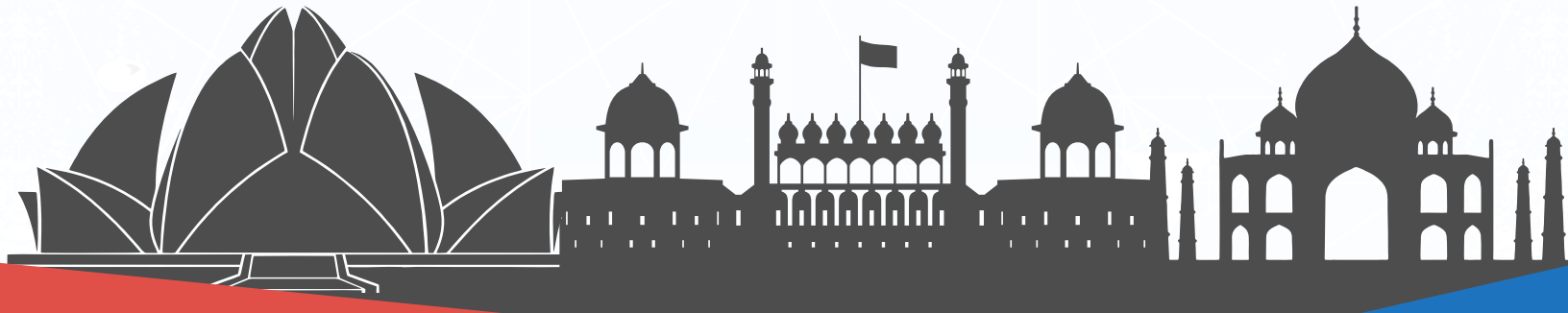
IEEE
RO-MAN
2019

The 28th IEEE International Conference on Robot & Human Interactive Communication

October 14-17, 2019
Le Meridien, Windsor Place, New Delhi, India

"Responsible Robotics and AI for the Real World"

THE CONFERENCE PROGRAM BOOK



www.ro-man2019.org

Program Book

28th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN2019)

October 14 – 18, 2019
New Delhi, India

Conference theme:
Responsible Robotics and AI for the Real World

TABLE OF CONTENT

MESSAGE FROM THE GENERAL CHAIRS..... 3
MESSAGE FROM THE LOCAL ORGANIZING COMMITTEE CHAIRS 5
ORGANIZING COMMITTEE 6
GENERAL INFORMATION 8
LOCATION AND VENUE 9
HOTEL CONFERENCE CENTER MAP AND FLOOR PLAN 10
PLENARY TALKS..... 11
SOCIAL EVENTS 13
EXHIBITION AND COMPETITIONS..... 16
WORKSHOPS AND TUTORIALS..... 20
SPECIAL SESSIONS 26
TECHNICAL PROGRAM..... 28
AUTHOR INDEX..... 71
KEYWORD INDEX 79
REVIEWERS LIST..... 81
SPONSORS..... 83

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Message from the General and Program Chairs

On behalf of the Organizing Committee, we welcome you to the new era of the International Conference on Robot and Human Interactive Communication. IEEE RAS/RSJ/KROS Ro-Man 2019 is being held for the first time in the Indian subcontinent. This conference is a leading forum where the state-of-the-art innovative results, the latest developments as well as future perspectives relating to robot and human interactive communication are presented and discussed.

The idea behind bringing the conference to India is manifold. We wish to make Ro-Man, which has a very rich history, as a venue for multidisciplinary research in the fast "Robotically-Developing" regions like Indian subcontinent, and to bridge the different communities and create mutually fruitful R&D collaboration platforms across continents. We believe that together we will be able to create more impactful technology, which will benefit the society and the world at large. Further, given the rise of robots and AI, and their application to various social circumstances, it is incumbent on us to make the technology responsible. This underlines our vision behind the theme of the conference: "Responsible Robotics and AI for the Real World". For the first time in the history of the conference, and perhaps in the robotics community Ro-Man belongs to, we have received an overwhelming number of high quality papers from the Indian subcontinent indicating the growing interest in the region. At the same time, we are having a global reach with contributions from more than 30 countries. We also have the ambition of making Ro-Man more inclusive and connected to the industry and end users. We are grateful to see bigger industrial participation through sponsorships, exhibitions and registrations. We are proud to join hands with one of the largest NGOs in India underlining our increasing commitment to social impact aspect of the conference. All these not only demonstrate the interest of the international community and the stakeholders, but also ensures the continued visibility, wider outreach, and the impact that the conference is going to make. Certainly, the objectives behind bringing Ro-Man to India have been achieved, thanks to you all.

The four days conference program includes invited talks, keynote talks, oral and poster presentations, workshops, panel discussions, exhibitions, demonstrations, and competitions. On the social event side, we start with a welcome reception, followed by a cultural event, gala dinner, award ceremony, local tours, and optional post and pre-conference tours in the nearby cities.

We received a total of overwhelming 295 submissions, 237 as regular papers, 41 as special session papers and 17 as Late Breaking Reports. The review was completed by the program committee by taking help from about 90 Associate Editors and about 600 reviewers worldwide. Each paper was reviewed by at least two reviewers and a large number of the papers had at least 3 reviewers. Each rejection decision was scrutinized carefully by the program committee to ensure fairness and positivity in the review process and in few ambiguous cases, additional reviews were sought to arrive at a conclusive decision. The complete program is divided into 25 oral sessions (20 - regular and 5 - special) in five parallel tracks and one interactive poster sessions. Selected papers will be invited for extended versions for submission to a Special Issue at the Advanced Robotics journal.

The combined effort of the international community and the local organizing committee is the backbone of any conference, and Ro-Man 2019 would not have taken this shape without such a synergy.

We expect this year’s Ro-Man to serve as the greater facilitator of the much-needed cross-disciplinary collaboration, as well as for creation of bigger ecosystems by bridging academics, industry, end users, policy makers, and the media, thereby ensuring meaningful societal impact. We are happy to see the overwhelming number of queries and responses for scientific and technological collaboration with Ro-Man community towards social causes. We also do our part in saving the environment and reducing the carbon footprint by taking a number of steps. This includes making use of biodegradable materials for conference kits, creating a shorter version of program booklet to print, and implementing the policy of reducing plastic, paper and food waste.

We would like to thank all the sponsors and partners of the conference, and IEEE RAS, RSJ, and KROS for being the financial co-sponsor and facilitator of the conference.

Finally, we would like to thank all the International Program Committee Members, Reviewers, Authors, and the Delegates for your contributions and participation in Ro-Man 2019, and help in continuing the legacy of Ro-Man. Without you, none of our efforts could have been of any use.

Welcome again to the vibrant week of Ro-Man in New Delhi, India, and we hope to see you next year in Naples, Italy.

Amit Kumar Pandey
(General Chair)

Santanu Chaudhury
(General Co-Chair)

Kazuhiko Kawamura
(Honorary General Chair)

Program Committee Chairs

John-John Cabibihan

Mary Anne Williams

T. Asokan

Laxmidhar Behera

MESSAGE FROM THE LOCAL ORGANIZING COMMITTEE CHAIRS

Dear Delegates,

We welcome you all to the 28th IEEE International Conference on Robots and Human Interactive Communications (Ro-MAN) to be held at Le Meridien Hotel in New Delhi, India during October 14-18, 2019. This is the first time Ro-MAN is taking place in the Indian subcontinent providing more reasons to celebrate the occasion.

October is a festive month in India during which a number of festivals, like Durga Puja, Dipawali, Navaratri and many others will take place. The weather will be pleasant if not too cold. The sky will be clear with no fog during this period, thanks to Delhi Government's effort in reducing the pollution level in the city. The conference venue is at the heart of the India's capital providing easy access to several other landmarks, such as, India Gate, President's palace, Lotus temple, Lodhi Gardens, Delhi Haat etc. We have planned for a conference tour of the city on October 17th afternoon. Interested delegates will also have the option of availing private and personal tours to other destinations before or after the conference.

The conference events are spread over 4 days with about 25 oral sessions (20 regular and 5 special sessions), one Poster session, 12 workshops, one competition and several exhibitions and demonstrations. In addition, we will have a welcome reception and a gala dinner. Please refer to the program book and schedule for more details.

It has been a yearlong preparation to reach this stage when we will be all together under a single roof. The local organizing committee has been at the helm of affairs on ground zero ensuring smooth running of the event. We have been supported by many in this journey and this would be an appropriate place to acknowledge their contributions and express our gratitude. First of all, we would like to thank Mr. Harish Mysore, President of IEEE India chapter for providing guidance and several local IEEE registration documents required for obtaining clearances from Govt. authorities. We are also grateful to The Robotic Society of India (RSI) for endorsing our event and providing the connect within its members for wider dissemination of information. We would like to thank all of our sponsors for providing the necessary financial support for this conference. A special thanks is due to many other committee members like Dr. Amit K. Pandey, Dr. Laxmidhar Behera, Mr. Ganga Kumar, Mr. Prakash Ambwani, Mr. Karan Gandhi and Mr. Ajay Rana who have worked beyond their prescribed roles to help us out of several hurdles.

We hope that this will be an exciting and engaging event to leave a deep impression among the participants. We will look forward to meet you all in person. We wish you all a happy and pleasant journey to India and back.

Yours Sincerely,

Swagat Kumar
Subir Saha
K Madhav Krishna

(Local Organizing Committee Chairs)

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Wang, Haoping
Wang, Shuihua
Yokota, Sho
Zollo, Loredana

GENERAL INFORMATION

Weather Information:

It will be a pleasant weather with maximum temperature being 33°C and minimum being 15°C. It will remain mostly sunny with clear skies during this period. More information is available at the following website:

https://www.holiday-weather.com/new_delhi/averages/october/

Emergency Contact:

In case of any emergency, please contact any one of the following members of the local organizing committee:

- Mr. Rajesh Charanda: +91 99101 99551
- Ms. Rashda Khanam: +91 99101 99551
- Mr. Prakash Ambwani: +91 98711 0892

Travel Advisory:

- Helpline Numbers: https://indianhelpline.com/DELHI-HELPLINE-NUMBERS/
- Avail services and hospitality from well known companies and vendors. If in doubt, please take help from the reception desk.

Delhi Metro Route Map:

Delhi Metro provides cheapest, safest and fastest mode of transport within New Delhi. It is advisable to buy a Metro pass at Rs. 50 (refundable) and use it for paying money at entry and exit gates. This will avoid standing in the queue. The smart cards are available at any customer service centre inside a metro station.

- Delhi Metro Map: http://www.delhimetrorail.com/Zoom_Map.aspx
- Metro Smart Card: https://www.dmrcsmartcard.com

Cabs / Taxi Rides:

It is quite easy and hassle free to use Uber or Ola to book cabs. Install Ola or Uber app on your phone to make use of the service. More information is available at the following links:

- Uber: https://www.uber.com/global/en/cities/new-delhi/
- Ola: https://www.gb.olacabs.com

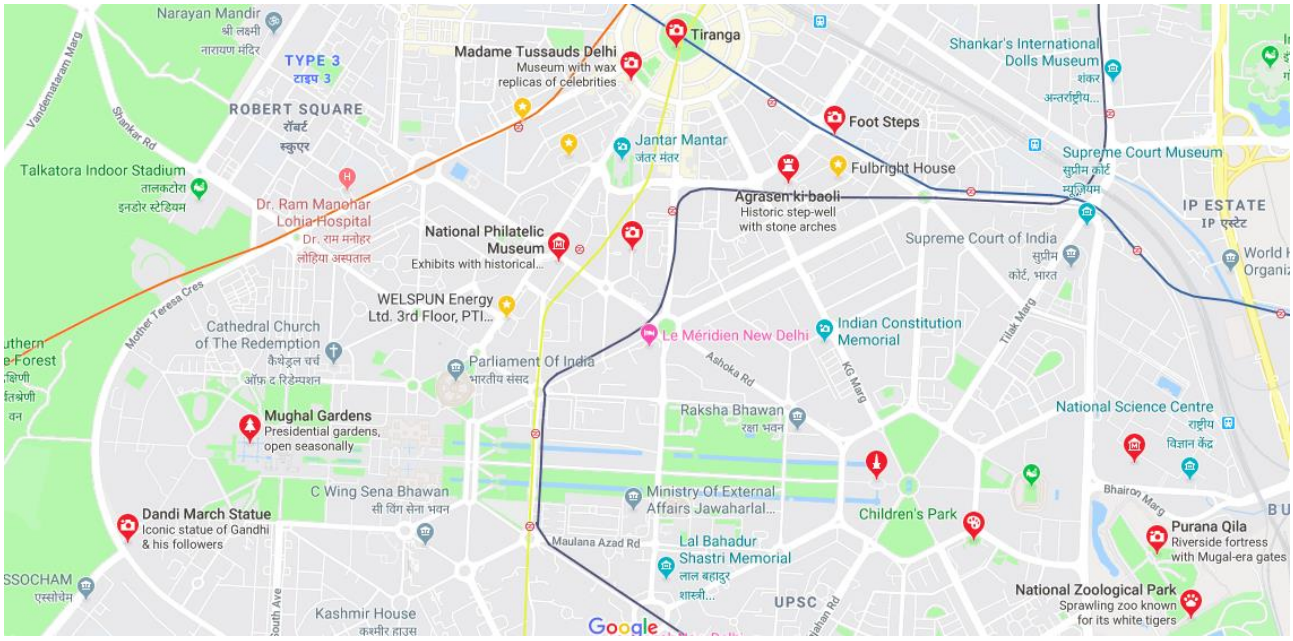
Avoid booking cabs from unknown sources. If required, take help from airport authorities.

LOCATION AND VENUE

Le Meridien, Windsor Place
(https://www.marriott.com/hotels/travel/delmd-le-meridien-new-delhi/)

New Delhi 110001, India Phone: +91 11 2371 0101

Over the last three decades, Le Meridien New Delhi has transformed itself into a masterpiece. The 5-star hotel is an epitome of world-class architecture, cuisine, design and fashion. Located in the heart of the city, the iconic glass building of Le Meridien New Delhi has been recognized as one of the 100 Icons of Delhi. The hotel is readily accessible to city's important facilities and institutions. The glass building is surrounded by ministries, government institutions, Media Centre and historical monuments. The shopping hubs Connaught Place and Janpath Market are within walking distance from the hotel. It's a perfect getaway for a business traveler who is also looking for some recreation nearby in the evening. The Le Meridien New Delhi can be summed as a Traveler's Paradise.



