Institute of Technology*
Co-Chair *Graeme Michael Best, University of Sydney*

14:00–14:15	ThDT11.1

Decentralized Leader-Follower Control under High Level Goals without Explicit Communication

A. Tsiamis[1], J. Tumova[2], C. P. Bechlioulis[1], G. C. Karras[1], D. V. Dimarogonas[2] and K. J. Kyriakopoulos[1]
[1]National Technical University of Athens, [2]KTH Royal Institute of Technology

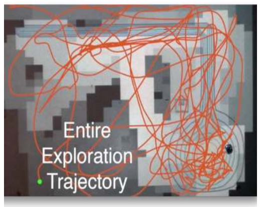
- Tight cooperation.
- No explicit communication, only sensor measurements available.
- High level specifications. Each agent has its own LTL formula.
- Leader-follower formation with leadership exchange. Liveness is ensured.
- Follower satisfies force/torque constraints. Leader implements position stabilization.

14:15–14:30	ThDT11.2

Optimal Exploration in Unknown Environments

Rowland O'Flaherty[1], Magnus Egerstedt[1]
[1]Georgia Institute of Technology, USA

This paper presents an optimal exploration algorithm, named *Ergodic Environmental Exploration* (E[3]), which minimizes the effort to explore an unknown environment with areas of varying degrees of importance.

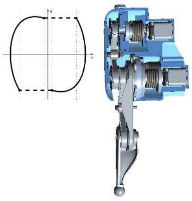


14:30–14:45	ThDT11.3

Targeted Jumping of Compliantly Actuated Hoppers based on Discrete Planning and Switching Control

Dominic Lakatos[1], Daniel Seidel[2], Werner Friedl[1] and Alin Albu-Schäffer[1,2]
[1]German Aerospace Center (DLR), Germany
[2]Technical University of Munich, Germany

- Hopping control exploiting the mechanical resonant properties of robotic legs with intrinsic elasticities
- Targeted jumping based on discrete planning collapsing the trajectory planning problem to a small number of parameter optimization problem
- Controller design, discrete planner derivation and experimental evaluation

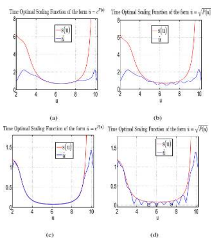


14:45–15:00	ThDT11.4

A class of Non-Linear Time Scaling Functions for Smooth Time Optimal Control along specified paths

Arun Kumar Singh, K.Madhava Krishna
RRC, IIIT-Hyderabad,India

- We introduce parametric exponential functions as an alternative to existing polynomial based non-linear time scaling functions ($\frac{du}{dt}$ in the figure).
- The proposed function satisfies the necessary positive definiteness condition by construction. In contrast, optimization with polynomials require additional linear matrix inequalities to enforce positive definiteness.The proposed function also provides better optimization output.

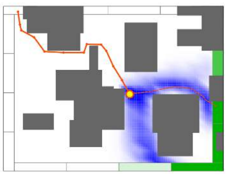


15:00–15:15	ThDT11.5

Bayesian Intention Inference for Trajectory Prediction with an Unknown Goal Destination

Graeme Best and Robert Fitch
ACFR, The University of Sydney, Australia

- An algorithm to **predict the unknown future trajectory** of a mobile agent (pedestrian, vehicle, animal) moving through a cluttered environment.
- **Bayesian intention inference** is used to estimate the agent's intended goal.
- This is used to find a **multi-modal probability distribution** for the future trajectory using Monte Carlo sampling.
- Experiments with **pedestrian datasets**.



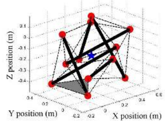
The predictive distribution for the intention and trajectory.

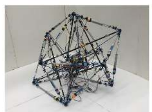
15:15–15:30	ThDT11.6

Robust Learning of Tensegrity Robot Control for Locomotion through Form-Finding

Kyunam Kim[1], Adrian K. Agogino[2,3], Aliakbar Toghyan[1], Deaho Moon[1], Laqshya Taneja[1] and Alice M. Agogino[1]
[1]UC Berkeley, USA [2]UC Santa Cruz, USA [3]NASA ARC, USA

- A dynamic relaxation technique is used to describe the shape of a tensegrity structure given the forces on its cables.
- A multi-step Monte Carlo based learning algorithm is deployed to determine the structural geometry providing the most robust basic mobility step.
- The above best geometry is tested on our physical robot and it successfully resulted in stepping of the robot.





Actuation and Mechanism

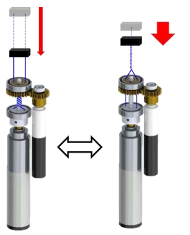
Chair *Kyung-Soo Kim, KAIST(Korea Advanced Institute of Science and Technology)*
Co-Chair *Renaud Ronsse, Université catholique de Louvain*

14:00–14:15	ThDT12.1

Dual-Mode Twisting Actuation Mechanism with an Active Clutch for Active Mode-Change and Simple Relaxation Process

Seok Hwan Jeong[1], Young June Shin[2], Kyung-Soo Kim[1] and Soohyun Kim[1]
[1]KAIST, Rep. of Korea [2]Agency for defense development, Rep. of Korea

- Novel **twisting actuation mechanism**
- **Automatic power transmission system** : wide force-speed operating range
- Two operating modes: **Force Mode** & **Speed Mode**
- Available for **tendon-driven** or **compact size robot** (ex. robot hand)

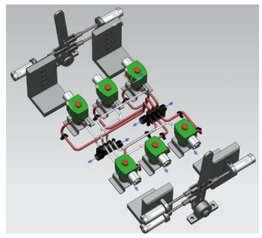


14:15–14:30	ThDT12.2

A Novel Variable Transmission with Digital Hydraulics

Zhenyu Gan, Katelyn Fry
R. Brent Gillespie and C. David Remy
University of Michigan, United States

- Theoretical and experimental study of novel variable transmission system with digital hydraulics.
- Relatively smooth transmission profile achievable with few cylinders
- Initial prototype tests indicate stiff system with little backlash and a very efficient transmission

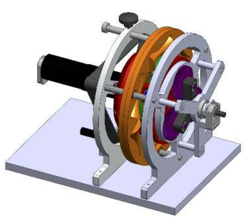


14:30–14:45	ThDT12.3

Novel Infinitely Variable Transmission Allowing Efficient Transmission Ratio Variations at Rest

Christophe Everarts, Bruno Dehez, and Renaud Ronsse
Université catholique de Louvain, Belgium

- New concept of **Continuously Variable Transmission** for legged locomotion applications.
- Output velocity varies **continuously from negative to positive** with constant input velocity.
- Ratio can be changed with **minimal energy consumption** even at **rest**.

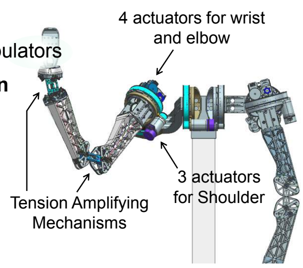


14:45–15:00	ThDT12.4

Design of Low Inertia Manipulator with High Stiffness and Strength Using Tension Amplifying Mechanisms

Yong-Jae Kim
Korea University of Technology and Education (Koreatech), Korea

- **High Stiffness & Strength**
  Comparable to industrial manipulators
- **Low Mass & Inertia as Human**
  Inherently safe and efficient
- **Specifications**
  Mass : 2.41 kg (moving part)
  Inertia : 0.571 kgm^2
  Stiffness : 2,420Nm/rad (elbow)

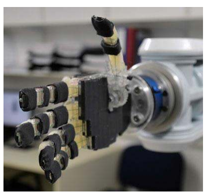


15:00–15:15	ThDT12.5

Open-Source, Anthropomorphic, Underactuated Robot Hands with a Selectively Lockable Differential Mechanism: Towards Affordable Prostheses

G. P. Kontoudis[1], M. V. Liarokapis[2], A. G. Zisimatos[1], C. I. Mavrogiannis[3] and K. J. Kyriakopoulos[1]
[1]NTUA, Greece [2]Yale Univ., USA [3]Cornell Univ., USA

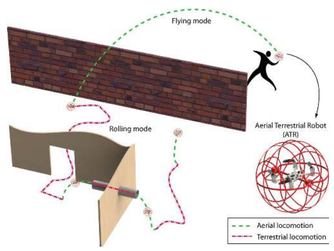
- An open-source design for the development of low-cost, low-complexity, anthropomorphic, underactuated robot hands with a selectively lockable differential mechanism.
- The proposed hand is the most light-weight (300 g) and low-cost (< 200 USD) prosthesis solution ever proposed and is able to achieve a total of 144 different grasping postures, with a single motor.



15:15–15:30	ThDT12.6

A Micro Spherical Rolling and Flying Robot

Christopher J. Dudley, Alexander C. Woods, and Kam K. Leang[1]
[1]Department of Mechanical Engineering, University of Utah, USA



Concept of the micro rolling and flying aerial terrestrial robot (ATR). The robot can be hand launched and operate in either flying or rolling mode.

Sensor-based Planning

Chair *Emanuele Ruffaldi, Scuola Superiore S.Anna*
Co-Chair *Joshua R. Smith, University of Washington*

14:00–14:15 ThDT13.1

An Event-Driven Control to Achieve Adaptive Walking Assist with Gait Primitives

Bokman Lim, Kyungrock Kim,
Jusuk Lee, Junwon Jang, and Youngbo Shim
Samsung Advanced Institute of Technology, Korea

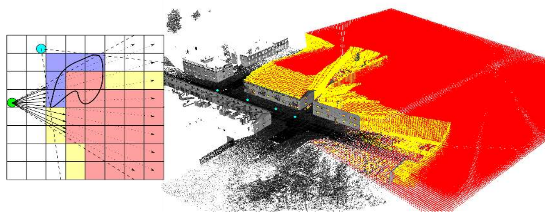
- This paper presents a control method for walking assist with hip exoskeleton robots.
- A novel finite state machine is constructed with gait primitives.
- Utilizing the user's previous opposite step motion, we predict the positive work intervals of the current step motion.
- Proposed assist method effectively enhanced walking regularity.

Hardware prototype for walking assist

14:15–14:30 ThDT13.2

Efficient algorithms for Next Best View evaluation

Fredrik Bissmarck[1], Martin Svensson[1]
and Gustav Tolt[1]
[1]Swedish Defence Research Agency (FOI), Sweden

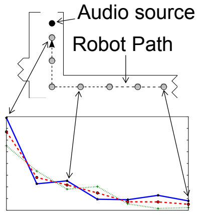


14:30–14:45 ThDT13.3

A Heuristic Approach for a Social Robot to Navigate to a Person based on Audio and Range Information

Nicolai Bæk Thomsen[1], Zheng-Hua Tan[1],
Børge Lindberg[1] and Søren Holdt Jensen[1]
[1]Aalborg University, Denmark

- Task: Navigation to completely occluded person based on audio from person.
- Problem: Strong reflections may cause robot to get stuck, i.e. pre-maturely terminating.
- Proposed solution: Use audio specific features to determine "goodness" of current position and to determine next action/movement.



Feature-value vs. position

14:45–15:00 ThDT13.4

Transmissive Optical Pretouch Sensing for Robotic Grasping

Di Guo[1,2], Patrick Lancaster[1], Liang-Ting Jiang[1]
Fuchun Sun[2] and Joshua R. Smith[1]
[1]University of Washington, USA [2]Tsinghua University, China

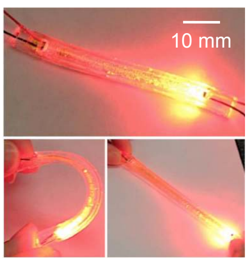
- A novel transmissive optical pretouch sensor is developed and has been fully integrated a PR2 robot.
- The proposed pretouch sensor can provide a simple, fast and reliable way to detect materials that previous sensors fail to detect.
- Heuristic algorithms are proposed for object detection in different situations with the proposed pretouch sensor.

15:00–15:15 ThDT13.5

Highly Stretchable Optical Sensors for Pressure, Strain, and Curvature Measurement

Celeste To[1], Tess Lee Hellebrekers[2],
and Yong-Lae Park[1]
[1]Carnegie Mellon University, USA
[2]University of Texas, Austin, USA

- Soft optical waveguide made of transparent stretchable silicone with embedded LED and photodiode.
- Thin gold layer coated on the waveguide forms microcracks when stretched or bent, causing optical power loss.
- Pressure, strain, and curvature calibration tests up to 350 kPa, 90%, and 0.12 mm^{-1}, respectively.

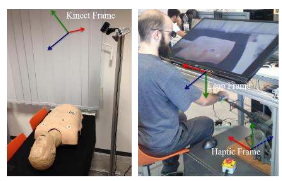


15:15–15:30 ThDT13.6

Encountered-type haptic interface for virtual interaction with real objects based on implicit surface haptic rendering for remote palpation

Alessandro Filippeschi[1], Filippo Brizzi[1],
Emanuele Ruffaldi[1], Juan Manuel Jacinto[1] and Carlo Alberto Avizzano[1]
[1]Scuola Superiore Sant'Anna, Italy

- Novel encountered-type haptic interface for virtual interaction with real object
- Co-located 3D visualization
- Interaction based on online scan of the object surface
- Force rendering based on implicit surfaces and on an elastic model of the indented material



Patient Site Doctor Site

Robotics in Construction

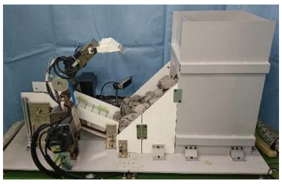
Chair *Alcherio Martinoli, EPFL*
Co-Chair *Griswald Brooks, Polytechnic School of Engineering, NYU*

14:00–14:15	ThDT14.1

Imitation-based Control of Automated Ore Excavator to Utilize Human Operator knowledge of bedrock condition estimation and excavating motion selection

R. Fukui[1], T. Niho[1], M. Nakao[1], M.Uetake[2]
[1]The University of Tokyo, Japan [2]Komatsu Ltd, Japan

- Development of imitation-based method to achieve autonomous bedrock excavation with high productivity
- Newly developed 1/10-scale excavation model
- Design of features to recognize the bedrock condition
- Nearest-Neighbor-based selection of excavation motions

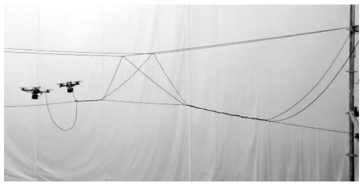


14:15–14:30	ThDT14.2

Knot-tying with Flying Machines for Aerial Construction

Federico Augugliaro, Emanuele Zarfati, Ammar Mirjan, and Raffaello D'Andrea
ETH Zurich, Switzerland

- Representing and realizing knots with flying machines
- Realization of a load-bearing rope bridge

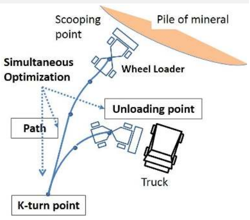


14:30–14:45	ThDT14.3

Simultaneous determination of an optimal unloading point and paths between scooping points and the unloading point for a wheel loader

Toshinobu Takei[1], Tsubasa Hoshi[1], Shigeru Sarata[2] and Takashi Tsubouchi[2]
[1]Seikei Univ., Japan [2]Univ. Tsukuba, Japan

- An optimal unloading point that minimizes total length of paths and those paths have been obtained by using a three-dimensional configuration score space.



14:45–15:00	ThDT14.4

Low-Profile Crawling for Humanoid Motion in Tight Spaces

Griswald Brooks[1], Prashanth Krishnamurthy[1], and Farshad Khorrami[1]
[1]NYU Polytechnic School of Engineering, USA

- Low-profile crawling gait for humanoid robots to enable operation in tight vertically constrained spaces, thus expanding the range of environments and tasks that can be handled
- Laterally symmetric periodic gait with cooperative motion of both arms and feet to generate forward crawling motion; Gait design based on a projected profile model
- Experimental implementation on NAO humanoid robot

15:00–15:15	ThDT14.5

Flutter Suppression of a Bridge Section Model Endowed with Actively Controlled Flap Arrays

Maria Boberg[1,2], Glauco Feltrin[2], and Alcherio Martinoli[1]
[1]EPFL, Switzerland [2]EMPA, Switzerland

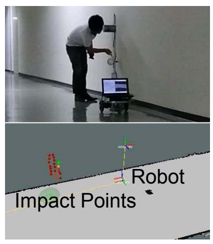
- Flutter suppression is achieved with actively controlled flaps
- Three linear control laws have been investigated: using only trailing flaps, only leading flaps, and all flaps
- A linear analytical model for flutter has been leveraged to optimize control parameters
- The work has been validated with wind tunnel experiments

15:15–15:30	ThDT14.6

Robot-assisted Acoustic Inspection of Infrastructures

Atsushi Watanabe[1], Jani Even[1], Luis Yoichi Morales[1] and Carlos Ishi[1]
[1] ATR, Japan

- **Problem:** fully automated inspection for everywhere is cost consuming
- **Concept:** human robot collaboration where human performs the actuation and the robot performs the recording
- **Method:** keeping sensor view by moving and estimates impact point from 3D pointcloud and sound
- **Result:** impact point position estimation position error: 32 [mm] and SD: 30 [mm].



Tendon/Wire Mechanisms

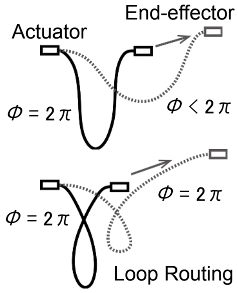
Chair *Jean-Sebastien Plante, Université de Sherbrooke*
Co-Chair *Kyu-Jin Cho, Seoul National University, Biorobotics Laboratory*

14:00–14:15	ThDT15.1

Feedforward Friction Compensation of Bowden-Cable Transmission Via Loop Routing

Useok Jeong[1] and Kyu-Jin Cho[1]
[1]Seoul National University, Korea

- Friction along the Bowden-cable changes with the position of the end-effector.
- Loop routing maintains the sheath's bending angle at 2π regardless of the end-effector's position in 2-D space.
- This minimizes the bending angle change of the sheath in 3-D space.
- Friction can be compensated with the feedforward control scheme.

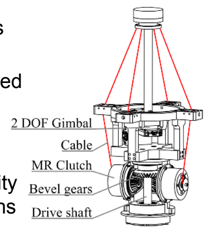


14:15–14:30	ThDT15.2

Projected PID Controller for TDMs Actuated by Magneto-Rheological Clutches

J. Viau[1], P. Chouinard[1],
J.-P. Lucking Bigué[1], G. Julió[1], F. Michaud[1], S. Shimoda[2] and J.-S. Plante[1]
[1]Université de Sherbrooke, Canada, [2] Riken, Japan

- Projected PID is a specialized motion controller for tendon-driven manipulators (TDM)
- Validation done on a 2-DOF TDM powered by magneto-rheological clutches, and a reconfigurable 2-DOF TDM powered by direct-drive electric motors
- Demonstrate high accuracy and the ability to compensate for configuration variations and actuator failures

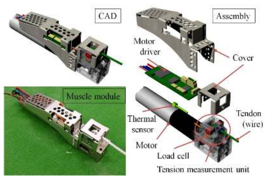


14:30–14:45	ThDT15.3

A Sensor-driver Integrated Muscle Module with High-tension Measurability and Flexibility for Tendon-driven Robots

Yuki Asano, Toyotaka Kozuki, Soichi Ookubo,
Koji Kawasaki, Takuma Shirai, Kohei Kimura, Kei Okada and Masayuki Inaba
The University of Tokyo

The developed module characteristics are
•Disorder reduction thanks to cable protection and components packaging
•Improvement of maintenance performance thanks to easy replacement structure
•Design facilitation by standardizing an actuator part over whole body robots
•Tendon-driven robotization of non-robotic structure



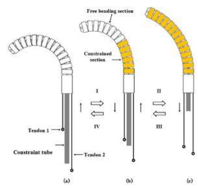
The developed muscle module

14:45–15:00	ThDT15.4

A Novel Constrained Tendon-driven Serpentine Manipulator

Zheng Li[1,2], Haoyong Yu[4], Hongliang Ren[4], Philip W.Y.Chiu[1,2] and Ruxu Du[3]
1 Institute of Digestive Disease, the Chinese University of Hong Kong, Hong Kong
2 Chow Yuk Ho Technology Centre for Innovative Medicine, CUHK, Hong Kong
3 Department of Mechanical and Automation Engineering, CUHK, Hong Kong
4 Dept. of Biomedical Engineering, National University of Singapore, Singapore

- A novel constrained tendon-driven serpentine manipulator (CTSM) is presented. It comprises of an underactuated flexible backbone and a translational constraint.
- Both the length and curvature of the bending section in the CTSM can be controlled.
- The workspace and dexterity of the CTSM can be improved and the improvement depends on the stiffness ratio between the constraint and the flexible backbone.

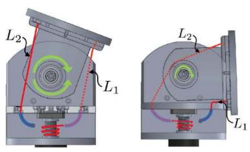

Constrained Tendon-driven Serpentine Manipulator (CTSM)

15:00–15:15	ThDT15.5

Stiffness Characteristics of New Modular Type Antagonistic Tendon-driven Joint Systems

Hyunhwan Jeong[1], Youngsu Cho[1],
Bongki Kang[1] Joono Cheong[1] and Youngsu Son[2]
[1]Korea University, S. Korea; [2]Korea Institute of Machinery and Materials, S. Korea

- We designed and developed new antagonistic tendon-driven joints for robotic applications.
- Stiffness characteristics of the joints were analyzed in comparison with common pulley type joints.
- Two singe tendon-driven joints were packaged into a module allowing two DOF rotation.



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Robot Companions and Social Human-Robot Interaction

Chair *Horst-Michael Gross, Ilmenau University of Technology*
Co-Chair *Abdelghani Chibani, Lissi Lab Paris EST University*

16:50–17:05 ThFT1.1

Towards an Imperfect Robot for Long-Term Companionship: Case Studies Using Cognitive Biases

Mriganka Biswas, John Christopher Murray
University of Lincoln, United Kingdom

17:05–17:20 ThFT1.2

Proxemics and Performance: Subjective Human Evaluations of Autonomous Sociable Robot Distance and Social Signal Understanding

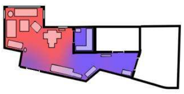
Ross Mead and Maja J Matarić
University of Southern California, USA

- **Background:** In previous work, we developed an autonomous *proxemic* (social distance) control system that maximizes robot *performance* (speech and gesture recognition rates) in HRI.
- **Problem:** Our approach results in atypical proxemic behavior.
- **Question:** What is more important: *proxemics* or *performance*?
- **Results:** Robot *performance* dominated human-robot *proxemics* in predicting subjective human evaluations of five factors: (1) competence, (2) anthropomorphism, (3) engagement, (4) likability, and (5) technology adoption.

17:20–17:35 ThFT1.3

Robot Companion for Domestic Health Assistance: Implementation, Test and Case Study under Everyday Conditions in Private Apartments

H.-M. Gross, S. Mueller, Ch. Schroeter, M. Volkhardt, A. Scheidig, K. Debes, K. Richter, N. Doering
Ilmenau University of Technology, Germany

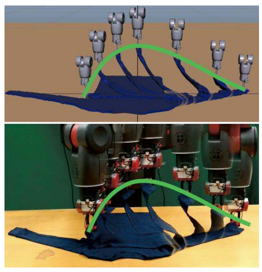


- Overview of the developed assistant, its system architecture & essential skills, behaviors, and services for domestic health assistance
- Novel approach for quantitative description and assessment of the navigation complexity of apartments for comparing function tests
- Results of comprehensive function tests in 12 apartments of project staff and seniors
- Findings of an explorative case study: 9 seniors (aged 68-92) up to 3 days alone with the robot

17:35–17:50 ThFT1.4

Folding Deformable Objects using Predictive Simulation and Trajectory Optimization

Yinxiao Li, Yonghao Yue, Danfei Xu, Eitan Grinspun, Peter Allen
Columbia University, USA



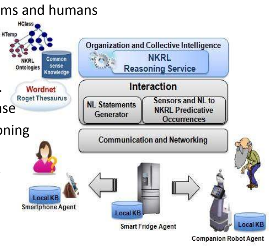
- An online optimization algorithm that learns optimal trajectories for manipulation from mathematical model evolution combined with predictive thin shell simulation.
- A fast and robust algorithm that can detect garment key points automatically
- A novel approach that adjusts the simulation environment to the robot working environment for the purpose of creating a similar manipulation result.

17:50–18:05 ThFT1.5

A Novel Approach based on Commonsense Knowledge Representation and Reasoning in Open World for Intelligent Ambient Assisted Living Services

Naouel Ayari*, Abdelghani Chibani*, Yacine Amirat* and Eric Matson**
*LISSI Laboratory, University of Paris-Est Créteil, France
**Lab/Rice Center, Purdue University, USA

- Distributed cognitive architecture for natural interactions between ubiquitous robots, systems and humans
  - Integrate seamlessly the actors of the ambient system,
  - Management of interactions with humans using natural language.
- Expressive model for commonsense knowledge representation and reasoning in open world.
- Cognitive assistance services for dependent people.



18:05–18:20 ThFT1.6

Navigating Blind People with a Smart Walker

Andreas Wachaja[1], Pratik Agarwal[1], Mathias Zink[1], Miguel Reyes A.[2], Knut Möller[2] and Wolfram Burgard[1]
[1]University of Freiburg, Germany,
[2]Hochschule Furtwangen University, Germany

- Smart walker for elderly blind people
- Laser-based mapping and localization
- Detection of positive and negative obstacles (e.g., downward leading stairs)
- Vibro-tactile feedback for navigation
- Model-based controller for humans that allows precise path guidance

New Actuators 2

Chair *Fumihito Arai, Nagoya University*
Co-Chair *Stéphane Régnier, University Pierre et Marie Curie*

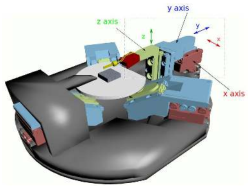
16:50–17:05 ThFT2.1

Nonlinear Modeling for A Class of Nano-Robotic Systems Using Piezoelectric Stick-Slip Actuators

Tianming Lu[1], Mokrane Boudaoud[1], David Hériban[2] and Stéphane Régnier[1]

[1] Institut des Systèmes Intelligents et de Robotique, Université Pierre et Marie Curie, CNRS UMR 7222, 4 Place Jussieu, F-75252 Paris Cedex, France.
[2] Percipio Robotics, Maison des Microtechniques, 18, rue Alain Savary, 25000 Besançon, France.