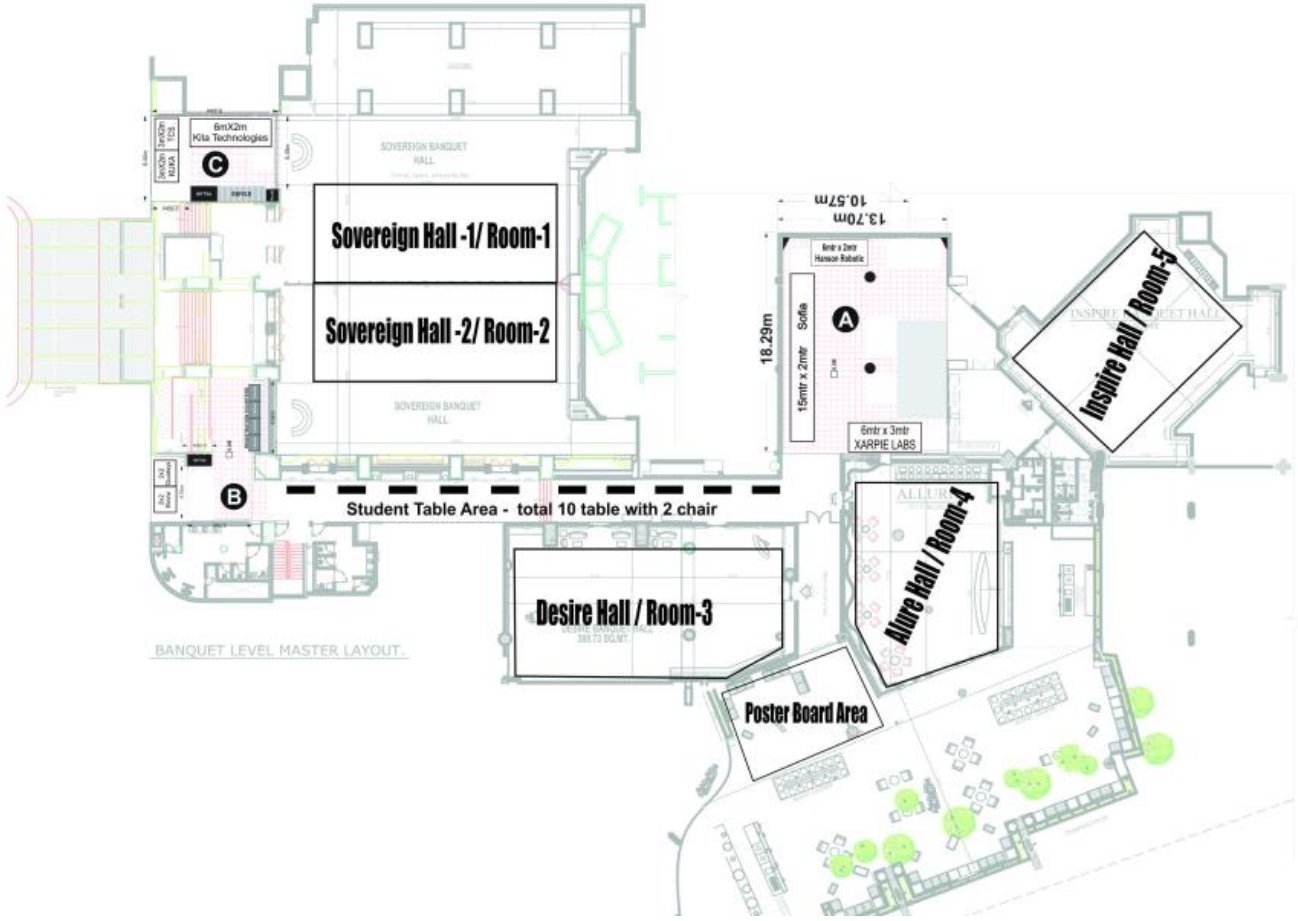
Le Meridien Hotel is located about 14 Kms from New Delhi International Airport and can be reached by Taxi or other public transport like DTC buses and Airport Metro Line. Being at the heart of the capital, there are many tourist attractions around this place. Some of them are Humayun Tomb, Lodhi Gardens, National Zoological Park, Madame Tussauds Museum, National Philatelic Museum, Purana Quila, India Gate, President's palace etc. Most of these places are easily accessible through Delhi Metro lines.

HOTEL CONFERENCE CENTER MAP AND FLOOR PLAN

Layout / Floor Maps – Le Meridien Hotel, Windsor Place, New Delhi

Key	Seminar Halls	Exhibition Venues
R1	Sovereign 1	A
R2	Sovereign 2	B
R3	Inspire	C
R4	Allure	
R5	Desire	

Ground Floor Map



PLENARY TALKS

Tuesday, October 15, 2019 **09:00-10:00**

On Human-Robot Joint Action

Dr. Rachid Alami, Laboratory for Analysis and Architecture of Systems (LAAS) - CNRS, FR

Abstract: This talk will address some key decisional issues that are necessary for a cognitive and interactive robot which shares space and tasks with humans. We adopt a constructive approach based on the identification and the effective implementation of individual and collaborative skills. The system is comprehensive since it aims at dealing with a complete set of abilities articulated so that the robot controller is effectively able to conduct in a flexible manner a human-robot collaborative problem solving and task achievement. These abilities include geometric reasoning and situation assessment based essentially on perspective-taking and affordances, management and exploitation of each agent (human and robot) knowledge in a separate cognitive model, human-aware task planning and interleaved execution of shared plans. We will also discuss the key issues linked to the pertinence and the acceptability by the human of the robot behaviour, and how this influence qualitatively the robot decisional, planning, control and communication processes.

Speaker Bio: Dr. Rachid Alami is a Senior Scientist at LAAS-CNRS. He received an engineering diploma in computer science in 1978 from ENSEEIHT, a Ph.D in Robotics in 1983 from Institut National Polytechnique and an Habilitation HDR in 1996 from Paul Sabatier University He contributed and took important responsibilities in several national, European and international research and/or collaborative projects (EUREKA: FAMOS, AMR and I-ARES projects, ESPRIT: MARTHA, PROMotion, ECLA, IST: COMETS, IST FP6 projects: COGNIRON, URUS, PHRIENDS, and FP7 projects: CHRIS, SAPHARI, ARCAS, SPENCER, H2020: MuMMER , France: ARA, VAP-RISP for planetary rovers, PROMIP, several ANR projects). His main research contributions fall in the fields of Robot Decisional and Control Architectures, Task and motion planning, multi-robot cooperation, and human-robot interaction. Rachid Alami is currently the head of the Robotics and InteractionS group at LAAS. He has been offered in 2019 the Academic Chair on Cognitive and Interactive Robotics at the Artificial and Natural Intelligence Toulouse Institute (ANITI).

Tuesday, October 15, 2019 **16:30-17:30**

Autonomous Driving: Simulation and Navigation

Prof. Dinesh Manocha, Department of Computer Science and Electrical & Computer Engineering, University of Maryland at College Park

Abstract: Autonomous driving has been an active area of research and development over the last decade. Despite considerable progress, there are many open challenges including automated driving in dense and urban scenes. In this talk, we give an overview of our recent work on simulation and navigation technologies for autonomous vehicles. We present a novel simulator, AutonoVi-Sim, that uses recent developments in physics-based simulation, robot motion planning, game engines, and behavior modeling. We describe novel methods for interactive simulation of multiple vehicles with unique steering or acceleration limits taking into account vehicle dynamics constraints. We present techniques for navigation with non-vehicle traffic participants such as cyclists and pedestrians. Our approach facilitates data analysis, allowing for capturing video from the vehicle's perspective, exporting sensor data such as relative positions of other traffic participants, camera data for a specific sensor, and detection and classification results. We highlight its performance in traffic and driving scenarios. We also present novel multi-agent simulation algorithms using reciprocal velocity obstacles that can model the behavior and trajectories of different traffic agents in dense scenarios, including cars, buses, bicycles and pedestrians. We also present novel methods for extracting trajectories from videos and use them for behavior modeling and safe navigation. These techniques are based on spectral analysis and demonstrated on urban datasets corresponding to ArgoVerse and TRAF.

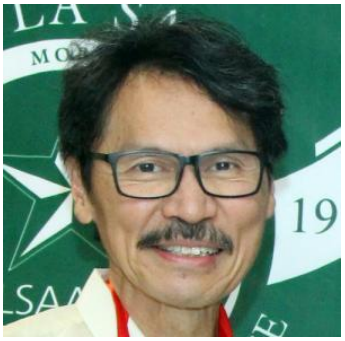
Speaker Bio: Dinesh Manocha is the Paul Chrisman Iribe Chair in Computer Science & Electrical and Computer Engineering at the University of Maryland College Park. He is also the Phi Delta Theta/Matthew Mason Distinguished Professor Emeritus of Computer Science at the University of North Carolina – Chapel Hill. He has won many awards, including Alfred P. Sloan Research Fellow, the NSF Career Award, the ONR Young Investigator Award, and the Hettleman Prize for scholarly achievement. His research interests include multi-agent simulation, virtual environments, physically-based modeling, and robotics. He has published more than 520 papers and supervised more than 36 PhD dissertations. He is an inventor of 10 patents, several of which have been licensed to industry. His work has been covered by the New York Times, NPR, Boston Globe, Washington Post, ZDNet, as well as DARPA Legacy Press Release. He is a Fellow of AAAI, AAAS, ACM, and IEEE, member of ACM SIGGRAPH Academy, and Pioneer of Solid Modeling Association. He received the Distinguished Alumni Award from IIT Delhi the Distinguished Career in Computer Science Award from Washington Academy of Sciences. He was a co-founder of Impulsonic, a developer of physics-based audio simulation technologies, which was acquired by Valve Inc in November 2016.

Wednesday, October 16, 2019 **09:00-10:00**

Intelligent Robotics for Quality Living for All

Prof. Marcelo H Ang Jr, Advanced Robotics Centre, National University of Singapore

Abstract: Robotics science and technology have evolved from the seminal applications in industrial robotics in manufacturing to today's varied applications in service, health care, education, entertainment and other industries including construction, mining and agriculture. One common theme in these emerging applications is the human-centered nature in unstructured environments, where robotic systems surround humans, aiding and working with us to enrich and enhance the quality of our lives. This talk presents our latest developments in fundamental capabilities in both "body" and "intelligence." An example of self-driving cars is presented. This talk will then conclude with the challenges in science and technology to further accelerate the robotics revolution.



Speaker Bio: He has received his BSc and MSc degrees in Mechanical Engineering from the De La Salle University in the Philippines and University of Hawaii, USA in 1981 and 1985, respectively, and his PhD in Electrical Engineering from the University of Rochester, New York in 1988 where he was an Assistant Professor of Electrical Engineering. In 1989, he joined the Department of Mechanical Engineering of the National University of Singapore where he is currently an Associate Professor and Acting Director of the Advanced Robotics Center. His research interests span the areas of robotics, mechatronics, autonomous systems, and applications of intelligent systems. He teaches robotics; creativity and innovation; applied electronics and instrumentation; computing; design and related topics. In addition to academic and research activities. He is also actively involved in the Singapore Robotic Games as its founding chairman, and the World Robot Olympiad as member of its Advisory Council.

SOCIAL AND CULTURAL EVENTS, AWARD CEREMONY

Free Local City Tour: October 17, 2019. Start time: 14:00 Hours, duration 4 hours

All registered delegates will be able to avail the free ticket for the local city tour. Tentative Landmarks to be covered: Lotus Temple, India Gate, President's Palace and Lodhi Garden. A light snack will be provided during the trip.

Number of Available seats: 200 (5 Buses, each with 40 persons' sitting capacity). The free tickets will be issued on a first-come-first-serve basis during the registration process.

Cultural Event, Gala Dinner and Award Ceremony: October 16, 2019, 19:00. Venue: Sovereign

Awards:

Ro-Man 2019 has best paper awards in different categories. The finalists and winners will be announced and awarded during the Gala Dinner.

Cultural Program: The cultural program is sponsored and hosted by Grameen Sneh Foundation. (https://www.grameensnehfoundation.org/)**.** Grameen Sneh Foundation is a registered non-governmental Organization established with a zealous endeavor of striving endlessly towards the welfare of underprivileged cancer patients, without distinction of caste or religion. Grameen Sneh Foundation, established in the year of 2009, with the mission to provide improved quality of life to every individual through sustained change in their social, physical, economical status with special emphasis on the rural people and most vulnerable section of the society like women, children and elder people.

The cultural event for the Ro-MAN 2019 conference includes the following parts:

1. Inaugural Dance on the Theme of Hausla-Fight Against Cancer, dedicated to cancer warriors ("YE HAUSLA HUM NAHI CHHORENGE.....") (Duration: 10-15 Minutes)

“Hausla” which in English translates as Courage is an annual programme organized by Grameen Sneh Foundation every year in different cities of India. As the name suggest, the event provides platform to cancer survivors for sharing their experience with other cancer patients in order to instill courage in their heart during their fight against this deadly disease – Cancer. HAUSLA' is a national move against cancer and it motivates Cancer patients and survivors and is a sustainable and informative campaign against cancer. HAUSLA supports cancer survivors emotionally, physically and mentally. Cancer patient's Mind, Body and Soul as a whole is emphasized in HAUSLA.

Till date Grameen Sneh Foundation has organized almost half a dozen such programmes under the banner “Hausla” across various cities. Many celebrities, eminent personalities, bollywood actors (Dr. Sonalman singh, Manisha Koirala, Shatrughan Sinha, Manoj Tiwari, etc.) along with famous artists, writers, senior bureaucrats, doctors amongst other participated in the event.

The programme comprises of Fashion show & Theatre Act by Cancer Survivors Awareness programme for attendants and cancer survivors including the Display of Art, Painting and other natural activities prepared by cancer survivors. The last in its series was organized in year 2018 in New Delhi where more than 1000 Cancer Survivors & Cancer patients participated and got benefited.

2. Odissi Dance (Duration: 25-30 Minutes)

Odissi dance is one of the invocatory dance form of Orissa. It has originated from the word "Udra" means Utkal. Devi shakti is one of the prominent dance feature of Indian classical dance. On this particular dance from we offer our salutation to "Aadi shakti”, a unified symbol of Divine forces. She represents the personification of universal mother and as the embodiment of power and also as symbol of peace. The proposed dance form will be choreographed by Guru Sri Chandrakant Sutar.

3. Bihar Darapan (Duration: 25-30 Minutes)

The land of Nalanda University, one of the first universities in the world, and Vaishali, one of the first examples of a republic, the state of Bihar inherits a historically influential image of India's cultural consciousness. From this land, Lord Buddha, Lord Mahavira and Guru Gobind Singh inspired for Buddhist, Jainim and Khalsa Panth. Great rulers like Samrat Ashoka, jurists like Chanakya, scholars like Banabhatta and astronomers like Aryabhata added to its rich legacy. Bihar has been the land of action for Mahatma Gandhi and the birthplace of Dr. Rajendra Prasad, the first President of Independent India. The flavors of music, food, folk songs all add to the rich cultural diversity reflected through this small ‘Bihar Darapan’.

4. Ganesh Vandana (Duration: 10-15 Minutes)

This group performance full of action and energy will provide a cultural glimpse of Ganesh festival, which is widely observed throughout India, especially in the states such as Maharashtra, Madhya Pradesh, Karnataka, Goa, Andhra Pradesh, Kerala, Telangana, Odisha, West Bengal, Gujrat and Chhattisgarh, Tamil Nadu and Indian diaspora worldwide. Lord Ganesha is considered as the dispeller of the obstacles (Vighna Harta).