- The work addresses modeling issues for a class of nano-robotic systems using piezoelectric stick-slip actuators;
- The model is based on the theory of the single state elasto-plastic model;
- The model describes the dynamics of a stick-slip actuator in time and frequency domains, for both scanning and stepping modes;
- The model describes the motion of the slider for both backward and forward drive directions;
- The model is in agreement with experiments.



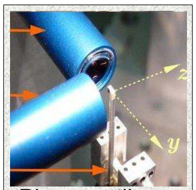
CAD view of the nano-robotic system. The Cartesian 3 DOF component is highlighted in the dashed block.

17:05–17:20 ThFT2.2*

Micropositioning of 2DOF Piezocantilever: LKF Compensation of Parasitic Disturbances

Juan Escareno[1], Joël Abadie[2], Emmanuel Piat[2] and Micky Rakotondrabe[2]
[1]IPSA, France [2]FEMTO-ST, France

- Linear Kalman Filter (LKF) + simple feedback control to counteract dynamic disturbances
- Rejection of Hysteresis, Creep and Cross-Couplings during 2D motion
- Hysteresis/creep model is not required
- Real-time experiments are presented to show the effectiveness



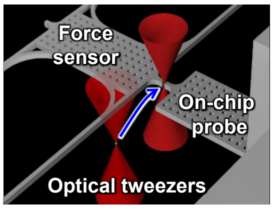
Piezocantilever 2DOF

17:20–17:35 ThFT2.3

Mechanical Characterization System of Cyanobacteria Using a Robot Integrated Microdluidic Chip

Takayuki Hasegawa[1], Shinya Sakuma[1], Kei Nanatani[2], Nobuyuki Uozumi[2] and Fumihito Arai[1]
[1]Nagoya University, Japan [2]Tohoku University, Japan

- The system combining optical tweezers with a robot integrated microfluidic chip was proposed for mechanical characterization of a single cyanobacteria.
- We succeeded in measuring cell mechanical characteristics by using proposed system.



17:35–17:50 ThFT2.4

Adaptability Analysis, Evaluation and Regulation of Compliant Underactuated Mechanisms

Wenrui Chen, Caihua Xiong
Huazhong University of Science and Technology, China

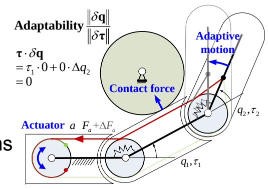
- Adaptability is measured as

$$Ad = \frac{\|\delta \mathbf{q}\|}{\|\delta \boldsymbol{\tau}\|}$$

- $\delta\mathbf{q}$ is adaptive motion
- $\delta\boldsymbol{\tau}$ is contact force

- Adaptability could be used to
- evaluate underactuated mechanisms
- Predict grasping process

- Adaptability is different from compliance



Visual Tracking

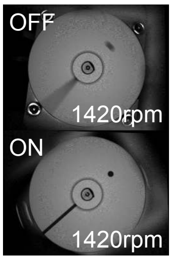
Chair *Dongheui Lee, Technical University of Munich*
Co-Chair *Yushing Cheung, National Cheung Kung University*

16:50–17:05 ThFT3.1

High-Speed Image Rotator for Blur-Canceling Roll Camera

Leo Miyashita[1], Yoshihiro Watanabe[1] and Masatoshi Ishikawa[3]
[1]University of Tokyo, Japan

- Blur-canceling vision system for rotation
- This system optically rotates the light flux of the image in front of a high-speed camera
- High-speed visual feedback and angle-doubling effect of a Dove prism enable dealing with the high-speed rotating target as a stationary object

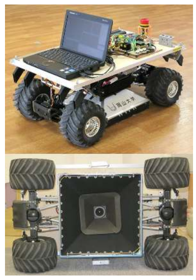


17:05–17:20 ThFT3.2

Path Tracking by a Mobile Robot Equipped with Only a Downward Facing Camera

Isaku Nagai[1] and Keigo Watanabe[1]
[1]Okayama University, Japan

- A unique and rapid algorithm for tracking and searching ground images without a feature-point extraction
- Groups of reference pixels are used to detect the relative translation and rotation between frames
- Average error of path tracking is 4.4 mm by the frequent error corrections made every time the vehicle travels 50 mm



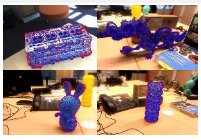
17:20–17:35 ThFT3.3

Generic Edgelet-based Tracking of 3D Objects in Real-Time

Angelique Loesch[1], Steve Bourgeois[1], Vincent Gay-Bellile[1] and Michel Dhome[2]
[1]CEA, LIST, France [2]Institut Pascal, France

This paper addresses the challenging issue of real-time camera localization relative to any object with texture or not, sharp edges or occluding contours. 3D contour points, dynamically extracted from a CAD model by rendering on GPU, are combined with a keyframe-based SLAM algorithm to estimate camera poses.

Our real-time tracking solution is accurate, robust to sudden motions and occlusions, and easy to deploy.



Our localization solution successfully tracks objects of different natures.

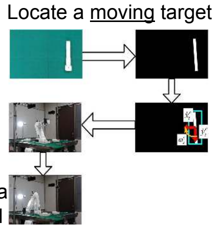
17:35–17:50 ThFT3.4

Visual Guided Adaptive Robotic Interceptions with Occluded Target Motion Estimation

Yushing Cheung[1], Ya-Ting Huang[2] and Jenn-Jier Lien[1]
[1]National Cheng Kung University, Taiwan, [2] Tongtai Machine & Tool Ltd., Taiwan

- Integration of visual tracking into joint space adaptive controllers with no joint singularity in an eye-to-hand system
- Mobile target tracking with a visual target motion estimator even if occlusion occurs
- The adaptive controllers for performance maintenance even if a gripper is switched
- Successful experimental validations with a conveyor speed <= 50 cm/s and occluded time <= 0.6 of the total operation time

Locate a moving target



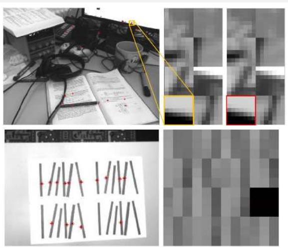
Grip a moving target

17:50–18:05 ThFT3.5

Semi-Direct EKF-based Monocular Visual-Inertial Odometry

Petri Tanskanen, Tobias Nägeli, Marc Pollefeys and Otmar Hilliges
ETH Zürich

- Visual-Inertial Odometry implemented as direct method in an EKF
- Points are tracked directly by the filter through photometric updates
- The method allows to track scenes containing only line-like structures

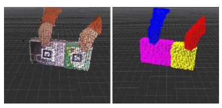


18:05–18:20 ThFT3.6

Real-time and Model-free Object Tracking using Particle Filter with Joint Color-Spatial Descriptor

Shile Li[1], Seongyong Koo[1], Dongheui Lee[1],
[1]Technical University of Munich, Germany

- Multiple object tracking and point-cloud segmentation (without prior knowledge)
- Real-time tracking using Particle Filtering (PF) with GPU implementation.
- Joint Color-Spatial Descriptor for the pose hypothesis evaluation in PF.
- Achieved Performance:
- 99% segmentation accuracy,
- 21 fps computation time.



Left: Input point-cloud. Right: Segmented point-cloud

Navigation

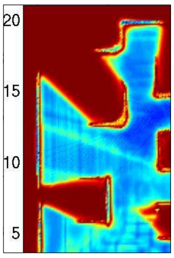
Chair *Kamal Gupta, Simon Fraser University*
Co-Chair *Renjun Li, Institute for Infocomm Research*

16:50–17:05 ThFT4.1

Mutual Information-based Exploration on Continuous Occupancy Maps

Maani Ghaffari Jadidi, Jaime Valls Miro and Gamini Dissanayake
University of Technology Sydney, Australia

- Development of an exploration method using a probabilistic frontier representation and continuous occupancy maps able to handle sparse observations.
- It is based on learning spatial correlation of map points with iterative Gaussian process-based regression from sparse range measurements, and mutual information surfaces estimation from a one-step ahead map posterior and conditional entropy.



17:05–17:20 ThFT4.2

A Localization Aware Sampling Strategy for Motion Planning under Uncertainty

Vinay Pilania, Kamal Gupta,
Robotic Algorithms & Motion Planning (RAMP) Lab
School of Engineering Science, Simon Fraser University, Canada

- A localization aware sampling (LAS) strategy that uses a new notion of **localization ability of a sample**.
- Put more samples in regions where sensor data is able to achieve higher uncertainty reduction while maintaining adequate samples in regions where uncertainty reduction is poor.
- Simulation results showed that our LAS reduces the planning time significantly with little compromise on path quality.
- A stochastic planner that uses our LAS is probabilistically complete under some reasonable conditions on parameters.

17:20–17:35 ThFT4.3

AuRoSS: An Autonomous Robotic Shelf Scanning System

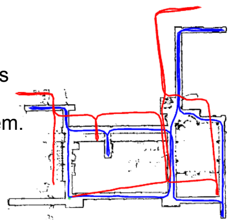
Renjun Li, Zhiyong Huang, Ernest Kurniawan, Chin Keong Ho
[1]Institute of Inforcomm Research, A*STAR, Singapore

17:35–17:50 ThFT4.4

Maximum Likelihood Tracking of a Personal Dead-Reckoning System

Surat Kwanmuang[1], Edwin Olson[2],
[1]Chulalongkorn University, Thailand [2]University of Michigan, USA

- To develop semi-autonomous robots capable of following a human leader.
- Map data collected by a robot can be used to improve the trajectory estimates of a human leader equipped with a Personal Dead-Reckoning (PDR) system.
- Our purpose methods: one based on a particle filter and two others based on maximum likelihood optimization using Stochastic Gradient Descent (SGD)

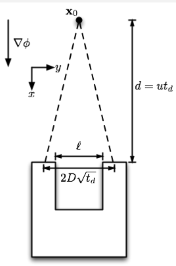


17:50–18:05 ThFT4.5

A drift-diffusion model for robotic obstacle avoidance

Paul Reverdy[1], B. Deniz Ilhan[1], and Daniel E. Koditschek[1]
[1]University of Pennsylvania, USA

- Stochastic framework for robot navigation in presence of obstacles
- Idea: add random walk to navigation function gradient field
- Result: probability of obstacle avoidance as function of dimensionless parameter
- Helps robot escape local minima, saddles
- Next steps: extensions to multiple obstacles, active control policies



18:05–18:20 ThFT4.6

Dynamic and Probabilistic Estimation of Manipulable Obstacles for Indoor Navigation

Christopher Clingerman[1], Peter J. Wei[2] and Daniel D. Lee[1]
[1]University of Pennsylvania, USA [2]Carnegie Mellon, USA

- Manipulable obstacles necessitate more intelligent navigation behavior from robots.
- We present a model for probabilistic cost in 2D discretized evidence grids based on independent gamma-distributed costs.
- Using theory from multi-armed bandits we derive a lower confidence bound for this distribution and use D*-Lite for fast dynamic (re-)planning.
- Our approach is verified experimentally.

Robot Audition 2

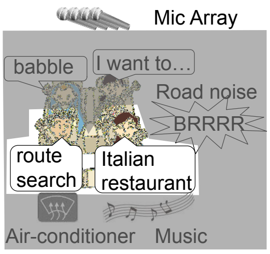
Chair *Kazuhiro Nakadai, Honda Research Inst. Japan Co., Ltd.*
Co-Chair *Francois Grondin, Universite de Sherbrooke*

16:50–17:05 ThFT5.1

Robot-Audition-Based Human-Machine Interface for a Car

Kazuhiro Nakadai,
Takeshi Mizumoto and Keisuke Nakamura
Honda Research Insititute Japan Co., Ltd., Japan

- **Multiparty** (driver & passenger), and **barge-in-able** dialog system for a car
- **Multimodal** expression with a small **robot agent**
- **Accurate voice recognition** without annoying push-to-talk button by a **4ch microphone array**
- **Suitable system design** in network communication for a car



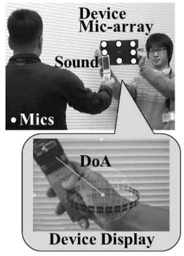
17:05–17:20 ThFT5.2

Interactive Sound Source Localization using Robot Audition for Tablet Devices

Keisuke Nakamura[1], Lana Sinapayen[1],
and Kazuhiro Nakadai[1]
[1]Honda Research Institute Japan Co., Ltd.