EXHIBITION AND COMPETITIONS

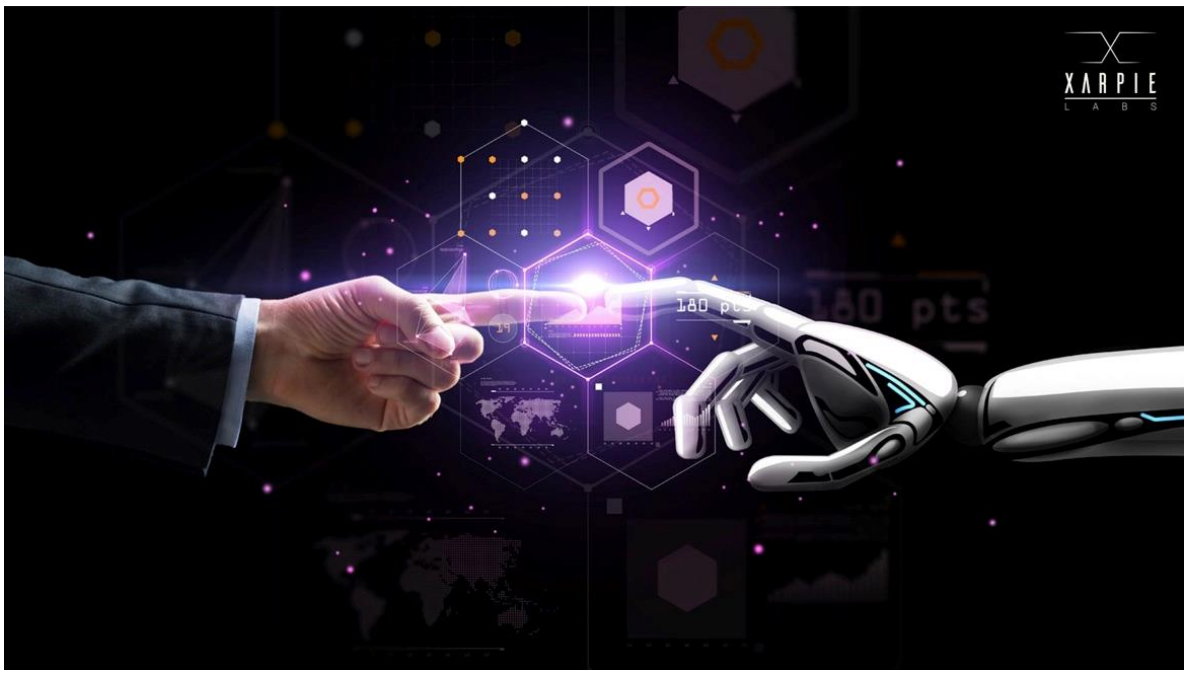
Exhibit 1: Visualization: from digital reality to humanoid intelligence

Xarpie Labs is one of India's fastest emerging digital reality companies specializing in visualization, simulation and creation of multisensory 3D experiences. Recognized by NASSCOM #natc2019 among leaders in emerging tech, Xarpie Labs has been working with technologies such as virtual reality (VR), augmented reality (AR) and immersive web experiences. It has successfully proved the validity of immersive visualizations in various industries.

Resting on the premise that Visualization is not just limited to sight, Xarpie Labs extends immersive perception to include interactive elements in its solutions. This has grown into the team's capability to build simulations especially for sectors like retail, healthcare, sport, defense, etc. Xarpie Labs has intrinsically helped businesses solve impediments through immaculate execution. Xarpie Labs' team identifies and adapts quickly to highly specific requirements, creating customized solutions unique to each business case. Xarpie Labs is already on a journey to become one of India's topmost digital reality companies.

The company's visualization and simulation capabilities have been a natural predecessor to enabling subtler, complex perception and interpretation. This is steering the company towards enlivening human and robot interactions. Xarpie Labs' future offerings will enable empowerment of humanoid robots with the ability to perceive, process, learn and communicate much like humans do.

The company will build technologies that could entail reviewing the perception that robotic intelligence might be non-contextual and 'artificial'. Value education and healthcare with the aid of humanoid robots may only be the tip of the iceberg. The possibilities of Xarpie Labs' contribution in the impending field of robotics are endless.



Xarpie Labs is proud to redefine visualization through the kaleidoscope of perception: from digital reality all the way through to humanoid intelligence. We call it "real" as opposed to "artificial".

Exhibit 2: Sophia the Robot from Hanson Robotics

Sophia the Robot, the AI humanoid robot, will be exhibited at this year's IEEE Ro-MAN conference. Sophia was developed by Hanson Robotics Limited, creator of the one of the world's most human-like expressive robots. Sophia aims to manifest a glimpse of what future robots will look like and how they will become an integral part of our society."

Sophia was created to be a research platform for Hanson Robotics' ongoing AI and robotics research work. Working with labs, universities, and companies around the world, she is an architecture and a platform for the development of real AI applications. The Sophia character is also an evolving science fiction character we use to help explore the future of AI and lifelike humanoids and to engage the public in the discussion of these issues. She has become a much sought after media personality, helping to advocate for AI research and the role of robotics and AI in people's lives. She has appeared on CBS 60 Minutes with Charlie Rose, the Tonight Show Starring Jimmy Fallon, Good Morning Britain, and has been a keynote speaker and panel member at some of the world's most prestigious conferences. She has also addressed members of the UN, ITU, and NATO.

Sophia has also received the title of Innovation Champion for the United Nations Development Programme (UNDP) to promote sustainable development with the use of technology and innovation in developing countries and named the new ambassador and future AI Tutor for iTutorGroup, the premier online education platform and largest English-language learning institution in the world. She was also named the 2018 Gold Edison AwardTM winner in Robotics.

Watch out for Sophia at the Hanson Robotics' booth in the exhibition hall. She will be available for interaction with guests, take questions from the visitors, and demonstrate some of her new features and capabilities.

Exhibit 3: IIWA Collaborative Robot from KUKA

The LBR iiwa is the world's first series-produced sensitive, and therefore HRC-compatible, robot. LBR stands for "Leichtbauroboter" (German for lightweight robot), iiwa for "intelligent industrial work assistant". This signals the beginning of a new era in industrial, sensitive robotics – and lays the foundations for innovative and sustainable production processes. For the first time, humans and robots can work together on highly sensitive tasks in close cooperation. This opens up the possibility of new applications and the way is paved for greater cost-effectiveness and utmost efficiency. The

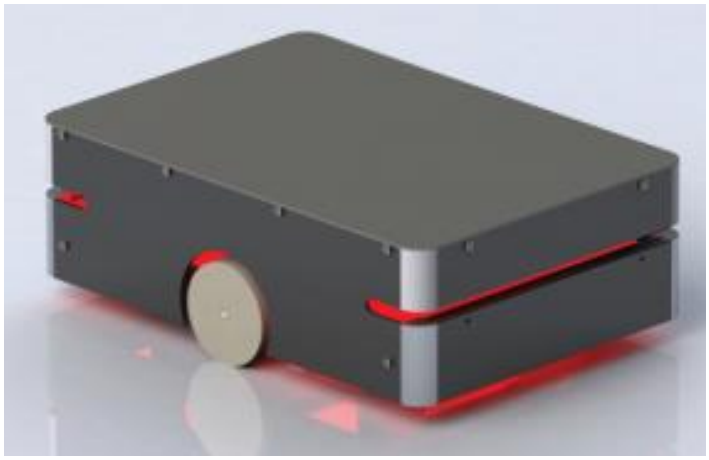
collaborative and sensitive LBR iiwa robot is available in two versions with payload capacities of 7 and 14 kilograms.

This robot will be on display as an exhibition at the Kuka booth. The capabilities of this robot, particularly collision detection, hand-guided motion, automatic mastering, null space motion, TCP force monitoring will be demonstrated during the exhibition.

Exhibit 4: Motion Capture System from Qualisys

As a leading global provider of optical motion capture technology within Life Science, Engineering and Entertainment, Qualisys has been supplying organizations with state-of-the-art camera systems and software for 30 years. Qualisys is ISO 9001:2015 certified and all clinical products comply with Medical Device Directive 93/42/EEC and have FDA clearance (K171547). These certifications are a reflection of our dedication to quality and our continued reinvestment in development, technology, and people. In this conference we are showcasing our technology, High end cameras for motion detection in above mentioned applications.

Exhibit 5: Collaborative Mobile Robot Platform from Peer Robotics



RM100, is a collaborative mobile platform that brings human-robot interaction for material handling in manufacturing and warehousing industries. Capable of carrying a payload on 100Kg, RM100 can autonomously navigate in a human populated environment using constant human detection and obstacle avoidance protocols.

Integrated with force feedback-based control, RM100 can detect external human force and activates the drive in the direction of guiding force. Using sensor fusion from multiple onboard sensors, RM100 can localize itself in any complex surrounding, reducing any human effort to provide initial position data to the robot. Equipped with additional layers of safety and natural interactive mode, RM100 is the perfect solution for a dynamic and ever-growing industries.

Competition: *Socialis Impremiere*: Robotics in the Social Context

This competition being organized in association with IIT Kanpur to encourage students to showcase their work at this premier conference. The participating teams are expected to demonstrate and show robot-based solutions to solve problems in the social context related to the following areas: ● Healthcare: Preventive or Interventional ● Waste management ● Agricultural Innovation ● Energy Production/Regulation ● Water Purification/ Distribution ● Disaster Prevention/ Evacuation ● Traffic Regulation and Management.

The shortlisted teams have been given 15 minutes to demonstrate their work both through slides presentation as well as physical demonstration.

Coordinators: Mr. Suryansh Agarwal, UG student at IIT Kanpur and Prof. Laxmidhar Behera, IIT Kanpur.

WORKSHOPS AND TUTORIALS

Workshops and tutorials will be held on Monday the 14th and on Thursday the 17th of October.

Monday, October 14, 2019

WS1: Cognitive and Interactive Robotics
WS2: Trust, Acceptance and Social Cues in Robot Interaction - SCRITA
WS5: Using HRI (Human-Robot Interaction) Technologies to Solve the Current Social Challenges in India and Asian Countries
WS6: Robot-Human Financial Transactions and Enforceable Agreements
WS8: Challenges of Human-Robot Interaction in Extreme and Hazardous Environments
WS10: Internet of intelligent robotic things for healthy living and active ageing: where we are and future trends
WS11: Robots for Learning: R4L - Building Interaction for Classroom Robots

Thursday, October 17, 2019

WS3: Blockchain Technologies for Robotic Systems
WS7: Social robots and artificial agents for developing countries: Challenges and opportunities
WS9: TransLearn: Robot Skill Transfer from Simulation to Real World Deployment in Manufacturing Industries and Warehouses
WS12: Social Human-Robot Interaction of Human-care Service Robots
WS13: Merging Artistic and Research Practices Toward More Expressive Robotic Systems

Monday, October 14, 2019 **WS5: Full-day, Room: R1**

Workshop on Using HRI (Human-Robot Interaction) Technologies to Solve the Current Social Challenges in India and Asian Countries

Workshop Website: https://www.hripreneur.io/

Abstract: The workshop of Using HRI (Human-Robot Interaction) Technologies to Solve the Current Social Challenges in India and Asia Countries provides an all-in-one forum to discuss and address the critical issues of how to transform the HRI-related lab research developments into commercializable products to solve the daily imperative demanding social problems. Particularly, we provide series of lectures from ideations, customer discoveries and HRI product development, to the business/financial modeling and raising capitals specifically for the HRI commercial products. This year, we plan to have innovation ideathon event where students, research labs, startups, companies, venture capitals and industry sectors can have a perfect networking venue to seek collaboration opportunities to solve the India and Asia local social challenges. The purpose of this workshop is aiming at fulfilling the unmet need to merge the scientific findings in Human-Robot Interaction research communities and the endusers, focus on the design & engineering journey of taking physical products to market. Particularly, We care about "social innovation," that is, solving social and environmental issues through enterprise. We believe a focus on users and customers ensures sustainable and scalable solutions. We hope through holding this workshop, pure lab researches can have smooth transitions into practical applications, and therefore have immediate impact to the human societies in the foreseeable future.

Organizers:
Ker-Jiun Wang, University of Pittsburgh, USA
Mohammad Shidujaman, Tsinghua University, China
Caroline Yan Zheng, Royal College of Art, UK
Prakash Thakur, EXGwear Inc., USA

Monday, October 14, 2019 **WS10: Half-day, Morning, Room: R2**

Workshop on Internet of intelligent robotic things for healthy living and active ageing: where we are and future trends

Workshop website: https://www.santannapisa.it/en/istituto/biorobotica/news/internet-intelligent-robotic-things-healthy-living-and-active-ageing-where

Abstract: This workshop has the purpose of bringing together researchers from different scientific communities either interested in or actively working on the application of ICT and robotics to provide services specifically designed for the elderly in order to enhance their everyday life and be provided with highquality healthcare services. We believe a multidisciplinary environment is ideal for fostering and promoting this research area because of its fundamentally interdisciplinary nature. To effectively provide useful robotic services for elderly users requires an intimate collaboration between psychologists, sociologists, computer scientists, and robotics researchers.

Organizers:
Filippo Cavallo, Scuola Superiore Sant'Anna, Italy
Laura Fiorini, Scuola Superiore Sant'Anna, Italy
Alessandro Di Nuovo, Sheffield Hallam University, UK
Yasuo Okabe, Kyoto University, Japan
N. Alberto Borghese, Università degli Studi di Milano, Italy

Monday, October 14, 2019 **WS8: Half-day, Afternoon, Room: R2**

Workshop on Challenges of Human-Robot Interaction in Extreme and Hazardous Environments

Workshop website: https://rainhub.org.uk/challenges-of-human-robot-interaction/

Abstract: The aim of this workshop is to bring together researchers working on robotics for extreme environments and researchers in Human-Robot Interaction, in order to allow both groups to share information on approaches to their common problems of how to produce autonomous interactive agents for extreme environments. In such areas, robots are required to reduce the risks associated with operations staff, typically by removing the requirement for people to enter the hazardous environments and to increase productivity in high consequence and cluttered facilities. Hence, the primary topic will be novel interaction with remotely located robotic agents that could be deployed in environments such as nuclear inspection and decommissioning, offshore energy and maintenance, space exploration, deep mining etc.

Organizers:
Ayan Ghosh, The University of Sheffield, UK
Robert Skilton, Culham Center for fusion Energy, UK
Emily Collins, The University of Liverpool, UK

Monday, October 14, 2019 **WS11: Half-day, Afternoon, Room: R3**

Workshop on Robots for Learning: R4L - Building Interaction for Classroom Robots

Workshop website: http://r4l.epfl.ch/RoMan2019/

Abstract: Since several years, several research groups have investigated the use of robots for learning and teaching. Their work is divided into two main streams that we could call the interaction stream (i-stream) and the building stream (b-stream). The I-stream develops embodied agents able to conduct rich interactions with learners. These are mainly humanoids, part of humanoïds or roboticized animals that engaged learners in activities (writing, playing, countin, …) and are able to interact about these activities. These robots namely provide verbal and non-verbal hints, encouragement and feedback on several dimensions of the task: performance, cognitive (e.g. level of (mis-)understanding), social (e.g. regulation turn taking in teams), meta-cognitive or emotional. In the b-stream, the learner's activities is to build the robots capacities. The most popular building activities consist of programming

a robot such Thymio, mostly to acquire programming skills. Many other projects in the Makers or FabLab educational initiatives explore the physical construction of the robot either by assembling components from a toolkit such as Lego Mindstorms or by using 3D printing, wiring, etc. These construction activities usually include programming is well, but generally target broader learning goals, mostly STEM skills. While the I-STREAM addresses research questions that are very close to HRI and ROMAN topics, the work on the b-stream is generally addressed in other venues, creating a divide within those who explore robots in education. This workshop proposes to bring these two streams together because many developments that exist in one stream could also benefit to the other stream. A typical example of these synergies are situations where a humannöid (i-stream) and a learner jointly manipulate a graspable robot (b-stream). This workshop aims to create many more bridges between these two streams.