- Sound Source Localization(SSL) using a tablet device featuring:

1. Elevation estimation using an active audition framework
2. Robustness improvement using a constrained optimization
3. Interactive sound exploration using augmented reality

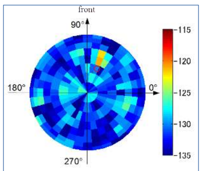


17:20–17:35 ThFT5.3

Design Model of Microphone Arrays for Multirotor Helicopters

Takahiro Ishiki[1], Makoto Kumon[1],
[1]Kumamoto University, Japan

- Microphone array layout equipped with a multirotor helicopter is considered in order to recognize acoustic information from the ground.
- A model of the rotor noise is proposed based on the dynamics of the helicopter taking the rotors' rotation into account, and it is used to assess the given microphone array.
- Delay-and-Sum Beam Former is applied to detect acoustic activity on the ground by a flying helicopter.



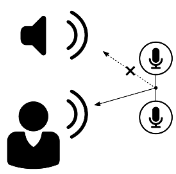
Power of the signal obtained by DSBF. Red circle shows the ground truth.

17:35–17:50 ThFT5.4

TDOA Estimation based on Binary Frequency Mask for SSL on Mobile Robots

François Grondin[1] and François Michaud[1]
[1]Université de Sherbrooke, Québec, Canada

- Challenge: localization ambiguities when target sound source is corrupted by coherent broadband noise.
- Proposed method: Binary mask with weighted generalized cross-correlation.
- Results: Proposed method improves TDOA discrimination, and brings the additional benefit of modulating the computing load according to voice activity.



17:50–18:05 ThFT5.5

Rospeex: A Cloud Robotics Platform for Human-Robot Spoken Dialogues

Komei Sugiura and Koji Zettsu
National Institute of Information and Communications Technology, Japan

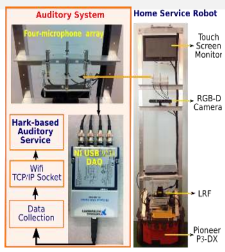
- Multilingual speech recognition & synthesis without authentication
- Rospeex server used by 12,000 unique users
- Cloud server logs are analyzed

18:05–18:20 ThFT5.6

An Open Platform of Auditory Perception for Home Service Robots

Ha Manh Do[1], Weihua Sheng[1], and Meiqin Liu[2]
[1]Oklahoma State University, USA
[2]Zhejiang University, China

- Home service robot with auditory perception capability
- Layered architecture for software implementation
- Sound source position estimation
- Multiple source speech recognition
- Human-assisted sound event recognition



Rehabilitation Robotics 3

Chair *Qining Wang, Peking University*
Co-Chair

16:50–17:05	ThFT6.1

Preliminary Feasibility Study of the H-Man Planar Robot for Quantitative Motor Assessment

Asif Hussain[1], Wayne Dailey[2], Charmayne Hughes[1], Paolo Tommasino[1], Aamani Budhota[1], W.G. Kumudu C. Gamage[1], Etienne Burdet[2], Domenico Campolo[1]
[1]NTU, Singapore; [2]ICL, UK

- H-Man, a planar 2-DOF robot for assessment and training of upper-limb motor functions
- Kinematic data from H-Man can quantitatively grade subject performance.
- Healthy subjects indicate no significant difference between limbs for reaching tasks. However between healthy and impaired subjects differences can be observed.

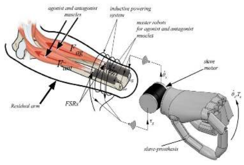

Participant using H-Man with visual interface

17:05–17:20	ThFT6.2

A Biomechatronic Extended Physiological Proprioception (EPP) Controller for Upper-Limb Prostheses

Anestis Mablekos-Alexiou, Georgios A. Bertos, Evangelos Papadopoulos Department of Mechanical Engineering, National Technical University of Athens, Greece

- A Biomechatronic – equivalent of the classic EPP Controller without the use of Bowden cables is proposed.
- The proposed topology maintains the proprioceptive control advantages of EPP and is more acceptable aesthetically.
- Initial simulation results for equivalency between the two topologies are presented.

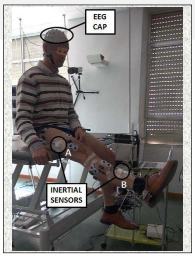


17:20–17:35	ThFT6.3

Single Joint Movement Decoding from EEG in Healthy and Incomplete SCI Subjects

A. Úbeda[1], Á. Costa[1], E. Iáñez[1], E. Piñuela-Martín[2], E. Márquez-Sánchez[2], A.J. del-Ama[2], A. Gil-Agudo[2] and J.M. Azorín[1]
[1]Miguel Hernández University, Spain
[2]National Hospital for Paraplegics, Spain

- Isotonic flexion/extension knee movements are decoded from EEG signals
- This analysis is aimed at reducing motion artifacts provoked by the gait process
- Meaningful information of movement planning starts around 2.5 seconds prior to the decoded angle

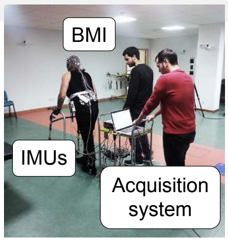


17:35–17:50	ThFT6.4

Starting and finishing gait detection using a BMI for spinal cord injury rehabilitation

E. Hortal, E. Márquez-Sánchez[2], Á. Costa[1], E. Piñuela-Martín[2], R. Salazar-Varas[3], A.J. del-Ama[2], A. Gil-Agudo[2] and J.M. Azorín[1]
[1]Miguel Hernández University, Spain
[2]National Hospital for Paraplegics, Spain
[3]Cinvestav, Mexico

- Starting and finishing gait detections are performed using EEG signals
- The BMI system has been validated by four incomplete SCI patients
- The results show a satisfactory behavior of the BMI, obtaining a good accuracy in the detection of the movement intentions



17:50–18:05	ThFT6.5

Adaptive gait assistance based on human-orthosis interaction

V. Rajasekaran[1], J. Aranda[1,2],and A. Casals[1,2]
[1]Universitat Politécnica de Catalunya, Barcelona-Tech
[2]Institute for Bioengineering of Catalonia, Barcelona, Spain

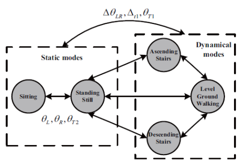
- Dynamic adaptive gait assistance using a wearable exoskeleton
- Real time joint stiffness adaptation in function of trajectory deviation and human-orthosis interaction torques
- Evaluated and verified with healthy subjects prior to performing in incomplete SCI individuals
- Personalized adjustment of the joint impedance is achieved after 10 trials

18:05–18:20	ThFT6.6

A Realtime Locomotion Mode Recognition Method for an Active Pelvis Orthosis

Kebin Yuan[1], Andrea Parri[2], Tingfang Yan[2], Long Wang[1], Marko Munih[3], Qining Wang[1], Nicola Vitiello[2]
[1]Peking University, China [2]Scuola Superiore Sant'Anna, Italy
[3]University of Ljubljana, Slovenia

- We present a realtime locomotion mode recognition method for an active pelvis orthosis.
- Five locomotion modes, including sitting, standing still, level-ground walking, ascending stairs, and descending stairs.
- Experimental results with three subjects achieve an average recognition accuracy of 99.87% and average recognition delay of 18.12% of one gait cycle.



Dexterous Manipulation 2

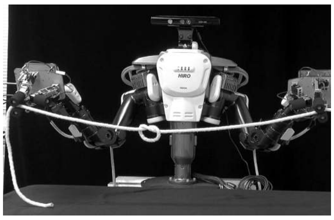
Chair *Shunsuke Kudoh, The University of Electro-Communications*
Co-Chair *Alberto Rodriguez, Massachusetts Institute of Technology*

16:50–17:05	ThFT7.1

In-air Knotting of Rope by a Dual-arm Multi-finger Robot

Shunsuke Kudoh, Tomoyuki Gomi, Ryota Katano, Testuo Tomizawa and Takashi Suehiro
The University of Electro-Communications, Japan

- Method for knotting a rope by a robot in the air, rather than on a table
- Extracted essential hand motions, *skill motion*, by observing human knotting performance
- Developing robot hands with the capability of executing the *skill motions*

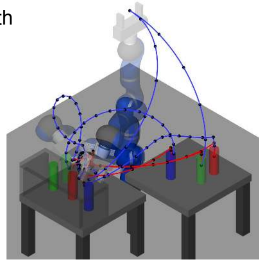


17:05–17:20	ThFT7.2

MOPL: A Multi-Modal Path Planner for Generic Manipulation Tasks

Sören Jentzsch[1], Andre Gaschler[1], Oussama Khatib[2] and Alois Knoll[1]
[1]fortiss GmbH, Germany [2]Stanford University, USA

- We solve manipulation problems with planning over multiple actions, including pushing and sliding
- Our MOPL planner samples in the combined space of robot and object configurations and spans search trees through contact manifolds
- MOPL can solve scenarios with different types of kinematics and generic manipulation actions

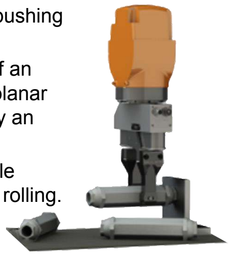


17:20–17:35	ThFT7.3

Prehensile Pushing: In-hand Manipulation with Push Primitives

Nikhil Chavan-Dafle[1] and Alberto Rodriguez[1]
[1]Massachusetts Institute of Technology, USA

- Manipulation of a grasped object by pushing it against its environment.
- Model of the quasi-dynamic motion of an object held by a set of point, line, or planar rigid frictional contacts and pushed by an external pusher (the environment).
- Demonstrate three primitive prehensile pushing actions: sliding, pivoting and rolling.

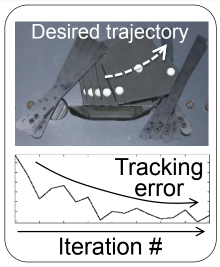


17:35–17:50	ThFT7.4

Iterative Learning Control for Whole-Arm Object Manipulation through Coordination of Torque/Velocity-Controlled Fingers

Masahito Yashima and Tasuku Yamawaki,
National Defense Academy of Japan, Japan

- The proposed control strategy consists of two main contributions
- The first is a novel iterative learning control scheme, which consists of two types of controllers
- The second is a method for assigning finger control modes
- The validity of the proposed strategy is experimentally shown by verifying the tracking performance of an object

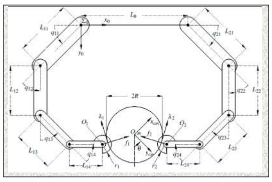


17:50–18:05	ThFT7.5

Dexterous Dynamic Optimal Grasping of a Circular Object with Pose Regulation using Redundant Robotic Soft-fingertips

Rodolfo García-Rodriguez[1], Marco Villalva-Lucio[2] and Vicente Parra-Vega[2]
[1]Universidad de los Andes, Chile [2]Cinvestav, Mexico

- Motivated by the fact that deformable fingertips with hemi-spherical shape can provide a rolling motion, a passivity-based controller is proposed to grasping and manipulate dynamically a circular object.
- The grasping and orientation of the circular object is based on to align dynamically the normal forces applied to the object that allow its manipulation with minimum tangent forces.

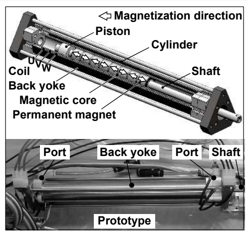


18:05–18:20	ThFT7.6

Development of a Pneumatic-Electromagnetic Hybrid Linear Actuator with an Integrated Structure

Yoshihiro Nakata[1], Tomoyuki Noda[2], Jun Morimoto[2] and Hiroshi Ishiguro[1]
[1]Osaka University, Japan [2]ATR CNS, Japan

- An original development work on compact direct-drive hybrid actuator (pneumatic-electromagnetic)
- Conventional: Space required: sum of the combined actuators and the transmission mechanisms
- State-of-the-art: Less space required thanks to the shared moving part and internal cylindrical space



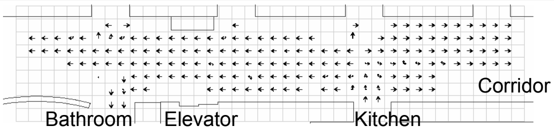
Mapping 4

Chair *Abubakr Muhammad, Lahore University of Management Sciences (LUMS)*
Co-Chair *Karsten Berns, University of Kaiserslautern*

16:50–17:05	ThFT8.1

Multi-scale Conditional Transition Map: Modeling Spatial-temporal Dynamics of Human Movements with Local and Long-term Correlations

Zhan Wang, Patric Jensfelt and John Folkesson
KTH Royal Institute of Technology



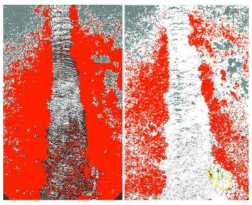
- Modeling human motion patterns by transitions of human location state on a grid map
- Building the transition map (MCTMap) by capturing both local correlations and long-term dependencies using the Input-Output HMM with a left-to-right structure and a hierarchical input

17:05–17:20	ThFT8.2

A Real-time Relative Probabilistic Mapping Algorithm for High-Speed Off-road Autonomous Driving

Cheng Chen[1,2], Yuqing He[1], Feng Gu[1], Chunguang Bu[1], Jianda Han[1]
[1]Shenyang Institute of Automation, Chinese Academy of Sciencees, China [2]SAIC Motor Corporation Ltd., China

- Relative Probabilistic Mapping (RPM) for high-speed and highly-vibrated off-road autonomous driving
- Reliable obstacle detection
- Kalman Filter + Gaussian Mixture Algorithm
- Real-time experiments with different LiDARs configuration

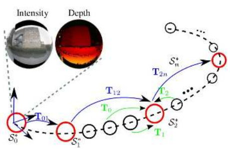


17:20–17:35	ThFT8.3

Dense Accurate Urban Mapping from Spherical RGB-D Images

Renato Martins[1], Eduardo Fernandez-Moral[1], and Patrick Rives[1]
[1]Inria Sophia Antipolis, France

- This work presents a topometric mapping approach composed of:
  - The selection of a sparse set of keyframe RGB-D spheres;
  - Regularization of the depth map by a photo-geometric segmentation;
  - Uncertainty error propagation and fusion of close spheres.
- Results: Better overall consistency of the map and larger convergence domain for localization.