Organizers:
Wafa Johal, École Polytechnique Fédérale Lausanne, Switzerland
Mohamed Chetouani, Sorbonne University, France
Pierre Dillenbourg, École Fédérale Polytechnique Lausanne, Switzerland
Tony Belpaeme, Plymouth University, UK

Monday, October 14, 2019 **WS2: Half-day, Morning, Room: R4**

Workshop on Trust, Acceptance and Social Cues in Robot Interaction - SCRITA

Workshop website: http://scrita2019.herts.ac.uk

Abstract: This Workshop will focus on users' trust in robots. We aim to explore different aspects of Human-Robot Interaction that can affect, enhance, undermine, or recovery of humans' trust in robots, such as the use of social cues, behaviour transparency (goals and actions), etc.. In particular, this session will bring together leading researchers in the field to share and discuss ideas and findings that can guide the design and development of robots that human users would accept and trust.

Organizers:
Alessandra Rossi, University of Hertfordshire, UK
Patrick Holthaus, University of Hertfordshire, UK
Sílvia Moros, University of Hertfordshire, UK
Marcus Scheunemann, University of Hertfordshire, UK
Giulia Perugia, University of Hertfordshire, UK

Monday, October 14, 2019 **WS6: Half-day, Morning, Room: R5**

Workshop on Robot-Human Financial Transactions and Enforceable Agreements

Workshop website: https://www.atr.cs.kent.edu/ro-man

Abstract: The concept of mutual agreements and contracts undergirds western civilization. In contemporary society, these agreements often encompass productive economic exchanges of value, such as the exchange of goods and services for monetary compensation. Exchanges of value, whether contractual or informal, are powerful societal tools. The purchase of goods and services can help humans achieve desired goals or tasks, and the concept of monetary compensation can shape human behavior, e.g. when used as an incentive mechanism. In its current state, HRI research considers the use of monetary compensation but fails to fully or accurately replicate such interaction due to the constraints of conventional money and the lack of tools to perform such exchanges of value between a robot and a human agent. In parallel, formal agreements between a human and a robot cannot be fully replicated nor incite realism due to the lack of agency in robots, restrictions in our legal system on the enforceability of such agreements, and the lack of technology that allows for these agreements to take place. Blockchain technology - smart contracts and cryptocurrencies, along with the study of cryptoeconomics serve as the enabling constructs of the latter. This novel workshop presents attendees with the (1) tools to faithfully allow financial transactions to take place between robots and humans without third-party mediation, (2) a framework to

interpret simple natural language agreements as digital, automatable, self-enforceable agreements - smart contracts, and (3) novel human-robot interaction models that can be unlocked by these tools.

Organizers:
Irvin Steve Cardenas, Kent State University, USA
Jong-Hoon Kim, Kent State University, USA

Monday, October 14, 2019 **WS1: Half-day, Afternoon Room: R5**

Workshop on Cognitive and Interactive Robotics

Workshop website: https://robotics.iiit.ac.in/roman-workshop/

Abstract: Research in cognitive robotics is concerned with endowing robots with higher level cognitive functions that enable them to reason, act and have conceptual understanding of the world like humans. For example, such robots must be able to reason about goals, actions, when to perceive and what to look for while they autonomously explore their environment and determine which are the important features that need to be considered for making a decision. They should also understand the cognitive states of other agents required for collaborative task execution, do dialogue exchange with other agents if they do not understand instructions and can enhance itself quickly by learning new behaviour automatically from the observations of a dynamic environment. In short, cognitive robotics is concerned with integrating AI, perception, reasoning, human-robot interactions, continual learning, and action with a theoretical and implementation framework. Such frameworks will have a big role to play in Service Robotics, Enterprise Robotics and Industry 4.0 which aims to revolutionalize current industrial automation through the use of technologies such as Cloud Computing, IOT, additive manufacturing, robotics and Artificial Intelligence.

Organizers:
Mohan Sridharan, Univ of Birmingham, UK
Arun Kumar Singh, Univ of Tartu, Estonia
Ilana Nisky, Ben Gurion
Rachid Alami, LAAS-CNRS, France
K Madhava Krishna, IIIT Hyderabad, India
Balaraman Ravindran, IIT Madras, India
Brojeshwar Bhowmick, TCS Research
Swagat Kumar, TCS Research
Rajesh Sinha, TCS Research
Balamuralidhar P, TCS Research
Arpan Pal, TCS Research

Thursday, October 17, 2019 **WS12: Half-day, Morning, Room: R1**

5th Workshop on Social Human-Robot Interaction of Human-care Service Robots

Workshop website: https://cares.blogs.auckland.ac.nz/education/activities-on-international-conferences-and-journals/ro-man-2019-workshop/

Abstract: Service robots with social intelligence are starting to be integrated into our everyday lives. The robots are intended to help improve aspects of quality of life as well as improve efficiency. We are organizing an exciting workshop at RO-MAN 2019 that is oriented towards sharing the ideas amongst participants with diverse backgrounds ranging from Human-Robot Interaction design, social intelligence, decision making, social psychology and aspects and robotic social skills. The purpose of this workshop is to explore how social robots can interact with humans socially and facilitate the integration of social robots into our daily lives. This workshop focuses on three social aspects of human-robot interaction: (1) technical implementation of social robots and products, (2) form,

function and behavior, and (3) human behavior and expectations as a means to understand the social aspects of interacting with these robots and products.

Organizers:
Ho Seok Ahn, The University of Auckland, New Zealand
JongSuk Choi, Korea Institute of Science and Technology (KIST), Republic of Korea
Hyungpil Moon, Sungkyunkwan University, Republic of Korea
Minsu Jang, Electronics and Telecommunications Research Institute (ETRI), Republic of Korea
Sonya S. Kwak, Korea Institute of Science and Technology (KIST), Republic of Korea
Yoonseob Lim, Korea Institute of Science and Technology (KIST), Republic of Korea

Thursday, October 17, 2019 **WS9: Half-day, Morning, Room: R2**

Workshop on TransLearn: Robot Skill Transfer from Simulation to Real World Deployment in Manufacturing Industries and Warehouses

Workshop website: https://translearn.github.io/

Abstract: Industry 4.0 will be driven by two main technologies: AI and Robotics. The combination of both allows robots to learn skills and tasks without explicitly programming them. Data-driven robot learning algorithms offer an untapped potential for significantly reducing robot programming cost, optimizing robot movements and enabling new robot application. Current learning algorithms, however, require a lot of data to learn complex industrial tasks. The generation of this data by real robots is cost-intensive and time-consuming. Simulations are attractive environments for training robots as they provide an abundant source of cheap, scalable and safe data. On the other hand, behaviors developed by agents in simulation are often specific to the characteristics of the simulator, and physics simulators do not reflect the physical world sufficiently well. Due to modelling errors, strategies that are successful in simulation may not transfer to their real world counterparts (“reality gap”).

Organizers:
Daniel Braun, KUKA
Manuel Kaspar, KUKA
Pascal Meißner, Karlsruhe Institute of Technology
Jonas Kiemel, Karlsruhe Institute of Technology
Swagat Kumar, TATA Consultancy Services
Rajesh Sinha, TATA Consultancy Services
Laxmidhar Behera, IIT Kanpur, India

Thursday, October 17, 2019 **WS7: Half-day, Morning, Room: R3**

Workshop on Social robots and artificial agents for developing countries: Challenges and opportunities

Workshop website: https://robotics4good.github.io/socialrobots4development/

Abstract: This inaugural workshop “Social robots and artificial agents for developing countries: Challenges and opportunities” will focus on the application of social robots and artificial agents to serve populations in developing countries. While social robots are making way into our lives these are primarily focused to serve populations in developed countries. There is a lack of human-robot interaction research in developing countries which is nearly half of the population on the planet. Social robots potentially can make a huge impact in the developing world where they are a distinct novelty and our understanding about how robots are perceived by these subjects is very limited. The focus of this workshop is on the following areas but not limited to: rural/urban development, education, health, gender issues, agriculture, environmental sustainability, social welfare, and sustainable development. We believe that these fields are those where social robots and artificial agents can have an impact on society in the developing world.

Organizers:

Amol Deshmukh, University of Glasgow, UK
Laxmidhar Behera, Indian Institute of Technology Kanpur, India
Akshay Nagarajan, Amrita University, Kerala, India
Amit Kumar Pandey, Hanson Robotics, Hong Kong

Thursday, October 17, 2019 **WS3: Half-day, Morning, Room: R4**

Workshop on Blockchain Technologies for Robotic Systems

Workshop website: https://researchers.pagesperso-orange.fr/bct4ros2019/

Abstract: This workshop seeks to move beyond the classical view of robotic systems to advance our understanding about the possibilities and limitations of combining robots with blockchain technology. Insights about the following questions are especially important: What blockchain tools are available to increase the reliability and transparency of robotic systems? What kind of algorithms are suitable to combine both technologies? Are there new models and methods to connect robots to blockchain-based technology such as "smart contracts"? Are distributed networks such as Bitcoin a feasible way to integrate robotic systems in our society? Are there new business models for robot ventures based on cryptographic algorithms?

Organizers:
Önder Gürcan, CEA LIST, France
Fabio Bonsignorio, Heron Robots, Italy

Thursday, October 17, 2019 **WS13: Half-day, Morning, Room: R5**

Workshop on Merging Artistic and Research Practices Toward More Expressive Robotic Systems

Workshop website: https://radlab.mechse.illinois.edu/roman-2019-workshop/

Abstract: As we work to bring robots out of the factory and into humans' everyday life, it is important to begin designing the contextual embedding and subsequent expression of these systems with greater care. Researchers and artists hold two critical components to helping design machines that make sense to lived human experience, which is situated in context and culture. However, for these communities to effectively collaborate, some transfer of concepts and approach must occur. In this full day workshop, participants will explore movement from an embodied perspective, see selected performances that leverage robotic systems in their expression, and work collaboratively through a series of facilitated exercises to develop new research collaborations embedded in artistic practice. Participants will learn about frameworks, pragmatics, and challenges in this space from a team of roboticist-dancers who collaborated as the director of a robotics lab and that lab's artist in residence in 2017-2018. The goal of this session will be to attune participants to the philosophy of movement artists and provide key takeaways that may be of use in robotics research. Selected performers will present their work to kick off the day and inspire fruitful interaction. In the second half of the day, participants will be paired up and given roles that correspond to "artistic lead" and "research lead". These teams will work to develop a new concept for leveraging robots to present artistic ideas and using artistic practice inside robotics research. The workshop will conclude with breakout sessions for targeted discussions about the benefits and challenges of working in this way and for brainstorming sessions that will hopefully further nurture new collaborations.

Organizers:
Amy LaViers, University of Illinois at Urbana-Champaign, USA
Catie Cuan, Stanford University, USA

SPECIAL SESSIONS

SS1: Transparency and Trust in Human-Robot Interaction
SS2: Social and Affective Robots
SS3: Social Human-Robot Interaction of Service Robots
SS4: Robotics for Rehabilitation
SS5: Medical Robotics and Intelligent Control Systems in the Indian Context

Tuesday, October 15, 2019 **TuAS1 – Room T5 - 10:30-12:00**

SS1: Transparency and Trust in Human-Robot Interaction

Topic: This Session will focus on the impact of robot transparency on human users trust of robot in health-care environments. We aim to explore difference aspects of Human-Robot Interaction that can affect, enhance, undermine and recovery of humans' trust in robots, such as behaviour transparency (goals and actions). In particular, this session will bring together leading researchers in the fields to share and discuss ideas and findings to guide the design and development of robots that human users would accept and trust.

Organizers:
Alessandra Rossi (UK)
Silvia Rossi (Italy)
Alan Wagner (USA)
Chung Hyuk Park (USA)

Tuesday, October 15, 2019 **TuBS1 – Room T5 - 13:00-14:30**

SS2: Social and Affective Robots

Topic: Robots are expected to act as mediators to elicit more active communication and provide life support for humans. Robots have found a number of applications in many aspects of our daily life, including elderly care, therapeutic and educational purposes (e.g. therapy for children with autism), entertainment, wellbeing and so on. The critical role of robots here is to interact with and assist humans in their every-day activities. Towards achieving naturalistic interaction, it is necessary to endow the robots with "social intelligence" and, in particular, the ability to be able to respond appropriately to human affect. This, in turn, would allow them to simulate the human-human interaction and communication by being more engaging and sensitive to our affective states. Considering a wide variety of users, the robots should be also capable of deciding what kind of services and interactions they perform. The accurate and autonomous evaluation is needed through the technology (with a minimum supervision of humans), especially if the users are children or people with special needs. For this user-centred human-robot interaction, it is required that the social robots can learn the user's emotional states and be able to respond to it accordingly. Advances in the affective computing field have recently allowed us to measure humans' affective states such as emotions, empathy and engagement from different modalities. These include audio (verbal and non-verbal vocalizations), visual (body posture and facial expressions) and physiological (heart rate and electrodermal activity) signals. While advanced modelling techniques based on computer vision and machine learning have been proposed so far to analyse human behaviour using these modalities, a little attention has been paid to analysis of affect from naturalistic behaviours as expressed in human-robot interactions (HRI). The main aim of Affective Robot Special Session is to bring together researchers working in Robotics and Artificial Intelligence, and exploit jointly the most recent advances in these two fields. This special session is oriented towards sharing the ideas of participants with diverse background ranging from robotics, machine learning, computer vision and social psychology. The goal is to facilitate the integration of social robotics and affective computing as an emerging field. In particular, the goal of the special session is to identify new concepts and challenges (methodologies, ethical questions) in designing and learning of robots that are affect-sensitive.

Organizers:
Jaeryoung Lee (Japan)
Ognjen Rudovic (USA)

Rosalind W. Picard (USA)

Tuesday, October 15, 2019 TuCS1 – Room T5 – 15:00-16:30

SS3: Social Human-Robot Interaction of Service Robots

Topic: The purpose of this special session is to explore how social robots can interact with humans socially and facilitate the integration of service robots. This special session focuses on three social aspects of human-robot interaction: (1) technical implementation of social robots and products, (2) form, function and behavior, and (3) human behavior and expectations as a means to understand the social aspects of interacting with these robots and products. This is the follow-up event of the special session with the same title at RO-MAN 2018, which will continue to pursue deeper understanding on social human-robot interaction.