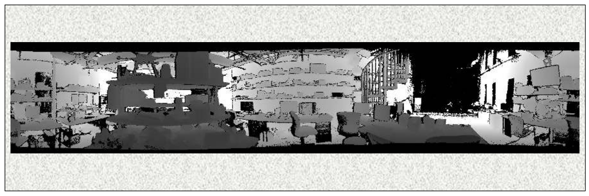


17:35–17:50	ThFT8.4

Mapping with Depth Panoramas

Camillo Taylor[1] , Anthony Cowley[1], Rafe Kettler[1], Kai Ninomiya[1], Mayank Gupta[1] and Boyang Niu[1]
[1]University of Pennsylvania, USA

- This paper describes the use of depth panoramas in the construction of detailed 3D models of extended environments.

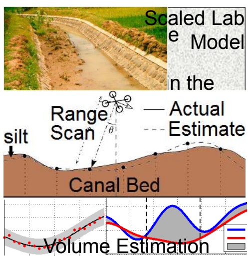


17:50–18:05	ThFT8.5

A Framework for Aerial Inspection of Siltation in Waterways

Hamza Anwar[1], Abubakr Muhammad[1] and Karsten Berns[2]
[1]CyPhyNetS, LUMS, Pakistan [2]Robotics Research Lab, University of Kaiserslautern, Germany

- **Gaussian Process Regression** for dried canal surface mapping
- Underlying silt **volume estimation**
- Incorporating flying robot's uncertain localization and sensor noise
- **Theoretical Bounds** on accuracy of estimated silt surface and contained silt volume
- Simulation and Lab **Experiments**

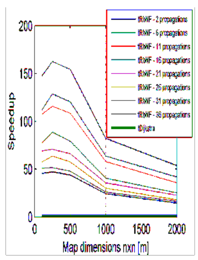


18:05–18:20	ThFT8.6

A Fast Cost-To-Go Map Approximation Algorithm on Known Large Scale Rough Terrains

Nadir Kapetanovic[1], Adnan Tahirovic[1] and Gianantonio Magnani[2]
[1]University of Sarajevo, Bosnia and Herzegovina, [2]Politecnico di Milano, Italy

- The proposed algorithm is simpler than the Dijkstra algorithm.
- The obtained cost-to-go map is near optimal.
- The proposed algorithm has an inherently parallel structure, so it can be coded to significantly outperform the Dijkstra algorithm in terms of runtime.



Legged Robots 4

Chair *Fumihiko Asano, Japan Advanced Institute of Science and Technology*
Co-Chair *Estelle Lubbe, North-West University, CSIR*

16:50–17:05 ThFT9.1

State Estimation For a Hexapod Robot

Estelle Lubbe[1], Daniel Withey[1] and Kenneth R. Uren[2]
[1]Council for Scientific and Industrial Research, South Africa
[2]North-West University, South Africa

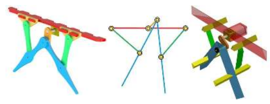
- EKF-based fusion of kinematic model and IMU data providing reliable full pose state estimation
- Implementation on a commercially-available robot making use of only commonly-available sensors.
- Cost effective platform solution for hexapod control algorithm development.

17:05–17:20 ThFT9.2

TriBot: A Minimally-Actuated Accessible Holonomic Hexapedal Locomotion Platform

Shadi Tasdighi Kalat, Siamak G. Faal, Ugur Celik, and Cagdas D. Onal
Soft Robotics Laboratory, WPI, USA

- Potential agents of a robotic swarm
- Holonomic hexapedal locomotion
- Two identical prototypes
- Different fabrication methods
  - Cut-and-Assemble (CA)
  - Cut-and-Fold (CF)
- Differences in performance and kinematic characteristics of two robots are rigorously evaluated

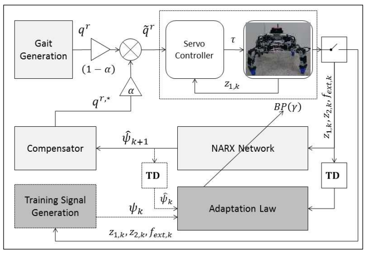


17:20–17:35 ThFT9.3

Trunk Stabilization of Multi-legged Robots Using On-line Learning via a NARX-NN Compensator

Brian Cairl[1], Farshad Khorrami[1]
[1]NYU Polytechnic School of Engineering, USA

- Stabilization/leveling trunk of a quadruped during open-loop gaiting
- Prediction of periodic disturbances via a NARX-NN
- Disturbance attenuation via modification of joint reference commands using NARX-NN

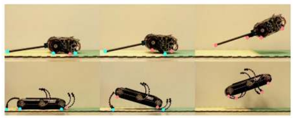


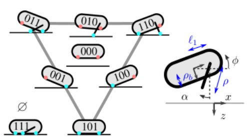
17:35–17:50 ThFT9.4

Tail-Assisted Rigid and Compliant Legged Leaping

Anna Brill[1], Avik De[1], Aaron Johnson[2] and Daniel Koditschek[1]
[1]University of Pennsylvania, USA [2]Carnegie Mellon University, USA

- This paper explores the design space of simple legged robots capable of leaping.
- Using a combination of formal reasoning and physical intuition, we analyze and test the leaping capabilities of the Penn Jerboa.
- The robot is shown to bound up a ledge 1.5x the hip height and cross a gap 2x the body length.



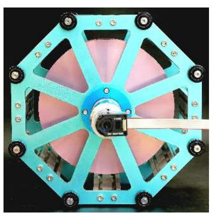


17:50–18:05 ThFT9.5

Underactuated Rimless Wheel with Small Passive Rollers Aiming at Verification Experiment for Sliding Limit Cycle Walking

Fumihiko Asano[1]
[1]School of Information Science, JAIST, Japan

- A prototype experimental machine of an underactuated rimless wheel (URW) is developed.
- The URW has small passive rollers at each corner of the regular octagon frame for generating a sliding walking gait.
- A mathematical model of the URW is developed and the typical walking gait is analyzed through numerical simulations.

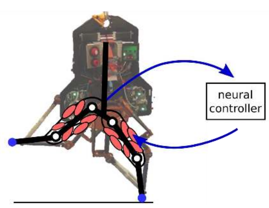


18:05–18:20 ThFT9.6

Toward a Virtual Neuromuscular Control for Robust Walking in Bipedal Robots

Zachary Batts[1], Seungmoon Song[1], and Hartmut Geyer[1]
[1]Carnegie Mellon University, USA

- Simulates muscles and reflexes to derive desired motor torques for planar simulation of ATRIAS robot.
- Tolerates random ground height disturbances (up to ±7cm).
- Resilient to horizontal impulses, modelling error, sensor noise.



Medical Systems, Healthcare, and Assisted Living

Chair *Venkat Krovi, University at Buffalo (SUNY Buffalo)*
Co-Chair *Kenji Suzuki, University of Tsukuba*

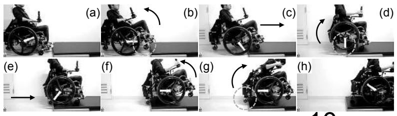
16:50–17:05 ThFT10.1

A Novel Step Climbing Strategy for a Wheelchair with Active-caster Add-on Mechanism

Yu Munakata, Masayoshi Wada
Tokyo University of Agriculture and Technology, Japan

- We propose **a novel add-on mechanism** equipped on the back of a ordinary wheelchair
- We confirm **the design condition** for satisfying the propose step climbing strategy by the geometrical and dynamical analyses
- After a prototype was built, we confirm **a user can pass over a step** by the proposed strategy and add-on mechanism

Add-on mechanism



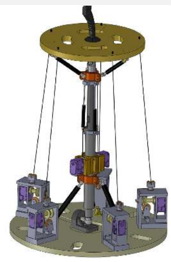
Step climbing strategy (height : 10 cm)

17:05–17:20 ThFT10.2

Modeling and Control of a Novel Home-Based Cable-Driven Parallel Platform Robot: PACER

Aliakbar Alamdari, Venkat N. Krovi
The State University of New York at Buffalo, USA

- Various control strategies of a modular cable-articulated parallel robotic manipulator called PACER (Parallel Articulated-Cable Exercise Robot) for human upper limb rehabilitation
  - Passive mode via feedback linearization controller
  - Active mode via admittance controller
  - Resistive mode via stiffness controller

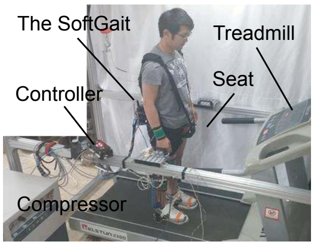


17:20–17:35 ThFT10.3

The SoftGait: A Simple and Powerful Weight-Support Device for Walking and Squatting

Yun-Pyo Hong[1], Donghan Koo[2],
Ji-il Park[3], Soohyun Kim[1] and Kyung-Soo Kim[1]
[1]Korea Advanced Institute of Science and Technology (KAIST), Korea [2]Hyundai-Motor Group, Korea [3]Korea army, Korea

- The SoftGait development with pneumatic actuators
- Low cost sensors' development using photo interrupters and FSRs
- High compliant actuator and its simple control
- Operation in three modes : walking, standing and squatting



17:35–17:50 ThFT10.4

Hidden Markov Modeling of Human Pathological Gait using Laser Range Finder for an Assisted Living Intelligent Robotic Walker

Xanthi S. Papageorgiou, Georgia Chalvatzaki, Costas S. Tzafestas and Petros Maragos
National Technical University of Athens, Greece

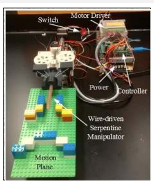
- Effective intelligent active mobility assistance robot, for walking pattern of a patient or an elderly
- Completely non-invasive framework for analyzing a pathological human walking gait pattern using Laser Range Finder
- Hidden Markov Model (HMM) for state estimation, and recognition of the gait data
- Towards recognition of pathological gait patterns and the subsequent classification of specific walking pathologies

A robotic prototype equipped with a Hokuyo Laser Sensor aiming to record the gait cycle data of the user (below knee level).

17:50–18:05 ThFT10.5

Minimum Sweeping Area Motion Planning for Flexible Serpentine Surgical Manipulator with Kinematic Constraints

Yanjie Chen[1,2], Zheng Li[3], Wenjun Xu[2],
Yaonan Wang[1,*] and Hongliang Ren[2,*]
[1]Hunan University, China
[2]National University of Singapore, Singapore
[3]The Chinese University of Hong Kong, Hong Kong



18:05–18:20 ThFT10.6

Step-Climbing Wheelchair with Lever Propelled Rotary Legs

Kai Sasaki, Yosuke Eguchi and Kenji Suzuki
Univ. of Tsukuba, Japan

- To develop a step-climbing wheelchair based on passive control using human upper limbs without active motors
- Using posture transition and rotary-leg mechanism
- Feasibility of a step-climbing wheelchair using posture transition and rotary-leg mechanism

Integrated Task and Motion Planning

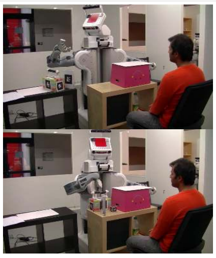
Chair *Kostas E. Bekris, Rutgers, the State University of New Jersey*
Co-Chair *Tomas Lozano-Perez, MIT*

16:50–17:05	ThFT11.1

Combining symbolic and geometric Planning to synthesize human-aware plans: towards more efficient combined search

Mamoun Gharbi[1,2], Raphaël Lallement[1,2], and Rachid Alami[2]
[1]INSAT, France [2]LAAS-CNRS, Univ. Toulouse, France

- Tightening the link between symbolic and geometric planning to tackle the ramification problem.
- Symbolic planner helps the geometric one by providing it with constraints and domain-expert knowledge
- Geometric planner helps the symbolic one by providing it with relevant cost (linked to social rules)

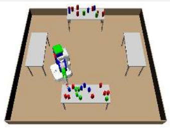


17:05–17:20	ThFT11.2

Backward-Forward Search for Manipulation Planning

Caelan Garrett[1], Tomás Lozano-Pérez[1], Leslie Kaelbling[1]
[1]MIT CSAIL, USA

- We present the **Hybrid Backward-Forward (HBF)** Algorithm for solving hybrid planning problems
- HBF can solve **high-dimensional manipulation planning problems** involving both prehensile and nonprehensile actions
- A backwards search through a simplified problem space focuses the sampling of actions in a top-level forward search
- Experiments show **improvements over competing planners**



- The goal of the manipulation problem above is for the 7 blue blocks to be on the left table and the 7 green blocks be on the right table. HBF was able to solve this problem in all 60 trials with a **median runtime of 82 seconds**

17:20–17:35	ThFT11.3

Effective Robot Teammate Behaviors for Supporting Sequential Manipulation Tasks

Bradley Hayes and Brian Scassellati
Yale University, USA

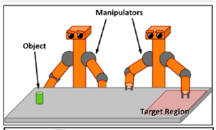
- We present a Task and Motion Planning approach to autonomously producing *supportive behaviors* for agents to use to assist others during sequential manipulation tasks.
- Our approach merges considerations derived from both symbolic and geometric planning domains.
- Our results show reductions in cognitive and kinematic burdens during task execution within a novel circuit building evaluation domain.