Organizers:
Minsu Jang (Korea)
Ho Seok Ahn (New Zealand)
Jongsuk Choi (Korea)

Wednesday, October 16, 2019 WeAT5 – Room T5 - 10:30-12:00

SS4: Robotics for Rehabilitation

Topic: In an increasingly connected world, robotics and automation have assumed a leading role in different facets of our society, and there is a need for productive collaboration and interaction between robots and humans. The main focus of this special session on robotics for rehabilitation is on the robot's science and systems aspects that are needed to interact, assist and cooperate with humans. The aim of this special session is to understand this topic from multiple perspectives: (i) physical and social interaction with humans; (ii) robot adaptation to a patient's performance during rehabilitation; (iii) human-robot interaction safety; iv) control strategies that enhance human-robot synergies; and v) assessment standards and tools for rehabilitation robotics. The special call is intended for researchers from areas spanning robotics, biomechanics, human-robot interaction, assistive and rehabilitation robotics, robotic systems design, field robotics, wearable robotics, biomedical and clinical domains. This special session will foster multidisciplinary discussion and consolidation of perspectives, methodologies and assessment tools to align and benefit research efforts in robotics for rehabilitation.

Organizers:
Vineet Vashista (India)
Neelesh Kumar (India)
Chemori Ahmed (France)

Wednesday, October 16, 2019 WeCT5 – Room T5 - 15:30-17:00

SS5: Medical Robotics and Intelligent Control Systems in the Indian Context

Topic: To provide practical information through theoretical innovations designed to help robotic engineers and researchers integrate emerging technologies for the development of health care. Thus this session will provide a forum for the exchange of ideas in support of practice quality improvement through the field of medical robotics and intelligent control systems.

Organizers:
M. Felix Orlando (India)
Yogesh Vijay Hote (India)
Pyari Mohan Pradhan (india)

TECHNICAL PROGRAM

RO-MAN 2019 Technical Program Tuesday October 15, 2019

Track 1	Track 2	Track 3	Track 4	Track 5
08:30-09:00 TuOR. Room R1 & R2 Inauguration				
09:00-10:00 TuI_PL Room R1 & R2 Plenary Talk I: On Human-Robot Joint Action by Dr. Rachid Alami, Laboratory for Analysis and Architecture of Systems (LAAS) - CNRS, France				
10:00-10:30 TuAM_TBr. Tea Break I				
10:30-12:00 TuAT1 Room R1 Cognitive Interaction Design	10:30-12:00 TuAT2 Room R2 Human Robot Interaction	10:30-12:00 TuAT3 Room R3 Social Robots I	10:30-12:00 TuAT4 Room R4 Tele-Operation and Autonomous Robots	10:30-12:00 TuAS1 Room R5 Transparency and Trust in Human Robot Interaction
12:00-13:00 TuL_Br Lunch Break I				
13:00-14:30 TuBT1 Room R1 Robots in Education	13:00-14:30 TuBT2 Room R2 Human Centred Robot Design	13:00-14:30 TuBT3 Room R3 Social Robots II	13:00-14:30 TuBT4 Room R4 Situation Awareness and Spatial Cognition	13:00-14:30 TuBS1 Room R5 Social and Affective Robots
14:30-15:00 TuPM_TBr Tea Break II				
15:00-16:30 TuCT1 Room R1 Cognitive Skills and Mental Models	15:00-16:30 TuCT2 Room R2 HRI and Collaboration in Manufacturing Environment	15:00-16:30 TuCT3 Room R3 Social Robots III	15:00-16:30 TuCT4 Room R4 Visual Perception and Autonomous Robots	15:00-16:30 TuCS1 Room R5 Social Human Robot Interaction of Service Robots
16:30-17:30 TuII_PL Room R1 & R2 Plenary Talk II: Autonomous Driving: Simulation and Navigation by Prof. Dinesh Manocha, Department of Computer Science and Electrical and Computer Engineering, University of Maryland at College Park.				

RO-MAN 2019 Technical Program Wednesday October 16, 2019

Track T1	Track T2	Track T3	Track T4	Track T5
09:00-10:00 WeIII_PL Room R1 & R2 Plenary Talk III: Intelligent Robotics for Quality Living for All by Prof. Marcelo H Ang Jr, National University of Singapore				
10:00-10:30 WeAM_TBr Tea Break III				
10:30-12:00 WeAT1 Room R1 Machine Learning and Adaptation	10:30-12:00 WeAT2 Room R2 Imitation Learning	10:30-12:00 WeAT3 Room R3 Motion Planning, Navigation, and Control in Human Centered Environment	10:30-12:00 WeAT4 Room R4 Medical Robotics	10:30-12:00 WeAT5 Room R5 Robotics for Rehabilitation
12:00-13:00 WeL_Br Lunch Break				
13:00-14:30 WeBT1 Room R1 Human Robot Collaboration and Cooperation	13:00-14:30 WeBT2 Room R2 Linguistic Communication and Dialogue	13:00-14:30 WeBT3 Room R3 Robot Companions	13:00-14:30 WeBT4 Room R4 Therapy and Rehabilitation	13:00-14:30 WeBT5 Room R5 Medical Robotics and Intelligent Control Systems in the Indian Context
14:30-15:00 WePM_TBr Tea Break IV				
15:00-17:00 WeCT1 Poster Slot 1	15:00-17:00 WeCT2 Poster Slot 2	15:00-17:00 WeCT3 Poster Slot 3	15:00-17:00 WeCT4 Poster Slot 4	15:00-17:00 WeCT5 Poster Slot 5
17:00-18:00 WePD Room R4 Panel Discussion on Responsible Robotics and AI for the Real World				

19:00-22:00 WeBanquet Room R1 & R2 Banquet Dinner, Cultural Show, and Award Ceremony

TuAT1	Room T8
Cognitive Interaction Design (Regular Session)	
Chair: Behera, Laxmidhar	IIT Kanpur
Co-Chair: Orlandini, Andrea	National Research Council of Italy

10:30-10:45 TuAT1.1

Learning Optimal Parameterized Policy for High Level Strategies in a Game Setting,

Prakash, Ravi (Indian Institute of Technology, Kanpur), Vohra, Mohit (Indian Institute of Technology, Kanpur), Behera, Laxmidhar (IIT Kanpur)

Complex and interactive robot manipulation skills such as playing a game of table tennis against a human opponent is a multifaceted challenge and a novel problem. Accurate dynamic trajectory generation in such dynamic situations and an appropriate controller in order to respond to the incoming table tennis ball from the opponent is only a prerequisite to win the game. Decision making is a major part of an intelligent robot and a policy is needed to choose and execute the action which receives highest reward. In this paper, we address this very important problem on how to learn the higher level optimal strategies that enable competitive behaviour with humans in such an interactive game setting. This paper presents a novel technique to learn a higher level strategy for the game of table tennis using P-Q Learning (a mixture of Pavlovian learning and Q-learning) to learn a parameterized policy. The cooperative learning framework of Kohenon Self Organizing Map (KSOM) along with Replay Memory is employed for faster strategy learning in this short horizon problem. The strategy is learnt in simulation, using a simulated human opponent and an ideal robot that can perform hitting motion in its workspace accurately. We show that our method is able to improve the average received reward significantly in comparison to the other state-of-the-art methods.

10:45-11:00 TuAT1.2

Learning Context-Sensitive Strategies in Space Fortress,

Agarwal, Akshat (Carnegie Mellon University), Hope, Ryan (Carnegie Mellon University), Sycara, Katia (Carnegie Mellon University)

Research in deep reinforcement learning (RL) has coalesced around improving performance on benchmarks like the Arcade Learning Environment. However, these benchmarks do not emphasize two important characteristics that are often present in real-world domains: requirement of changing strategy conditioned on latent contexts, and temporal sensitivity. As a result, research in RL has not given these challenges their due, resulting in algorithms which do not understand critical changes in context, and have little notion of real world time. This paper introduces the game of Space Fortress as a RL benchmark which specifically targets these characteristics. We show that existing state-of-the-art RL algorithms are unable to learn to play the Space Fortress game, and then confirm that this poor performance is due to the RL algorithms' context insensitivity. We also identify independent axes along which to vary context and temporal sensitivity, allowing Space Fortress to be used as a testbed for understanding both characteristics in combination and also in isolation. We release Space Fortress as an open-source Gym environment.

11:00-11:15 TuAT1.3

Estimating Optimal Placement for a Robot in Social Group Interaction,

Pathi, Sai Krishna (Örebro University), Kristofferson, Annica (Mälardalen University), Kiselev, Andrey (Orebro University), Loutfi, Amy (Örebro University)

In this paper, we present a model to propose an optimal placement for a robot in a social group interaction. Our model estimates the O-space according to the F-formation theory. The method automatically calculates a suitable placement for the robot. An evaluation of the method has been performed by conducting an experiment where participants stand in different formations and a robot is teleoperated to join the group. In one condition, the operator positions the robot according to the specified location given by our algorithm. In another condition, operators have the freedom to position the robot according to their personal choice. Follow-up questionnaires were performed to determine which of the placements were preferred by the participants. The results indicate that the proposed method for automatic placement of the robot is supported from the participants. The contribution of this work resides in a novel method to automatically estimate the best placement of the robot, as well as the results from user experiments to verify the quality of this method. These results suggest that teleoperated robots such as mobile robot telepresence systems could benefit from tools that assist operators in placing the robot in groups in a socially accepted manner.

11:15-11:30 TuAT1.4

ROS-TiPlEx: How to Make Experts in A.I. Planning and Robotics Talk Together and Be Happy,

La Viola, Carlo (ISTC-CNR), Orlandini, Andrea (National Research Council of Italy), Umbrico, Alessandro (National Research Council of Italy), Cesta, Amedeo (CNR -- National Research Council of Italy, ISTC)

This paper presents a novel comprehensive framework called ROS-TiPlEx (Timeline-based Planning and Execution with ROS) to provide a shared environment in which experts in robotics and planning can easily interact to, respectively, encode information about low-level robot control and define task planning and execution models. ROS-TiPlEx aims at facilitating the interaction between both kind of experts, thus, enhancing and possibly speeding up the process of an integrated control design.

11:30-11:45 TuAT1.5

Robot with an Olfactory Display: Decorating Its Movements by Smells,

Senbonmatsu, Hikaru (University of Tsukuba), Tanaka, Fumihide (University of Tsukuba)

This study explored olfactory displays for social robots. In particular, we tested decorating robot movements by using smells as a way for nonverbal expression. To this end, two prototype devices which enabled a humanoid robot to present smells during its movements were developed based on the following design requirements: (1) the smell presentation had to be synchronized with the robot movements, (2) the devices could be easily mounted to the robot, (3) the devices could present and switch between multiple smells, and (4) the intensity of the smell presentation was controllable. Initial pilot tests were conducted with human participants.

11:45-12:00 TuAT1.6

Learning Sequential Human-Robot Interaction Tasks from Demonstrations: The Role of Temporal Reasoning,

Carpio Mazariegos, Estuardo Rene (University of New Hampshire), Clark-Turner, Madison (University of New Hampshire), Begum, Momotaz (University of New Hampshire)

There are many human-robot interaction (HRI) tasks that are highly structured and follow a certain temporal sequence. Learning such tasks from demonstrations requires understanding the underlying rules governing the interactions. This involves identifying and generalizing the key spatial and temporal features of the task and capturing the high level relationships among them. Despite its crucial role in sequential task learning, temporal reasoning is often ignored in existing learning from demonstration (LfD) research. This paper proposes a holistic LfD framework that learns the underlying temporal structure of sequential HRI tasks. The proposed Temporal-Reasoning-based LfD (TR-LfD) framework relies on an automated spatial reasoning layer to identify and generalize relevant spatial features, and a temporal reasoning layer to analyze and learn the high-level temporal structure of a HRI task. We evaluate the performance of this framework by learning a well-explored task in HRI research: robot-mediated autism intervention. The source code for this implementation is available at https://github.com/AssistiveRoboticsUNH/TR-LfD.

TuAT2	Room T2
Human Robot Interaction (Regular Session)	
Chair: Indurkhya, Bipin	Jagiellonian University
Co-Chair: Edwards, Autumn	Western Michigan University

10:30-10:45 TuAT2.1

Generation of Expressive Motions for a Tabletop Robot Interpolating from Hand-Made Animations,

Mier, Gonzalo (Pablo De Olavide University), Caballero, Fernando (Universidad Pablo De Olavide), Nakamura, Keisuke (Honda Research Institute Japan Co., Ltd), Merino, Luis (Universidad Pablo De Olavide), Gomez, Randy (Honda Research Institute Japan Co., Ltd)

Motion is an important modality for human-robot interaction. Besides a fundamental component to carry out tasks, through motion a robot can express intentions and expressions as well. In this paper, we focus on a tabletop robot in which motion, among other modalities, is used to convey expressions. The robot incorporates a set of pre-programmed motion animations that show different expressions with different intensities. These have been created by designers with expertise in animation. However, these animations are discrete open-loop macro actions. The objective in the paper is to analyze if these examples can be used as demonstrations, and combined by the robot to express to additional intensities/expressions, or shape the motion while performing additional tasks. Challenges are the representation space used, and the scarce number of examples. The paper compares three different learning from demonstration approaches for the task at hand. A user study is presented to evaluate the resultant motions learnt from the demonstrations.

10:45-11:00 TuAT2.2

A Common Social Distance Scale for Robots and Humans,

Banks, Jaime (Texas Tech University), Edwards, Autumn (Western Michigan University)

From keeping robots as in-home helpers to banning their presence or functions, a person's willingness to engage in variably intimate interactions are signals of social distance: the degree of felt understanding of and intimacy with an individual or group that characterizes pre-social and social connections. To date, social distance has been examined through surrogate metrics not actually representing the construct (e.g., self-disclosure or physical proximity). To address this gap between operations and measurement, this project details a four-stage social distance scale development project, inclusive of systematic item pool-generation, candidate item ratings for laypersons thinking about social distance, testing of candidate items via scalogram and initial validity analyses, and final testing for cumulative structure and predictive validity. The final metric yields a 15-item (18, counting applications with a 'none' option), three-dimension scale for physical distance, relational distance, and conversational distance.

11:00-11:15 TuAT2.3

Transparent Robot Behavior Using Augmented Reality in Close Human-Robot Interaction,

Bolano, Gabriele (FZI Forschungszentrum Informatik), Juelg, Christian (FZI Forschungszentrum Informatik), Roennau, Arne (FZI Forschungszentrum Informatik, Karlsruhe), Dillmann, Rüdiger (FZI - Forschungszentrum Informatik - Karlsruhe)

Most robots consistently repeat their motion without changes in a precise and consistent manner. But nowadays there are also robots able to dynamically change their motion and plan according to the people and environment that surround them. Furthermore, they are able to interact with humans and cooperate with them. With no information about the robot targets and intentions, the user feels uncomfortable even with a safe robot. In close human-robot collaboration, it is very important to make the user able to understand the robot intentions in a quick and intuitive way. In this work we have developed a system to use augmented reality to project directly into the workspace useful information. The robot intuitively shows its planned motion and task state. The AR module interacts with a vision system in order to display the changes in the workspace in a dynamic way. The representation of information about possible collisions and changes of plan allows the human to have a more comfortable and efficient interaction with the robot. The system is evaluated in different setups.