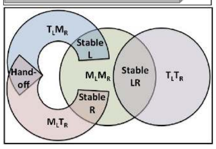
17:35–17:50	ThFT11.4

Planning Representations and Algorithms For Prehensile Multi-arm Manipulation

Andrew Dobson[1], Kostas E. Bekris[1],
[1]Rutgers University, USA

- Proposes a general, minimal state representation and search method for multi-arm manipulation.
- Preprocessing allows fast query resolution with significantly shorter paths than state-of-the-art comparison.
- Shows equivalence classes between different manipulation challenges.



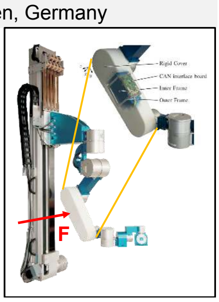


17:50–18:05	ThFT11.5

Motion Planning for Redundant Manipulators in Uncertain Environments based on Tactile Feedback

Christoph Schütz, Julian Pfaff, Felix Sygulla, Daniel Rixen and Heinz Ulbrich
Technische Universität München, Germany

- New intrinsic **Tactile Sensing** module
- **Minimization** and control of external contact forces
- Extended **Resolved Motion Rate Control** scheme
- Controller Design based on **Feedback Linearization**
- Planning in **Real-Time** (1ms)

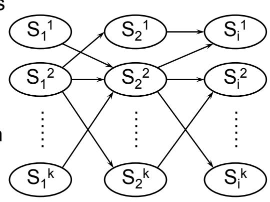


18:05–18:20	ThFT11.6

Humanoid Full-Body Manipulation Planning with Multiple Initial Guesses and Key Postures

Bowei Tang[1], Tianyu Chen[1], and Christopher Atkeson[1]
[1]Carnegie Mellon University, United States

- Divide trajectory into key postures
- Generate multiple diverse initial guesses to get separated local optimal solutions
- Choose local optimal solutions of each key postures to get solution series
- Connect solution series to get continuous trajectory



Robot Reinforcement Learning

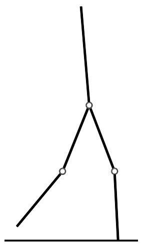
Chair
Co-Chair *Jochen J. Steil, Bielefeld University*

16:50–17:05 ThFT12.1

Settling Time Reduction for Underactuated Walking Robots

Sotiris Apostolopoulos[1,2], Marion Leibold[1] and Martin Buss[1,2]
[1]Chair of Automatic Control Engineering TUM, Germany
[2]Institute for Advanced Study IAS-TUM, Germany

- A methodology for improving the settling time of transitions between different walking controllers by introducing a multi-step transition to the target controller
- Formulation as a MDP and solution with Reinforcement Learning
- Simplification of the learning process with the utilization of the Hybrid Zero Dynamics
- Comparison with a one-step transition strategy shows a success rate of 84%



17:05–17:20 ThFT12.2

Interactive Learning for Sensitivity Factors of a Human-Powered Lower Exoskeleton

Rui Huang[1], Hong Cheng[1], Qiming Chen[1] , Huu-Toan Tran[1] and Xichuan Lin[1]
[1]University of Electronic Science and Technology of China, China

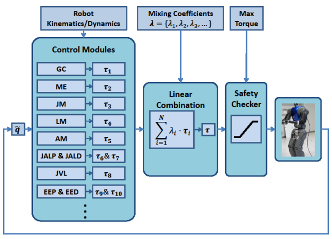
- Adaptive Sensitivity Amplification Control (ASAC) strategy based on reinforcement learning has been presented in this paper.
- Reinforcement learning methods are utilized to learn the controller online.
- Gaussian Process Regression (GPR) is employed to estimate the joint trajectories
- Control performances of proposed control. strategy are both validated on a single DOF platform and HUALEX system.

17:20–17:35 ThFT12.3

Multiple Task Optimization with a Mixture of Controllers for Motion Generation

Niels Dehio, René Felix Reinhart and Jochen J. Steil
Research Institute for Cognition and Robotics (CoR-Lab)
Bielefeld University, Germany

- Simultaneous mastering of multiple tasks by mixture of torque control modules
- Stochastic optimization of mixture coefficients
- Demonstration for pendulum and humanoid robot COMAN in simulation

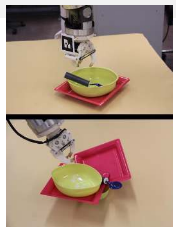


17:35–17:50 ThFT12.4

Safe Robot Execution in Model-Based Reinforcement Learning

David Martínez[1], Guillem Alenyà[1], Carme Torras[1]
[1] Institut de Robòtica i Informàtica Industrial, CSIC-UPC, Spain

- Objective: anticipate **irrecoverable execution errors** during learning.
- Identify the **dangerous** effects by using a careful **risk analysis** of actions.
- Resort to active **interaction** with a **human** operator in risky cases.
- Application example: clearing tableware.



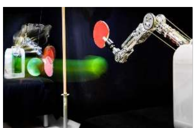
Top: safe stack
Bottom: dangerous stack

17:50–18:05 ThFT12.5

Reinforcement Learning vs Human Programming in Tetherball Robot Games

S. Parisi[1], H. Abdulsamad[1], A. Paraschos[1], C. Daniel[1] and J. Peters[1,2]
[1]Technische Universität Darmstadt, Germany
[2]Max Planck Institute for Intelligent Systems Tübingen, Germany

- Hand-crafting solutions for robotic tasks requires deep insights into the platform and the problem at hand.
- Comparing reinforcement learning against designed behaviors is not straightforward.
- We created an easy-to-use framework using state-of-the-art components in motor skill learning, investigated the effects of its open parameters and compared it to manually designed programs.



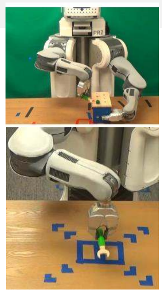
The tetherball game provides a pre-defined success measure, the game score.

18:05–18:20 ThFT12.6

Learning Compound Multi-Step Controllers under Unknown Dynamics

Weiqiao Han, Sergey Levine
Pieter Abbeel
UC Berkeley

- **Challenge**: episodic reinforcement learning requires resetting the environment, and motion skills must be situated in the context of other skills to execute complex tasks
- **Approach**: we train sequences of controllers for compound tasks together, together with reset controllers that can reset the state during learning



Task Planning

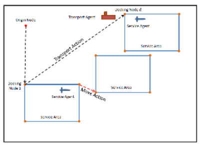
Chair *Rachid Alami, CNRS*
Co-Chair *Alejandro Agostini, University of Goettingen*

16:50–17:05	ThFT13.1

A Solution to the Service Agent Transport Problem

Matthew J. Bays[1] and Thomas A. Wettergren[2]
[1]Naval Surface Warfare Center, Panama City Division, USA
[2]Naval Undersea Warfare Center, Newport Division, USA

- We introduce a new problem in the area of scheduling and route planning operations called the service agent transport problem (SATP).
- The goal of the SATP is to plan a schedule of service agent and transport agent actions such that all locations are serviced in the shortest amount of time.



17:05–17:20	ThFT13.2

A Novel, Distributed Scheduling Algorithm for Time-Critical, Multi-Agent Systems

Amanda Whitbrook, Qinggang Meng, and Paul W. H. Chung
Loughborough University, UK

- The distributed Performance Impact (PI) task-allocation algorithm has been enhanced to include a degree of either ε-greedy or soft max action selection.
- This introduces a level of exploration to the architecture which can permit new areas of the search space to be explored, improving solution fitness in some cases.
- Experiments showed that the introduction of more exploration improved baseline PI's task allocation performance by up to about 8%, and enabled the algorithm to solve additional problems that failed using the baseline version.

17:20–17:35	ThFT13.3

Online Task Merging with a Hierarchical Hybrid Task Planner for Mobile Robots

Sebastian Stock[1,2], Masoumeh Mansouri[3], Federico Pecora[3] and Joachim Hertzberg[1,2]
[1]Osnabrück University, Germany [2]DFKI Robotics Innovation Center, Osnabrück Branch, Germany [3]Örebro University, Sweden

- New hierarchical task planner CHIMP can reason about causal, temporal, resource and external knowledge
- Meta-CSP approach allows to add further kinds of knowledge
- Online task merging of new goals into existing plans during plan execution
- Integrated on a PR2

17:35–17:50	ThFT13.4

The HATP Hierarchical Planner: Formalisation and an Initial Study of its Usability and Practicality

Lavindra de Silva[1] and Raphael Lallement[2] and Rachid Alami[2]
[1]Univeristy of Nottingham, Nottingham, UK
[2]LAAS-CNRS/Univ. de Toulouse, Toulouse, France

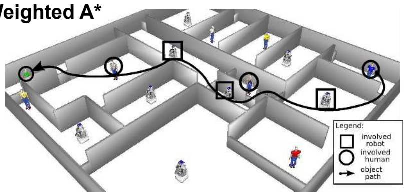
- HTN planners have generally relied on specialised languages for domain and problem representations
- We need HTN planners that are based on more familiar concepts, e.g. from structured programming
- HATP (Hierarchical Agent- based Task Planner) HTN planner offers such "syntactic sugar"
- We develop a formalism to unambiguously capture HATP's syntax and an important subset of its semantics
- We demonstrate that HATP is practical

17:50–18:05	ThFT13.5

Planning handovers involving humans and robots in constrained environment

Jules Waldhart, Mamoun Gharbi[1] and Rachid Alami[1]
[1]LAAS-CNRS, Univ Toulouse, France

- Multi-agent transport problem with **robots** and **humans**
- Model for efficient on-line search, **task** and **motion planning**
- Search with **Lazy Weighted A***
- Adapt to humans, share effort
- Generates full trajectories



18:05–18:20	ThFT13.6

Using Structural Bootstrapping for Object Substitution in Robotic Executions of Human-like Manipulation Tasks

A. Agostini[1], M.J. Aein[1], S. Szedmak[2], E.E. Aksoy[1], J. Piater[2] and F. Wörgötter[1]
[1]III Institute of Physics & BCCN, University of Göttingen
[2]Intelligent and Interactive Systems, ICS, University of Innsbruck

- Finds replacements of missing objects required for the execution of tasks.
- Task plans are generated from prototypical (e.g. library) planning problem definitions.
- If objects for plan execution are missing, looks for replacements using an intelligent database coding object affordances.

Salad making scenario

Robotics in Agriculture and Forestry

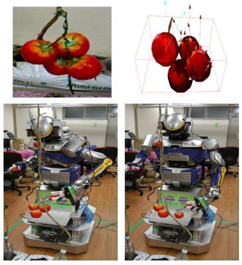
Chair *Guillem Alenyà, CSIC-UPC*
Co-Chair *Miguel Torres-Torriti, Pontificia Universidad Catolica de Chile*

16:50–17:05 ThFT14.1

Reasoning-Based Vision Recognition for Agricultural Humanoid Robot Toward Tomato Harvesting

Xiangyu Chen[1], Krishneel Chand Chaudhary[1], Yoshimaru Tanaka[1], Kotaro Nagahama[1], Hiroaki Yaguchi[1], Kei Okada[1] and Masayuki Inaba[1]
[1]The University of Tokyo, Japan

- Agricultural tomato harvesting humanoid robot system.
- Reasoning-Based vision recognition approach for the estimation of pedicel for each tomato.
- Experiments on picking tomatoes that gathered in one branch.



17:05–17:20 ThFT14.2

Computational Approaches for Improving the Performance of Path Tracking Controllers

Fernando A. Auat Cheein[1], Saso Blazic[2] and Miguel Torres-Torriti[3]
[1]Universidad Técnica Federico Santa María,Chile [2]University of Ljubljana, Slovenia [3]Pontificia Universidad Católica, Chile

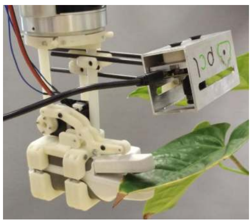
- In industrial applications, controller tuning is a time consuming task which is especially critical when gain values have impact on the robot's energy resources.
- We propose a set of approaches to automatically improve the performance of path tracking controllers in agricultural applications of automated machinery, by tuning the controllers.
- The results show that the controller's performance is improved up to 15%.

17:20–17:35 ThFT14.3

3D Sensor planning framework for leaf probing

Sergi Foix[1], Guillem Alenyà[1] and Carme Torras[1]
[1]CSIC-UPC, Barcelona (Spain)

- **Active exploration** for manipulation tasks on plants.
- Acquired data are recorded in a **multi-layer occupancy grid map.**
- View selection is driven by a **maximum-information-gain** gathering approach.
- **Task termination criterion** is explicitly encoded into the map.

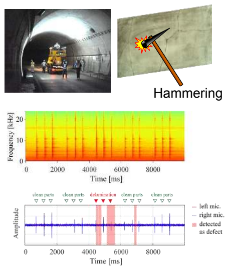


17:35–17:50 ThFT14.4

Improvement of Environmental Adaptivity of Defect Detector for Hammering Test Using Boosting Algorithm

Hiromitsu Fujii, Atsushi Yamashita and Hajime Asama
The University of Tokyo

- Automation of infrastructure inspection by hammering test is highly demanded particularly in concrete tunnels
- Our contributions are
  - Noise robust defect detector to inspect at actual sites
  - Calibration algorithm based on boosting for adjusting a defect detector to different environment

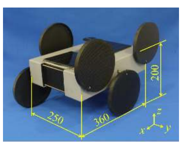


17:50–18:05 ThFT14.5

Novel Method of Estimating Surface Condition for Tiny Mobile Robot to Improve Locomotion Performance

Katsuaki Tanaka[1], Hiroyuki Ishii[1], Yuya Okamoto[1], Daisuke Kuroiwa[1], Ysaku Miura[1], Daiki Endo[1], Junko Mitsuzuka[1], Qing Shi[1], Satoshi Okabayashi[1], Yusuke Sugahara[2] and Atsuo Takanishi[1]
[1]Waseda University, Japan [2]Kokushikan University, Japan

- The purpose of this work is to design a model for estimating the surface condition using a tiny mobile robot
- Recognizing the surface condition has been suggested to improve the locomotion performance of a mobile robot
- A model for estimating the hardness and unevenness of a surface condition using a tiny mobile robot was designed using easily mounted sensors.



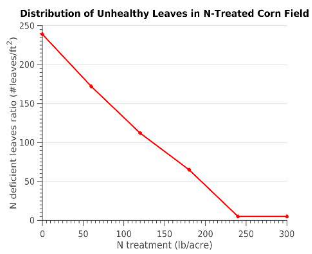
18:05–18:20 ThFT14.6

Automation Solutions for the Evaluation of Plant Health in Corn Fields

D. Zermas, D. Teng, P. Stanitsas, M. Bazakos, D. Kaiser, V. Morellas, D. Mulla, and N. Papanikolopoulos
University of Minnesota, USA

Just by sending a drone to count leaves, we...

- **Detect** the existence of N-deficiency in the corn field
- **Estimate** how much fertilizer to buy
- **Increase** corn production



Variable Stiffness Actuator Design and Control

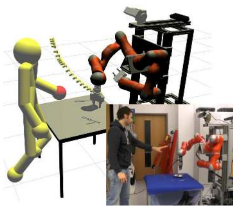
Chair *Sami Haddadin, Leibniz University Hanover*
Co-Chair *Stefano Stramigioli, University of Twente*

16:50–17:05	ThFT15.1

Robotic Agents Capable of Natural and Safe Physical Interaction with Human Co-workers

M. Beetz[1], G. Bartels[1], A. Albu-Schäffer[2], F. Balint-Benczedi[1], R. Belder[2], D. Beßler[1], S. Haddadin[3], A. Maldonado[1], N. Mansfeld[2], T. Wiedemeyer[1], R. Weitschat[2], J. Worch[1]
[1]Universität Bremen [2]DLR [3]Leibniz Universität Hannover

- Extends *cognition-enabled plan-based control* with *safety-related* concepts
- Motion controllers ensure *reactive safety*, while plan-based executive assembles *safe motion configurations*
- Experimental recordings available through *online knowledge processing system*

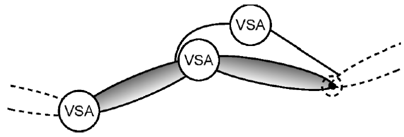


17:05–17:20	ThFT15.2

Compliant Manipulators on Graphs

Stefan S. Groothuis[1], Stefano Stramigioli[1], and Raffaella Carloni[1]
[1]RaM, University of Twente, The Netherlands

- Modeling method of compliant manipulators driven by variable stiffness actuators based on graph theory
- Arbitrary connection of arbitrary amount of actuators is possible and straight-forwardly modeled

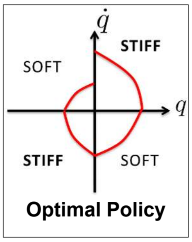


17:20–17:35	ThFT15.3

Variable Stiffness Control for Oscillation Damping

G. M. Gasparri†, M. Garabini†, L. Pallottino† , L.Malagia†, M. Catalano‡,G. Grioli‡ and A.Bicchi†‡
†Centro E. Piaggio, Univ. di Pisa, Italy ‡ADVR, IIT, Italy

- A **model-free** control law for damping **Variable Stiffness Actuators** by changing their stiffness.
- Solution derived from the **optimal control** problem of energy minimization of a one degree of freedom spring-mass model without damping.
- **Stability proof** for multi-dof case through Lyapunov stability theorem.
- **Experimental validation**.

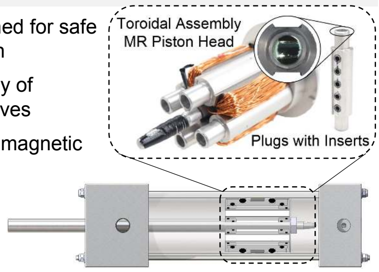


17:35–17:50	ThFT15.4

Development of a Backdrivable MR Hydraulic Piston for Passive and Active Linear Actuation

Gonzalo Aguirre D., Mitsuhiro Kamezaki, Morgan French and Shigeki Sugano
Waseda University, Japan

- Hydraulic power designed for safe human-robot interaction
- Novel Toroidal assembly of magnetorheological valves
- Mathematical model of magnetic circuit
- 65% saturation of MRF
- Up to 1kN Peak Force

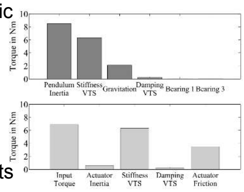


17:50–18:05	ThFT15.5

A System. Appr. to Exp. Modeling & Assess. of Elastic Actuat. by Comp.-Wise Para. Ident.

M. Lendermann[1], F. Stuhlenmiller[1], P. Erler[1,2], P. Beckerle[1,2], and S. Rinderknecht[1,2]
[1]TU Darmstadt, Germany [2]IMS, Germany

- Component-wise identification of elastic actuators dynamics
- Evaluation of mechanical effects by simulation and experiment
- Assessment of individual parameter influence on natural dynamics
- Joint damping can have relevant effects

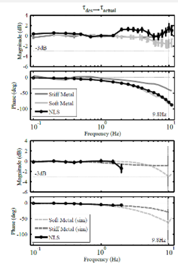


18:05–18:20	ThFT15.6

Control and Evaluation of Series Elastic Actuators with Nonlinear Rubber Springs

Jessica Austin[1], Alexander Schepelmann[1], and Hartmut Geyer[1]
[1]Carnegie Mellon University, USA

- We propose a state observer to capture hysteretic effects of urethane rubber in a compact nonlinear spring prototype.
- SEA testbed experiments compare performance of the prototype + observer to soft and stiff linear metal springs.
- Experiments show the potential performance advantages enabled by the nonlinear spring and inform requirements for rubber selection in future prototypes.



Late Breaking Posters (ThAP)

Thursday, October 1, 8:30–18:30 Foyer G

Chair Jianwei Zhang, University of Hamburg
Co-Chair Alois Knoll, Technische Universität München

The Two-Legged Robot CENTAUROB
Shucen Du, Josef Schlattmann, Stefan Schulz, Arthur Seibel
Hamburg University of Technology

Experimental Validation of Integrated Robot Design Using Ball Throwing Robot
Tetsuro Miyazaki, Akihiro Kanekiyo, Yutaka Tsuchiyama, Kazushi Sanada
Yokohama National University

Combined Ultrasound and OCT Imaging for Robotic Needle Placement
Sven-Thomas Antoni, Christoph Otte, Omer Rajput, Kevin Schulz, Alexander Schläfer
Hamburg University of Technology

Online power detection and velocity evaluation for a schooling robotic fish in a side-by-side array
Liang Li, Guangming Xie
Peking University

Object Pose Estimation Using Tactile to Geometric Covariance Matching
Joao Bimbo, Kaspar Althoefer, Hongbin Liu
King's College London

A Semi-Autonomous Algorithm for Multi-Vehicle Collision Avoidance at Intersections with Multi-Conflict Points
Heejin Ahn, Domitilla Del Vecchio
MIT

Telerobotic Manipulation with Haptic Interaction Based on Real-Time Point Cloud Modeling
Bing Qiao, Zhanya Liu, Qiao Lin, Rendong Li
Nanjing University of Aeronautics and Astronautics

Illuminating Search Spaces in Robotics
Jean-Baptiste Mouret[1], Jeff Clune[2]
Université Pierre et Marie Curie[1], University of Wyoming[2]

Microgripper with Sensorized End-Effectors for Microassembly
Bilal Komati, Cédric Clévy, Philippe Lutz
University of Franche-Comté

First Experimental Investigations on Wheel-Walking for Improving Triple-Bogie Rover Locomotion Performances
Martin Azkarate
ESA/ESTEC

Intelligent Trial and Error for Damage Recovery with a Hexapod Robot and Single-Unit Pattern Generators
Danesh Tarapore[1], Antoine Cully[2], Jean-Baptiste Mouret[2]
University of York[1], Université Pierre et Marie Curie[2]

Discriminative Map Matching Using View Dependent Map Descriptor
Enfu Liu, Kanji Tanaka
Univ. of Fukui

Vehicle Speed Control by a Robotic Driver Using a Controller Considering Parametric Variations of a Driver Model
Naoto Mizutani[1], Hirokazu Matsui[1], Ken'ichi Yano[1], Toshimichi Takahashi[2]
Mie University[1], Meidensha Corp.[2]

Design Patterns for Swarms of Robot Foragers
Lenka Pitonakova, Richard Crowder, Seth Bullock
Univ. of Southampton

Toward a Robot System Supporting Communication between People with Dementia and Their Relatives
Yoshinori Kuno, Satoru Goto, Yoshimi Matsuda, Toshiki Kikugawa, Antony Lam, Yoshinori Kobayashi
Saitama University

Robotic Auditory Attention Based on Distance from Sound Sources
Quang Nguyen, Jongsuk Choi
Korea Institute of Science and Technology

Two-Dimensional Input Shaping Control for Improved Tracking of a SCARA Robot with a Spherical Pendulum
Chul-Goo Kang, Manh-Tuan Ha, Dong-Chan Lee
Konkuk University

See What I Mean? Probabilistic Optimization of Robot Pointing Gestures
Khurram Gulzar, Ville Kyrki
Aalto University

Late Breaking Report on the 2015 RoboCup Standard Platform League Drop-In Player Competition
Katie Genter[1], Tim Laue[2], Peter Stone[1]
The University of Texas[1], University of Bremen[2]

Dynamic Estimator Module for Multi-link System
Yichao Mao, Qiuguo Zhu, Rong Xiong
Zhejiang University

A Self-Assembly Strategy for Swarm Robots
Niken Syafitri, Richard Crowder, Paul H. Chappell, Jared Daniel Mazlan
University of Southampton

The Coordination of Movement for Two-Legged Robots Based on Energy Optimization
Qiuguo Zhu, Xuechao Jia, Rong Xiong, Jun Wu
Zhejiang University

A Novel Plant-Inspired Osmotic Actuator for Robotics Applications
Alfredo Argiolas[1], Gian Luigi Puleo[2], Edoardo Sinibaldi[2], Barbara Mazzolai[2]
Scuola Superiore Sant'Anna[1], IIT[2]

Waypoint Control for Servicing WSNs with UVs
Srikanth Kandanuru Venkata Sudarshan, Aaron Becker
University of Houston

Actuation-based Semantic Analysis of Text and Handwriting
Thomas C. Henderson, Narong Boonsirisumpun, Anshul Joshi
University of Utah

Towards Situated Open-World Reference Resolution
Tom Williams[1], Stephanie Schreitter[2], Saurav Acharya[1], Matthias Scheutz[1]
Tufts University[1], Austrian Research Institute for Artifical Intelligence[2]

Vibration Modelling and Control of Micro Air Vehicle based on the FW-H Equation
Li Fu, Yanwu Zhang, Xiaohuang Hu
Beihang University