11:15-11:30 TuAT2.4

Your Robot Is Watching: Using Surface Cues to Evaluate the Trustworthiness of Human Actions,

Surendran, Vidullan (Pennsylvania State University), Wagner, Alan Richard (Penn State University)

A number of important human-robot applications demand trust. Although a great deal of research has examined how and why people trust robots, less work has explored how robots might decide whether to trust humans. Surface cues are perceptual clues that provide hints as to a person's intent and are predictive of behavior. This paper proposes and evaluates a model for recognizing trust surface cues by a robot and predicting if a person's behavior is deceitful in the context of a trust game. The model was tested in simulation and on a physical robot that plays an interactive card game. A human study was conducted where subjects played the game against a simulation, the robot, and a human opponent. Video data was hand coded by two coders with an inter-rater reliability of 0.41 based on Levenshtein distance. It was found that the model outperformed/matched the human coders on 50% of the subjects. Overall, this paper contributes a method that may begin to allow robots to evaluate the surface cues generated by a person to determine whether or not it should trust them.

11:30-11:45 TuAT2.5

Spatially Situated End-User Robot Programming in Augmented Reality,

Kapinus, Michal (Brno University of Technology, Faculty of Information Technology), Beran, Vitezslav (Brno University of Technology), Materna, Zdenek (Faculty of Information Technology, Brno University of Technology), Bambusek, Daniel (Brno University of Technology, Faculty of Information Technology)

Nowadays, industrial robots are being programmed using proprietary tools developed by robot manufacturer. A skilled robot programmer is needed to create even as simple task as pick a well-known object and put it somewhere else. Contrary, in every-day life people are using end-user programming to make different electronic devices work in expected manner, without even noticing they are actually programming. We propose augmented reality-enabled end-user programming system allowing regular shop-floor workers to program industrial robotic tasks. The user interface prototype for this system was evaluated in the user study with 7 participants with respect to usability, mental workload and user experience.

11:45-12:00 TuAT2.6

Human-Robot Interaction through Fingertip Haptic Devices for Cooperative Manipulation Tasks,

Musić, Selma (Technische Universität München), Prattichizzo, Domenico (University of Siena), Hirche, Sandra (Technische Universität München)

Teleoperation of multi-robot systems, e.g. dual manipulators, in cooperative manipulation tasks requires haptic feedback of multi-contact interaction forces. Classical haptic devices restrict the workspace of the human operator and provide only one contact point. An alternative solution is to enable the operator to command the robot system via free-hand motions which extends the workspace of the human. In such a setting, a multi-contact haptic feedback may be provided to the human through multiple wearable haptic devices, e.g.fingertip devices that display forces on the human fingertips. In this paper we evaluate the benefit of using wearable haptic fingertip devices to interact with a bimanual robot setup in a pick-and-place manipulation task. We show that haptic feedback through wearable devices improves task performance compared to the base condition of no haptic feedback. Therefore, wearable haptic devices are a promising interface for guidance of multi-robot manipulation systems.

TuAT3 Room T3

Social Robots I (Regular Session)

Chair: Cabibihan, John-John Qatar University

Co-Chair: Deshmukh, Amol University of Glasgow

10:30-10:45 TuAT3.1

Social and Entertainment Gratifications of Videogame Play Comparing Robot, AI, and Human Partners,

Bowman, Nick (Texas Tech University), Banks, Jaime (Texas Tech University)

As social robots' and AI agents' roles are becoming more diverse, those machines increasingly function as sociable partners. This trend raises questions about whether social gaming gratifications known to emerge in human-human co-play may (not) also manifest in human-machine co-play. In the present study, we examined social outcomes of playing a videogame with a human partner as compared to an ostensible social robot or A.I (i.e., computer-controlled player) partner. Participants (N = 103) were randomly assigned to three experimental conditions in which they played a cooperative video game with either a human, embodied robot, or non-embodied AI. Results indicated that few statistically significant or meaningful differences existed between any of the partner types on perceived closeness with partner, relatedness need satisfaction, or entertainment outcomes. However, qualitative data suggested that human and robot partners were both seen as more sociable, while AI partners were seen as more functional.

10:45-11:00 TuAT3.2

The Influence of Emotions on Time Perception in a Cognitive System for Social Robotics,

Cominelli, Lorenzo (E. Piaggio Research Center), Garofalo, Roberto (E. Piaggio Research Center), De Rossi, Danilo (University of Pisa)

In this paper, we discuss some evidences provided by neuroscience and psychology studies on human time perception, in terms of its representation and its psychological distortion due to emotional state variations. We propose, then, a novel model inspired by these recent findings to be applied in social robotics control architectures, with a specific reference to an existing and already tested bio-inspired cognitive architecture called SEAI (Social Emotional Artificial Intelligence). An hypothesis on how to represent emotional state influence on time perception in SEAI will be presented, discussing the consequent potential of the system with this integrated feature.

11:00-11:15 TuAT3.3

Shakespeare and Robots: Participatory Performance Art for Older Adults,

Greer, Julienne (Universtiy of Texas at Arlington), Doelling, Kris (Previously University of Texas at Arlington), Xu, Ling (University of Texas at Arlington, School of Social Work), Fields, Noelle (University of Texas at Arlington)

Theatre arts, social work, and engineering researchers investigated the therapeutic benefits of an interdisciplinary multi-modal intervention with older adults using a social robotic platform in an independent living facility. This pilot study incorporated Shakespearean text and the social robot, NAO, performing and concurrently encouraging the older adult to perform as a function of a participatory performance arts model. The findings of this human-robot study include a reduction in depression and an increase in social engagement with the robot in the older adults who participated in the intervention.

11:15-11:30 TuAT3.4

Recognition of Aggressive Interactions of Children Toward Robotic Toys,

Alhaddad, Ahmad Yaser (Qatar University), Cabibihan, John-John (Qatar University), Bonarini, Andrea (Politecnico Di Milano)

Social robots are now being considered to be a part of the therapy of children with autism. During the interactions, some aggressive behaviors could lead to harmful scenarios. The ability of a social robot to detect such behaviors and react to intervene or to notify the therapist would improve the outcomes of therapy and prevent any potential harm toward another person or to the robot. In this study, we investigate the feasibility of an artificial neural network in classifying 6 interaction behaviors between a child and a small robotic toy. The behaviors were: hit, shake, throw, pickup, drop, and no interaction or idle. Due to the ease of acquiring data from adult participants, a model was developed based on adults' data and was evaluated with children's data. The developed model was able to achieve promising results based on the accuracy (i.e. 80%), classification report (i.e. overall F1-score = 80%), and confusion matrix. The findings highlight the possibility of characterizing children's negative interactions with robotic toys to improve safety.

11:30-11:45 TuAT3.5

The Power to Persuade: A Study of Social Power in Human-RobotInteraction,

Hashemian, Mojgan (INESC-ID), Paiva, Ana (INESC-ID and Instituto Superior Técnico, TechnicalUniversity Of), Mascarenhas, Samuel (INESC-ID / Instituto Superior Técnico, University of Lisbon), Santos, Pedro A. (Instituto Superior Tecnico), Prada, Rui (INESC ID, Instituto Superior Tecnico, University of Lisbon)

Recent advances on Social Robotics raise the question whether a social robot can be used as a persuasive agent. To date, a body of literature has been performed using various approaches to answer this research question, ranging from the use of non-verbal behavior to the exploration of different embodiment characteristics. In this paper, we investigate the role of social power for making social robots more persuasive. Social power is defined as one's ability to influence another to do something which s/he would not do without the presence of such power. Different theories classify alternative ways to achieve social power, such as providing a reward, using coercion, or acting as an expert. In this work, we explored two types of persuasive strategies that are based on social power (specifically Reward and Expertise) and created two social robots that would employ such strategies. To examine the effectiveness of these strategies we performed a user study with 51 participants using two social robots in an adversarial setting in which both robots try to persuade the user on a concrete choice. The results show that even though each of the strategies caused the robots to be perceived differently in terms of their competence and warmth, both were similarly persuasive.

11:45-12:00 TuAT3.6

Eyes on You: Field Study of Robot Vendor Using Human-Like Eye Component "Akagachi",

Hayashi, Kotaro (Toyohashi University of Technology), Toshimitsu, Yasunori (MIT)

Eye gaze is an important non-verbal behavior for communication robots as it serves as the onset of communication. Existing communication robots have various eyes because design choices for an appropriate eye have yet to be determined, so many robots are designed on the basis of individual designers' ideas. Thus, this study focuses on human-like eye gaze in a real environment. We developed a human-like eye gaze component called Akagachi for various robots and conducted an observational field study by implementing it to a vendor robot called Reika. We conducted a field study in a theme park where Reika sells soft-serve ice cream in a food stall and analyzed the behaviors of 978 visitors. Our results indicate that Reika elicits significantly more interaction from people with eye gaze than without it.

TuAT4 Room T4

Tele-Operation and Autonomous Robots (Regular Session)

Chair: Fitter, Naomi T. University of Southern California

Co-Chair: Ikeda, Tetsushi Hiroshima City University

10:30-10:45 TuAT4.1

Haptic Directional Information for Spatial Exploration,

Ghosh, Ayan (The University of Sheffield), Penders, Jacques (Sheffield Hallam University), Soranzo, Alessandro (Sheffield Hallam University)

This paper investigates the efficacy of a tactile and haptic human robot interface developed and trialled to aid navigation in poor visibility and audibility conditions, which occur, for example, in e.g. search and rescue. The new developed interface generates haptic directional information that will support human navigation when other senses are not or only partially accessible. The central question of this paper was whether humans are able to interpret haptic signals as denoting different spatial directions. The effectiveness of the haptic signals was measured in a novel experimental set up. Participants were given a stick (replicating the robot interface) and asked to reproduce the specific spatial information denoted by each of the haptic signals. The task performance was examined quantitatively and results show that the haptic signals can denote distinguishable spatial directions, supporting the hypothesis that tactile and haptic information can be effectively used to aid human navigation. Implications for robotics application of the newly developed interface are discussed.

10:45-11:00 TuAT4.2

User Interface Tradeoffs for Remote Deictic Gesturing,

Fitter, Naomi T. (University of Southern California), Joung, Youngseok (University of Southern California), Hu, Zijian (University of Southern California), Demeter, Marton (University of Southern California), Mataric, Maja (University of Southern California)

Telepresence robots can help to connect people by providing videoconferencing and navigation abilities in far-away environments. Despite this potential, current commercial telepresence robots lack certain nonverbal expressive abilities that are important for permitting the operator to communicate effectively in the remote environment. To help improve the utility of telepresence robots, we added an expressive, non-manipulating arm to our custom telepresence robot system and developed three user interfaces to control deictic gesturing by the arm: onscreen, dial-based, and skeleton tracking methods. A usability study helped us evaluate user presence feelings, task load, preferences, and opinions while performing deictic gestures with the robot arm during a mock order packing task. The majority of participants preferred the dial-based method of controlling the robot, and survey responses revealed differences in physical demand and effort level across user interfaces. These results can guide robotics researchers interested in extending the nonverbal communication abilities of telepresence robots.

11:00-11:15 TuAT4.3

Improving Robot Transparency: An Investigation with Mobile Augmented Reality,

Rotsidis, Alexandros (University of Bath), Theodorou, Andreas (University of Bath), Bryson, Joanna (University of Bath), Wortham, Robert Hale (University of Bath)

Autonomous robots can be difficult to understand by their developers, let alone by end users. Yet, as they become increasingly integral parts of our societies, the need for affordable easy to use tools to provide transparency grows. The rise of the smartphone and the improvements in mobile computing performance have gradually allowed Augmented Reality (AR) to become more mobile and affordable. In this paper we review relevant robot systems architecture and propose a new software tool to provide robot transparency through the use of AR technology. Our new tool, ABOD3-AR provides real-time graphical visualisation and debugging of a robot's goals and priorities as a means for both designers and end users to gain a better mental model of the internal state and decision making processes taking place within a robot. We also report on our on-going research programme and planned studies to further understand the effects of transparency to naive users and experts.

11:15-11:30 TuAT4.4

Investigation of the Driver's Seat That Displays Future Vehicle Motion,

イシイ, ユウキ (広島市立大学), Ikeda, Tetsushi (Hiroshima City University), Kobayashi, Toru (Hiroshima City University), Kato, Yumiko (St. Marianna University School of Medicine), Utsumi, Akira (ATR Intelligent Robotics and Communication Labs), Nagasawa, Isamu (SUBARU Co., LTD), Iwaki, Satoshi (Hiroshima City University)

Automated driving reduces the burden on the driver, however also makes it difficult for the driver to understand the current situation and predict the future movement of the vehicle. When the acceleration due

to automated driving occurs without future prediction, the driver's anxiety and discomfort are increased compared to the case in manual driving. To facilitate the prediction of the future behavior of the vehicle by the driver, this paper aims to design and evaluate a haptic interface that actuates the vehicle seat. Our system displays to the driver the movement of the vehicle a few seconds in the future, which allows the driver to make predictions and preparations. Using a driving simulator, we compared the conditions where the movement of the car was displayed in advance for the length of different time. The subjective evaluation of the driver showed that the predictability of the behavior of the vehicle were significantly increased compared to the case without display. The experiment also showed that comfortable feeling significantly decreased if the preceding display is too early.

11:30-11:45 TuAT4.5

Combining Electromyography and Fiducial Marker Based Tracking for Intuitive Telemanipulation with a Robot Arm Hand System,

Dwivedi, Anany (University of Auckland), Gorjup, Gal (The University of Auckland), Kwon, Yongje (The University of Auckland), Liarokapis, Minas (The University of Auckland)

Teleoperation and telemanipulation have since the early years of robotics found use in a wide range of applications, including exploration, maintenance, and response in remote or hazardous environments, healthcare, and education settings. As the capabilities of robot manipulators grow, so does the control complexity and the remote execution of intricate manipulation tasks still remains challenging for the user. This paper proposes an intuitive telemanipulation framework based on electromyography (EMG) and fiducial marker based tracking that can be used with a dexterous robot arm hand system. The EMG subsystem captures the myoelectric activations of the user during the execution of specific hand postures and gestures and translates them into the desired grasp type for the robot hand. The pose of the tracked fiducial marker is used as a task-space goal for the robot end-effector. The system performance is experimentally validated in a remote operation setting, where the system successfully performs a telemanipulation task.

11:45-12:00 TuAT4.6

Humanoid Co-Workers: How Is It Like to Work with a Robot?,

Vishwanath, Ajay (Nanyang Technological University), Singh, Aalind (Institute for Media Innovation), Chua, Yi Han Victoria (Nanyang Technological University), Dauwels, Justin (Nanyang Technological University), Thalmann, Nadia Magnenat (Nanyang Technological University)

Human-robot interaction in corporate workplaces is a research area which remains unexplored. In this paper, we present the results and analysis of a social experiment we conducted by introducing a humanoid robot (Nadine) into a collaborative social workplace. The humanoid's primary task was to function as a receptionist and provide general assistance to the customers. Moreover, the employees who interacted with Nadine were given over a month to get used to her capabilities, after which, the feedback was collected from the staff on the grounds of influence on productivity, affect experienced during interaction and their views on social robots assisting with regular tasks. Our results show that the usage of social robots for assisting with normal day-to-day tasks is taken quite positively by the co-workers and that in the near future, more capable humanoid social robots can be used in workplaces for assisting with menial tasks. Finally, we posit that surveys such as ours could result in constructive opinions based on technological awareness, rather than opinions from media-driven fears about the threats of technology.

TuAS1 Room T5

Transparency and Trust in Human Robot Interaction (Special Session)

Chair: Rossi, Silvia — Universita' Di Napoli Federico II

Co-Chair: Rossi, Alessandra — University of Hertfordshire

10:30-10:45 TuAS1.1

Verbal Explanations for Deep Reinforcement Learning Neural Networks with Attention on Extracted Features,

Wang, Xinzhi (Tsinghua University), Yuan, Shengcheng (LazyComposer Inc., Beijing), Zhang, Hui (Tsinghua University), Sycara, Katia (Carnegie Mellon University), Lewis, Mike (Univ of Pittsburgh)

In recent years, there has been increasing interest in transparency in Deep Neural Networks. Most of the works on transparency have been done for image classification. In this paper, we report on work of transparency in Deep Reinforcement Learning Networks (DRLNs). Such networks have been extremely successful in learning action control in Atari games. In this paper, we focus on generating verbal (natural language) descriptions and explanations of deep reinforcement learning policies. Successful generation of verbal explanations would allow better understanding by people (e.g., users, debuggers) of the inner workings of DRLNs which could ultimately increase trust in these systems. We present a generation model which consists of three parts: an encoder on feature extraction, an attention structure on selecting features from the output of the encoder, and a decoder on generating the explanation in natural language. Four variants of the attention structure - full attention, global attention, adaptive attention and object attention - are designed and compared. The adaptive attention structure performs the best among all the variants, even though the object attention structure is given additional information on object locations. Additionally, our experiment results showed that the proposed encoder outperforms two baseline encoders (Resnet and VGG) on the capability of distinguishing the game state images.

10:45-11:00 TuAS1.2

Coherent and Incoherent Robot Emotional Behavior for Humorous and Engaging Recommendations,

Rossi, Silvia (Universita' Di Napoli Federico II), Cimmino, Teresa (University of Naples Federico II), Matarese, Marco (University of Naples Federico II), Raiano, Mario (University of Naples Federico II)

Social robots are effective in influencing and motivating human behavior. To gain a deeper understanding of how the robot emotional non-verbal behaviors might shape the human perception of the interaction while providing recommendations, we conducted a between-subjects experimental study using a humanoid robot in a movie recommendation scenario. This experiment aims at evaluating whether an incoherent use of emotional behavior, with respect to the presented contents, may produce a sort of humorous effect that positively affect the user perception of the recommendation. We evaluated, using an off-the-shelf solution, engagement and emotions shown by the users. Our results showed that a robot incoherent behavior does not distract the user, but it increases his/her engagement producing a positive emotional response. Such a difference is significant in the case of female subjects and depends on the considered emotions.

11:00-11:15 TuAS1.3

Getting to Know Kaspar: Effects of People's Awareness of a Robot's Capabilities on Their Trust in the Robot,

Rossi, Alessandra (University of Hertfordshire), Moros, Sílvia (University of Hertfordshire), Dautenhahn, Kerstin (University of

Waterloo), Koay, Kheng Lee (University of Hertfordshire), Walters, Michael Leonard (University of Hertfordshire)

In this work we investigate how humans' awareness of a social robot's capabilities affect their trust in the robot. We present a user study that relates knowledge on different quality levels to participants' ratings of trust. Primary school pupils were asked to rate their trust in the robot after three types of interactions: a video demonstration, a live interaction, and a programming task. The study revealed that the pupils' trust is not significantly affected across different domains after each session. It did not appear to be significant differences in trust tendencies for the different experiences either; however, our results suggest that human users trust a robot more the more awareness about the robot they have.

11:15-11:30 TuAS1.4

Privacy First: Designing Responsible and Inclusive Social Robot Applications for in the Wild Studies,

Tonkin, Meg (University of Technology Sydney), Vitale, Jonathan (University of Technology Sydney), Herse, Sarita (University of Technology Sydney), Raza, Syed Ali (University of Technology, Sydney), Madhisetty, Srinivas (University of Technology Sydney), Kang, Le (University of Technology Sydney), Vu, The Duc (University of Technology Sydney), Johnston, Benjamin (University of Technology, Sydney), Williams, Mary-Anne (University of Technology Sydney)

Deploying social robots applications in public spaces for conducting in the wild studies is a significant challenge but critical to the advancement of social robotics. Real world environments are complex, dynamic, and uncertain. Human-Robot interactions can be unstructured and unanticipated. In addition, when the robot is intended to be a shared public resource, management issues such as user access and user privacy arise, leading to design choices that can impact on users' trust and the adoption of the designed system. In this paper we propose a user registration and login system for a social robot and report on people's preferences when registering their personal details with the robot to access services. This study is the first iteration of a larger body of work investigating potential use cases for the Pepper social robot at a government managed centre for startups and innovation. We prototyped and deployed a system for user registration with the robot, which gives users control over registering and accessing services with either face recognition technology or a QR code. The QR code played a critical role in increasing the number of users adopting the technology. We discuss the need to develop social robot applications that responsibly adhere to privacy principles, are inclusive, and cater for a broad spectrum of people.

11:30-11:45 TuAS1.5

Trust Repair in Human-Swarm Teams,

Liu, Rui (Kent State University), Cai, Zekun (University of Pittsburgh), Lewis, Mike (Univ of Pittsburgh), Lyons, Joseph (AFRL), Sycara, Katia (Carnegie Mellon University)

begin{abstract} Swarm robots are coordinated via simple control laws to generate emergent behaviors such as flocking, rendezvous, and deployment. Human-swarm teaming has been widely proposed for scenarios, such as human-supervised teams of unmanned aerial vehicles (UAV) for disaster rescue, UAV and ground vehicle cooperation for building security, and soldier-UAV teaming in combat. Effective cooperation requires an appropriate level of trust, between a human and a swarm. When an UAV swarm is deployed in a real-world environment, its performance is subject to real-world factors, such as system reliability and wind disturbances. Degraded performance of a robot can cause undesired swarm behaviors, decreasing human trust. This loss of trust, in turn, can trigger human intervention in UAVs' task executions, decreasing cooperation effectiveness if inappropriate. Therefore, to promote effective cooperation we propose and test a trust-repairing method (textit{Trust-repair}) restoring performance and human trust in the swarm to an appropriate level by correcting undesired swarm behaviors. Faulty swarms caused by both external and internal factors were simulated to evaluate the performance of the textit{Trust-repair} algorithm in repairing swarm performance and restoring human trust. Results show that textit{Trust-repair} is effective in restoring trust to a level intermediate between normal and faulty conditions. end{abstract}

11:45-12:00 TuAS1.6

"You Are Doing so Great!" – the Effect of a Robot's Interaction Style on Self-Efficacy in HRI,

Zafari, Setareh (Vienna University of Technology), Schwaninger, Isabel (TU Wien), Hirschmanner, Matthias (TU Wien), Schmidbauer, Christina (Vienna University of Technology), Weiss, Astrid (Vienna Univerity of Technology), Koeszegi, Sabine Theresia (Vienna University of Technology)

People form mental models about robots' behavior and intentions, as they interact with them. The aim of this paper is to evaluate the effect of two different interaction styles on self-efficacy in human-robot interaction (HRI), people's perception of the robot and task engagement. We conducted a user study in which a social robot assists people while building a house of cards. Data from our experimental study revealed that people engaged longer in the task while interacting with a robot that provides person related feedback than with a robot that gives no person or task related feedback. Moreover, people interacting with a robot with a person-oriented interaction style reported a higher self-efficacy in HRI, perceived higher Agreeableness of the robot and found the interaction less frustrating, as compared to a robot with a task-oriented interaction style. This suggests that a robot's interaction style can be considered as a key factor for increasing people's perceived self-efficacy in HRI, which is essential for establishing trust and enabling Human-Robot Collaboration.

TuBT1 Room T8

Robots in Education (Regular Session)

Chair: Robins, Ben — University of Hertfordshire

Co-Chair: Johal, Wafa — École Polytechnique Fédérale De Lausanne

13:00-13:15 TuBT1.1

A Participatory Design Process of a Robotic Tutor of Assistive Sign Language for Children with Autism,

Axelsson, Minja (Aalto University), Racca, Mattia (Aalto University), Weir, Daryl (Futurice Oy), Kyrki, Ville (Aalto University)

We present the participatory design process of a robotic tutor of assistive sign language for children with autism spectrum disorder (ASD). Robots have been used in autism therapy, and to teach sign language to neurotypical children. The application of teaching assistive sign language --- the most common form of assistive and augmentative communication used by people with ASD --- is novel. The robot's function is to prompt children to imitate the assistive signs that it performs. The robot was therefore co-designed to appeal to children with ASD, taking into account the characteristics of ASD during the design process: impaired language and communication, impaired social behavior, and narrow flexibility in daily activities. To accommodate these characteristics, a multidisciplinary team defined design guidelines specific to robots for children with ASD, which were followed in the participatory design process. With a pilot study where the robot prompted children to imitate nine assistive signs, we found

support for the effectiveness of the design. The children successfully imitated the robot and kept their focus, as measured by their eye gaze, on it. Children and their companions reported positive experiences with the robot, and companions evaluated it as potentially useful, suggesting that robotic devices could be used to teach assistive sign language to children with ASD.

13:15-13:30 TuBT1.2

Robot Analytics: What Do Human-Robot Interaction Traces Tell Us about Learning?,

Nasir, Jauwairia (EPFL), Norman, Utku (Swiss Federal Institute of Technology in Lausanne (EPFL)), Johal, Wafa (École Polytechnique Fédérale De Lausanne), Olsen, Jennifer (EPFL), Shahmoradi, Sina (EPFL), Dillenbourg, Pierre (EPFL)

In this paper, we propose that the data generated by educational robots can be better used by applying learning analytics methods and techniques which can lead to a deeper understanding of the learners apprehension and behavior as well as refined guidelines for roboticists and improved interventions by the teachers. As a step towards this, we put forward analyzing behavior and task performance at team and/or individual levels by coupling robot data with the data from conventional methods of assessment through quizzes. Classifying learners/teams in the behavioral feature space with respect to the task performance gives insight into the relevant behavior patterns for high performance, which could be backed by feature ranking. As a use case, we present an open-ended learning activity using tangible robots in a classroom-level setting. The pilot study, spanning over approximately an hour, is conducted with 25 children in teams of two that are aged between 11-12. A linear separation is observed between the high and low performing teams where two of the behavioral features, namely number of distinct attempts and the visits to the destination, are found to be important. Although the pilot study in its current form has limitations, it contributes to highlighting the potential of the use of learning analytics in educational robotics.

13:30-13:45 TuBT1.3

Improv with Robots: Creativity, Inspiration, Co-Performance,

Rond, Jesse (Oregon State University), Sanchez, Alan (Oregon State University), Berger, Jaden (Oregon State University), Knight, Heather (Oregon State University)

Improvisational actors are adept at creative exploration within a set of boundaries. These boundaries come from each scene having ``games'' that establish the rules-of-play. In this paper, we introduce a game that allows an expressive motion robot to collaboratively develop a narrative with an improviser. When testing this game on eight improv performers, our team explored two research questions: (1) Can a simple robot be a creative partner to a human improviser, and (2) Can improvisers expand our understanding of robot expressive motion? After conducting 16 scenes and 40 motion demonstrations, we found that performers viewed our robot as a supportive teammate who positively inspired the scene's direction. The improvisers also provided insightful perspectives on robot motion, which led us to create a movement categorization scheme based on their various interpretations. We discuss our lessons learned, show the benefits of merging social robotics with improvisational theater, and hope this will encourage further exploration of this cross-disciplinary intersection.

13:45-14:00 TuBT1.4

CoWriting Kazakh: Transitioning to a New Latin Script Using Social Robots,

Kim, Anton (Nazarbayev University), Omarova, Meruyert (Nazarbayev University), Zhaksylyk, Adil (Nazarbayev University), Asselborn, Thibault (EPFL), Johal, Wafa (École Polytechnique Fédérale De Lausanne), Dillenbourg, Pierre (EPFL), Sandygulova, Anara (Nazarbayev University)

In the Republic of Kazakhstan, the transition from Cyrillic towards Latin alphabet raises challenges to teach the whole population in writing the new script. This paper presents a CoWriting Kazakh system that aims to implement an autonomous behavior of a social robot that would assist children in learning a new script. Considering the fact that the current generation of primary school children have to be fluent in both Kazakh scripts, this exploratory study aims to investigate which learning approach provides better effect. Participants were asked to teach a humanoid robot NAO how to write Kazakh words using one of the scripts, Latin vs Cyrillic. We hypothesize that it is more effective when a child mentally converts the word to Latin in comparison to having the robot perform conversion itself. The findings reject this hypothesis, but further research is needed as it is suggested that the way the pre-test was performed might have caused the obtained results.

14:00-14:15 TuBT1.5

Design and Perception of a Social Robot to Promote Hand Washing among Children in a Rural Indian School,

Radhakrishnan, Unnikrishnan (Amrita University), Deshmukh, Amol (University of Glasgow), Ramesh, Shanker (AMMACHI Labs, Amrita Vishwa Vidyapeetham, Amritapuri, India), K Babu, Sooraj (AMMACHI Labs, Amrita Vishwa Vidyapeetham, Amritapuri, India), A, Parameswari (Ammachilabs, Amrita Vishwa Vidyapeetham, Amritapuri, India), Rao R, Bhavani (Amrita Vishwa Vidyapeetham University)

We introduce “Pepe”, a social robot for encouraging proper handwashing behaviour among children. We discuss the motivation, the robot design and a pilot study conducted at a primary school located in the Western Ghats mountain ranges of Southern India with a significant presence of indigenous tribes. The study included individual & group interviews with a randomly selected sample of 45 children to gauge their perception of the Pepe robot across various dimensions including gender, animacy & technology acceptance. We also discuss some HRI implications for running user studies with rural children.

14:15-14:30 TuBT1.6

The Effect of Interaction and Design Participation on Teenagers' Attitudes towards Social Robots,

Björling, Elin (University of Washington), Xu, Wendy M. (University of Washington), Cabrera, Maria Eugenia (University of Washington), Cakmak, Maya (University of Washington)

Understanding people's attitudes towards robots and how those attitudes are affected by exposure to robots is essential to the effective design and development of social robots. Although researchers have been studying attitudes towards robots among adults and even children for more than a decade, little has been explored assessing attitudes among teens--a highly vulnerable population that presents unique opportunities and challenges for social robots. Our work aims to close this gap. In this paper we present findings from several participatory robot interaction and design sessions with 136 teenagers who completed a modified version of the Negative Attitudes Towards Robots Scale (NARS) before participation in a robot interaction. Our data reveal that most teens are 1) highly optimistic about the helpfulness of robots, 2) do not feel nervous talking with a robot, but also 3) do not trust a robot with their data. Ninety teens also completed a post-interaction survey and reported a significant change in the emotional attitudes subscale of the NARS. We discuss the implications

of our findings on the design of social robots for teens.