A Novel Four-Arm Space Robot for On-Orbit Servicing on Large-scale Spacecraft
Meng Chen, Ping Tang, Huaiwu Zou
Institute of Aerospace System Engineering Shanghai

Method for Exceptional Human Robot Interaction Using Crowd-Knowledge
Eunji Kim[1], Lee Namyeon[2], Park Kwangho[3], Ohbyung Kwon[1]
Kyung Hee University[1], Sungkyul University[2], Center for Advanced Information Technology[3]

Identification of the Dynamic Model of 6 RSS Parallel Robot's Actuators
Sahar Alinia, Wenfang Xie, Soung Hoa
Concordia University

Control Strategy Research on the Coordinated Manipulation for Redundant Dual-arm Robot
Huaiwu Zou, Meng Chen
Institute of Aerospace System Engineering Shanghai

A Gigantic Robotic System and Control for Maintenance of Offshore Wind Turbine
Dong Gun Lee[1], Sehoon Oh[2], Hyoung Il Son[3]
Samsung Heavy Industries[1], Daegu Gyeongbuk Institute of Science and Technology[2], Chonnam National University[3]

The Deterministic Spider: A Benchmark for Evaluating Efficiency of Swarm Search
Linh Tran, George M. Fricke, Joshua P. Hecker, Melanie Moses
University of New Mexico

Soft Linear Actuation by Helical Springs in a Plant Inspired Robotic Root
Ali Sadeghi[1], Barbara Mazzolai[1], Alessio Mondini[2]
IIT[1], Scuola Superiore Sant'Anna[2]

Vision based Guidance Line Extraction for Autonomous Weed Control Robot in Paddy Field
Keun Ha Choi, Soohyun Kim
KAIST

Centroidal Momentum Analysis for Defining a Stability Index for Human-Exoskeleton Interactive Walking: Perturbation Detection in Human Gait
Je Hyung Jung, Jan Veneman
Tecnalia

A Rover for Whale
Yuichi Tsumaki, Akihito Suzuki
Yamagata University

A Method of Trajectory Planning for Unmanned Ground Vehicle Based on Ant Colony Algorithm
Yan Li, Jianhua Shan, Hao Xu, Xiangrong Xu
Anhui University of Technology

Robotic Implementation of Motor-Sensory Closed-Loop Perception (CLP)
Eldad Assa, Ehud Ahissar
Weizmann Institute of Science

Real-Time Simultaneous Arm and Base Planning with PDRM
Marianne Bakken, Øystein Hov Holhjem, Asbjørn Berge, Henrik Schumann-Olsen
SINTEF

Direct Matching for Improving Image-based Registration
Fernando Israel Ireta Munoz[1], Andrew I. Comport[2]
Universite de Nice Sophia Antipolis[1], CNRS-I3S/UNS[2]

SEMBIO: An Energy Efficient Underwater Swarm Robot for Environmental Monitoring
Ammar Amory, Erik Maehle
University Lübeck

Robotic Manipulation for Bi-Manual Folding Assembly
Diogo Almeida, Yiannis Karayiannidis
Royal Institute of Technology, KTH

Combining Global and Local Path Planner Using Theta* and the Expanded Guide Circle (EGC) Algorithm
Young Bo Shim, Gon-Woo Kim
Chungbuk National University

Soft Robotic Gripper with Tunable Effective Length
Wen Li, Tianmiao Wang, Ziyu Ren
Beihang University

A Smart Biomimetic and Self Tuning Lower Limb Prosthesis to Improve Rehabilitation
M. Awad[1], A. Abouhossein[1], C. Crisp[1], A. Dehghani-Sanij[1], R. Richardson[1], D. Moser[2], S. Zahedi[2]
University of Leeds[1], Chas A Blatchford & Sons Ltd[2]

How to Control a Swarm's Shape (When Every Robot Receives Exactly the Same Control Inputs)
Shiva Shahrokhi, Aaron Becker
University of Houston

Impact of a Viscoelastic Parameters of a Prosthetic Ankle on the Knee Power over Level Ground Walking
A. Abouhossein, et.al.
University of Leeds, Chas A Blatchford & Sons Ltd

Real-Time Gait Event Detection using a Miniature Gyroscope to Improve Rehabilitation for Artificial Lower Limb Users
H.F. Maqbool, M.A. Husman, M. Awad, A. Abouhossein, A. Dehghani-Sanij
University of Leeds

Hierarchical Coverage Ratio for Cooperative Sensing by Multiple UAVs
Junji Takahashi, Yoshito Tobe
Aoyama Gakuin University

Simulation of Human Industrial Robot Collaboration — Optimisation of Handover Position
Fredrik Ore[1], Bhanoday Reddy Vemula[1], Lars Hanson[2], Magnus Wiktorsson[1]
Mälardalen University[1], Skövde University[2]

Online Ensemble Learning of Sensorimotor Contingencies
Martina Zambelli, Yiannis Demiris
Imperial College London

Crowdsourcing of Virtual Human-Robot Interaction for Robot Learning of Collaborative Action and Communication Behaviors
Jeffrey Too Chuan Tan[1], Yoshinobu Hagiwara[2], Tetsunari Inamura[2]
University of Tokyo[1], National Institute of Informatics[2]

Series Elastic Haptic Paddle for Hands-On Education
Mert Capanoglu, Ata Otaran, Ogun Onur Kibar, Ozan Tokatli, Volkan Patoglu
Sabanci University

Natural Configuration Estimation of Elastic Wire with Consideration of Mass
Hwan Taek Ryu, Byung-Ju Yi, Youngjin Choi
Hanyang University

Convolution-based Trajectory Generation under Discontinuously Assigned Target Angles
Geon Lee, Youngjin Choi
Hanyang University

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John Walker, Nathan Britton, Kazuya Yoshida
Tohoku University

A Drastic Pose Change and Perching Algorithm for the Wall Climbing Drone
Hyun Myung
KAIST

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Sajjad Manzoor, Youngjin Choi
Hanyang University

Multiple-Place Foraging Algorithm: A Distributed Foraging Model for Evolutionary Swarm Robotics
Qi Lu, Joshua P. Hecker, Melanie Moses, Tatiana Flanagan
University of New Mexico

A Robust Camera Pose Estimation Method for an Inaccurate 3D Map
Hyungjin Kim, Hyun Myung
KAIST

A High-Level State Estimation and Verification Scheme for Dual Armed Humanoids performing Assembly Tasks
Juan Luis Rojas[1], Wen Wei Kuang[1], Kensuke Harada[2]
Sun Yat Sen University[1], National Inst. of AIST Japan[2]

A Deep Learning-based Jellyfish Distribution Monitoring System using an Unmanned Aerial Vehicle
Jungmo Koo, Hanguen Kim, Donghoon Kim, Sungwook Jung, Hyun Myung
KAIST

Google Map Referenced UAV Navigation via Simultaneous Feature Detection and Description
Mo Shan[1], Ajay Charan[2]
Temasek Laboratories @ NUS[1], Indian Institute of Technology Jodhpur[2]

Robust Leg Detection and Tracking based on Low-Cost RGB-D Sensor
Hoang Minh Do, Jongsuk Choi
Korea Inst. of Science and Technology

Self-Adaptive Index Finger Mechanism for Partial Prosthesis
Dukchan Yoon, Youngjin Choi
Hanyang University

Observation Planning for 3D Indoor Mapping and Planning Cost versus Plan Quality Trade-off
Yuki Okada, Jun Miura
Toyohashi University of Technology

Design of a New 3-DOF Foldable Mechanism without Parasitic Motion
Long Kang, Byung-Ju Yi
Hanyang University

A Dense Visual-Inertial Fusion Approach for Tracking of Aggressive Motions
Yonggen Ling, Shaojie Shen
Hong Kong University of Science and Technology

Lower Extremity Tactile Apparent Movement Perception during Standing and Walking
Daniel Kuan Yu Chen[1], Junkai Xu[2], Peter B. Shull[2], Iain Anderson[1], Thor F. Besier[1]
Auckland Bioengineering Institute[1], Shanghai Jiao Tong University[2]

Robust and Real-Time Arrow Traffic Lights Recognition in Complex Urban Environments for High Resolution Camera
Xiangron Xu
Anhui University of Technology

Influence of Musculoskeletal Model on Impulses Experienced at Joints, Case Study: Sawing Task
Abid Imran, Byung-Ju Yi
Hanyang University

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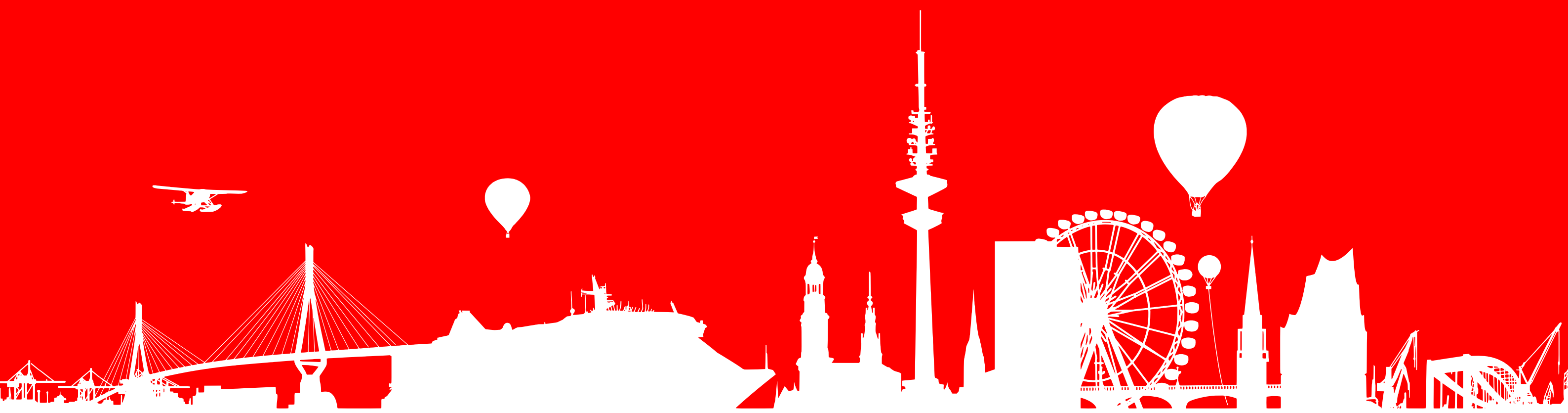

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IROS 2016

IEEE/RSJ International Conference on Intelligent Robots and Systems

October 9~14, 2016 Daejeon Convention Center, Daejeon, Korea

www.iros2016.org

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Call for Papers

The 2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2016) will be held in Daejeon, Korea, during October 9-14, 2016. The venue for IROS 2016 is the Daejeon Convention Center (DCC).

Daejeon is the leading city of science and technology in Korea, adjacent to the Daedeok Innopolis, a large research complex where 20,000 engineering graduates are working for over 250 research institutes, universities, and technology companies such as Electronics and Telecommunications Research Institute (ETRI), Korea Institute of Machinery & Materials (KIMM), Korea Aerospace Research Institute (KARI), Korea Atomic Energy Research Institute (KAERI), Korea Advanced Institute of Science and Technology (KAIST), and Silicon Works Co.

Daejeon has many cultural attractions such as the Daejeon Culture and Arts Center, the Municipal Museum of Arts, and Baekjae Cultural Zone. Various attractions and activities such as making Korean pottery, ginseng cultivation, and temple stay programs are accessible from Daejeon.

Theme: Road to companionship with intelligent robots in everyday life and workspaces

Innovative research results on topics related (but not limited) to the following are invited: robot design, robot kinematics/dynamics/control, system integration, AI in robotics, sensor/actuator networks, distributed and cloud robotics, bio-inspired systems, service robots, robotics in automation, biomedical applications, autonomous vehicles (land, sea, and air), robot perception, manipulation with multifinger hands, micro/nano systems, sensor information, multimodal interface and human robot interaction, and robot vision.

Call for Contributions

Prospective authors are invited to submit high-quality papers representing original results in all areas of robotics. Best Conference Papers and Best Student Papers will be awarded. Detailed instructions for submissions are available on the conference website. The accepted papers will be presented in oral sessions, interactive sessions, video sessions, and interactive demo sessions.

Tutorials, Workshops, Exhibitions & Competitions

As with previous IROS conferences, the organizers intend to arrange an extensive program of forums, competitions, workshops and tutorials. IROS2016 willingly accept proposals for special sessions such as industry/government forum, venture idea competition, robot technology competitions. Tutorials and workshops that address topics related to the conference scope are welcome. IROS2016 invites all robot related industrial partners to exhibit their products. Several robot competitions will be held in parallel to the technical program.

Important Dates

Special sessions/forum proposals due	January 18, 2016
Notification of acceptance for special sessions/forums	February 1, 2016
Deadline of full-length papers/videos submission	March 1, 2016
Workshop/tutorial proposals due	March 7, 2016
Notification of acceptance for workshops/tutorials	April 15, 2016
Notification of acceptance for papers/videos	July 1, 2016
Deadline of final papers/videos submission	August 1, 2016