TuBT2	Room T2
Human Centred Robot Design (Regular Session)	
Chair: Kato, Shohei	Nagoya Institute of Technology
Co-Chair: Kim, Joonhwan	Korea Advanced Institute of Science and Technology(KAIST)

13:00-13:15 TuBT2.1

Unconventional Uses of Structural Compliance in Adaptive Hands,

Chang, Che-Ming (University of Auckland), Gerez, Lucas (The University of Auckland), Elangovan, Nathan (University of Auckland), Zisimatos, Agisilaos (National Technical University of Athens), Liarokapis, Minas (The University of Auckland)

Adaptive robot hands are typically created by introducing structural compliance either in their joints (e.g., implementation of flexure joints) or in their finger-pads. In this paper, we present a series of alternative uses of structural compliance for the development of simple, adaptive, compliant and/or under-actuated robot grippers and hands that can efficiently and robustly execute a variety of grasping and dexterous, in-hand manipulation tasks. The proposed designs utilize only one actuator per finger to control multiple degrees of freedom and they retain the superior grasping capabilities of the adaptive grasping mechanisms even under significant object pose or other environmental uncertainties. More specifically, in this work, we introduce, discuss, and evaluate: a) the concept of compliance adjustable motions that can be predetermined by tuning the in-series compliance of the tendon routing system and by appropriately selecting the imposed tendon loads, b) a design paradigm of pre-shaped, compliant robot fingers that adapt / conform to the object geometry and, c) a hyper-adaptive finger-pad design that maximizes the area of the contact patches between the hand and the object, maximizing also grasp stability. The proposed hands use mechanical adaptability to facilitate and simplify the efficient execution of robust grasping and dexterous, in-hand manipulation tasks by design.

13:15-13:30 TuBT2.2

Design and Analysis of a Soft Bidirectional Bending Actuator for Human-Robot Interaction Applications,

Singh, Kumar Surjdeo (Indian Institute of Technology Madras), Thondiyath, Asokan (IIT Madras)

The design of a novel, soft bidirectional actuator which can improve the human-robot interactions in collaborative applications is proposed in this paper. This actuator is advantageous over the existing designs due to the additional degree of freedom for the same number of pressure inputs as found in the conventional designs. This improves the workspace of the bidirectional actuator significantly and is able to achieve higher angles of bidirectional bending at much lower values of input pressure. This is achieved by eliminating the passive impedance offered by one side of the bending chamber in compression when the other side of the chamber is inflated. A simple kinematic model of the actuator is presented and theoretical and finite element analysis is carried out to predict the fundamental behavior of the actuator. The results are validated through experiments using a fabricated model of the soft bidirectional bending actuator.

13:30-13:45 TuBT2.3

Instrumented Shoe Based Foot Clearance and Foot-To-Ground Angle Measurement System for the Gait Analysis,

Tiwari, Ashutosh (Indian Institute of Technology), Saxena, Somya (PGI Chandigarh), Joshi, Deepak (Indian Institute of Technology)

This paper presents a wireless gait analysis system that incorporates anatomically located infrared (IR) distance sensor on the shoe for the measurement of various gait parameters such as foot-to-ground angle (FGA), foot clearance (FC). The system has been validated against the BTS bioengineering 3D motion capture gold standard method in gait analysis laboratory with FC RMSE error of 6.31% of the full range and FGA RMSE error of 5.53% of the full range. The squared correlation coefficient r2 for FC and FGA is equal to 0.970 and 0.935, respectively. This system has a sensor position adjustment mechanism in two degrees of freedom, which facilitates the adaptability of the system to any foot size. The system is inexpensive, simple to use, and provides accuracy at par to the existing systems. This system finds application in a variety of clinical domains, for example, neurological disease diagnosis affecting ambulation such as Parkinson's and cerebral palsy, gait rehabilitation, and sports fields. The future scope of this work includes validation of the shoe with different foot sizes and with different walking speed.

13:45-14:00 TuBT2.4

Energy Conscious Over-Actuated Multi-Agent Payload Transport Robot,

Tallamraju, Rahul (International Institute of Information Technology, Hyderabad), Verma, Pulkit (International Institute of Information Technology), Sripada, Venkatesh (Oregon State University, Corvallis, USA), Agrawal, Shrey (International Institute of Information Technology, Hyderabad), Karlapalem, Kamalakar (IIIT-Hyderabad)

In this work, we consider a multi-wheeled payload transport system. Each of the wheels can be selectively actuated. When they are not actuated, wheels are free moving and do not consume battery power. The payload transport system is modeled as an actuated multi-agent system, with each wheel-motor pair as an agent. Kinematic and dynamic models are developed to ensure that the payload transport system moves as desired. We design optimization formulations to decide on the number of wheels to be active and which of the wheels to be active so that the battery is conserved and the wear on the motors is reduced. The proposed multi-level control framework over the agents ensures that near-optimal number of agents is active for the payload transport system to function. Through simulation studies we show that our solution ensures energy efficient operation and increases the distance traveled by the payload transport system, for the same battery power. We have built the payload transport system and provide results for preliminary experimental validation.

14:00-14:15 TuBT2.5

Effect of Human Hand Dynamics on Haptic Rendering of Stiff Springs Using Virtual Mass Feedback,

Desai, Indrajit (Indian Institute of Technology Bombay), Gupta, Abhishek (Indian Institute of Technology, Bombay), Chakraborty, Debraj (Indian Institute of Technology Bombay)

Hard surfaces are typically simulated in a haptic interface as stiff springs. Stable interaction with these surfaces using force feedback is challenging due to the discrete nature of the controller. Previous research has shown that adding a virtual damping or virtual mass to the rendered surface helps to increase the stiffness of the surface for stable interaction. In this paper, we analyze the effect of adding virtual mass on the range of stiffness that can be stably rendered. The analysis is performed in the discrete time domain. Specifically, we study the coupled~(with human hand dynamics) stability of the haptic interface. Stability, when the human interacts with the robot, is investigated by considering different human hand models. Our analysis shows that, when the human operator is coupled to an uncoupled stable system, an increase in the mass of a human hand decreases maximum renderable stiffness. Moreover, the increase in human hand

damping increases the stably renderable stiffness.

14:15-14:30 TuBT2.6

DronePick: Object Picking and Delivery Teleoperation with the Drone Controlled by a Wearable Tactile Display,

Ibrahimov, Roman (Skolkovo Institute of Technology and Science), Tsykunov, Evgeny (Skolkovo Institute of Science and Technology), Shirokun, Vladimir (Skolkovo Institute of Science and Technology), Somov, Andrey (Skolkovo Institute of Technology and Science), Tsetserukou, Dzmitry (Skolkovo Institute of Science and Technology)

We report on the teleoperation system DronePick which provides remote object picking and delivery by a human-controlled quadcopter. The main novelty of the proposed system is that the human user continuously gets the visual and haptic feedback for accurate teleoperation. DronePick consists of a quadcopter equipped with a magnetic grabber, a tactile glove with finger motion tracking sensor, hand tracking system, and the Virtual Reality (VR) application. The human operator teleoperates the quadcopter by changing the position of the hand. The proposed vibrotactile patterns representing the location of the remote object relative to the quadcopter are delivered to the glove. It helps the operator to determine when the quadcopter is right above the object. When the “pick” command is sent by clasping the hand in the glove, the quadcopter decreases its altitude and the magnetic grabber attaches the target object. The whole scenario is in parallel simulated in VR. The air flow from the quadcopter and the relative positions of VR objects help the operator to determine the exact position of the delivered object to be picked. The experiments showed that the vibrotactile patterns were recognized by the users at the high recognition rates: the average 99% recognition rate and the average 2.36s recognition time. The real-life implementation of DronePick featuring object picking and delivering to the human was developed and tested.

TuBT3 Room T3

Social Robots II (Regular Session)

Chair: Sandygulova, Anara — Nazarbayev University

Co-Chair: Cabibihan, John-John — Qatar University

13:00-13:15 TuBT3.1

Design of a Robotic Crib Mobile to Support Studies in the Early Detection of Cerebral Palsy: A Pilot Study,

Jamshad, Rabeya (Georgia Institute of Technology), Fry, Katelyn (Georgia Institute of Technology), Chen, Yu-ping (Georgia State University), Howard, Ayanna (Georgia Institute of Technology)

According to data from the Centers for Disease Control and Prevention, developmental disorders such as Autism Spectrum Disorder (ASD) and Cerebral Palsy (CP) affect nearly one in six children between the ages of 3 to 17 in the United States alone. In order to improve the quality of life for these individuals, there is increased emphasis on providing early intervention at infancy, when key developmental milestones are being achieved. This however requires accurate early detection of motor development delays in at-risk infants. Our research focuses on enabling early detection through the design of a robotic crib mobile that affects infant behavior. Stimuli integrated into the robotic mobile can be used to encourage certain motions such as kicking among infants in order to study infant motor development and identify at-risk populations. In this paper, we propose the design of such a robotic crib mobile and discuss preliminary results from deploying the mobile in the infants' home environment during a pilot study.

13:15-13:30 TuBT3.2

AppGAN: Generative Adversarial Networks for Generating Robot Approach Behaviors into Small Groups of People,

Yang, Fangkai (KTH Royal Institute of Technology), Peters, Christopher (Royal Institute of Technology)

Robots that navigate to approach free-standing conversational groups should do so in a safe and socially acceptable manner. This is challenging since it not only requires the robot to plot trajectories that avoid collisions with members of the group, but also to do so without making those in the group feel uncomfortable, for example, by moving too close to them or approaching them from behind. Previous trajectory prediction models focus primarily on formations of walking pedestrians, and those models that do consider approach behaviours into free-standing conversational groups typically have handcrafted features and are only evaluated via simulation methods, limiting their effectiveness. In this paper, we propose AppGAN, a novel trajectory prediction model capable of generating trajectories into free-standing conversational groups trained on a dataset of safe and socially acceptable paths. We evaluate the performance of our model with state-of-the-art trajectory prediction methods on a semi-synthetic dataset. We show that our model outperforms baselines by taking advantage of the GAN framework and our novel group interaction module.

13:30-13:45 TuBT3.3

Effective Robot Evacuation Strategies in Emergencies,

Nayyar, Mollik (The Pennsylvania State University), Wagner, Alan Richard (Penn State University)

Recent efforts in human-robot interaction research has shed some light on the impact of human-robot interactions on human decisions during emergencies. It has been shown that presence of crowds during emergencies can influence evacuees to follow the crowd to find an exit. Research has shown that robots can be effective in guiding humans during emergencies and can reduce this `follow the crowd' behavior potentially providing life-saving benefit. These findings make robot guided evacuation methodologies an important area to explore further. In this paper we propose techniques that can be used to design effective evacuation methods. We explore the different strategies that can be employed to help evacuees find an exit sooner and avoid over-crowding to increase their chances of survival. We study two primary strategies, 1) shepherding method and 2) handoff method. Simulated experiments are performed to study the effectiveness of each strategy. The results show that shepherding method is more effective in directing people to the exit.

13:45-14:00 TuBT3.4

Surprise! Predicting Infant Visual Attention in a Socially Assistive Robot Contingent Learning Paradigm,

Klein, Lauren (University of Southern California), Itti, Laurent (University of Southern California), Smith, Beth (University of Southern California), Rosales, Marcelo R. (University of Southern California), Nikolaidis, Stefanos (University of Southern California), Mataric, Maja (University of Southern California)

Early intervention to address developmental disability in infants has the potential to promote improved outcomes in neurodevelopmental structure and function [1]. Researchers are starting to explore Socially Assistive Robotics (SAR) as a tool for delivering early interventions that are synergistic with and enhance human-administered therapy. For SAR to be effective, the robot must be able to consistently attract the attention of the infant in order to engage the infant in a desired activity.

This work presents the analysis of eye gaze tracking data from five 6-8 month old infants interacting with a Nao robot that kicked its leg as a contingent reward for infant leg movement. We evaluate a Bayesian model of low-level surprise on video data from the infants' head-mounted camera and on the timing of robot behaviors as a predictor of infant visual attention. The results demonstrate that over 67% of infant gaze locations were in areas the model evaluated to be more surprising than average. We also present an initial exploration using surprise to predict the extent to which the robot attracts infant visual attention during specific intervals in the study. This work is the first to validate the surprise model on infants; our results indicate the potential for using surprise to inform robot behaviors that attract infant attention during SAR interactions.

14:00-14:15 TuBT3.5

Learning Socially Appropriate Robot Approaching Behavior Toward Groups Using Deep Reinforcement Learning,

Gao, Yuan (Uppsala University), Yang, Fangkai (KTH Royal Institute of Technology), Frisk, Martin (Uppsala University), Hernandez, Daniel (University of York), Peters, Christopher (Royal Institute of Technology), Castellano, Ginevra (Uppsala University)

Deep reinforcement learning has recently been widely applied in robotics to study tasks such as locomotion and grasping, but its application to social human-robot interaction (HRI) remains a challenge. In this paper, we present a deep learning scheme that acquires a prior model of robot approaching behavior in simulation and applies it to real-world interaction with a physical robot approaching groups of humans. The scheme, which we refer to as Staged Social Behavior Learning (SSBL), considers different stages of learning in social scenarios. We learn robot approaching behaviors towards small groups in simulation and evaluate the performance of the model using objective and subjective measures in a perceptual study and a HRI user study with human participants. Results show that our model generates more socially appropriate behavior compared to a state-of-the-art model.

14:15-14:30 TuBT3.6

What Do Children Want from a Social Robot? Toward Gratifications Measures for Child-Robot Interaction,

De Jong, Chiara (University of Amsterdam), Kühne, Rinaldo (University of Amsterdam), Peter, Jochen (University of Amsterdam), van Straten, Caroline Lianne (University of Amsterdam), Barco, Alex (ASCoR, University of Amsterdam)

Social robots have, in the case of children, rarely been studied from a uses-and-gratifications perspective. As social robots differ from more traditional media, the first aim of this study was to explore the gratifications that children seek and obtain from social robots. This was investigated in a study among 87 children. The second aim was to develop and initially validate measures for those gratifications. We studied this among a sample of 24 children. The measures for hedonic and social gratifications-obtained worked reasonably well. The measures for hedonic and informative gratifications-sought seemed problematic, whereas the others were acceptable. Our measures present a first step toward enabling future research on children's gratifications of social robots.

TuBT4 Room T4

Situation Awareness and Spatial Cognition (Regular Session)

Chair: Pandey, Amit Kumar — Hanson Robotics

Co-Chair: Louie, Wing-Yue Geoffrey — Oakland University

13:00-13:15 TuBT4.1

Desk Organization: Effect of Multimodal Inputs on Spatial Relational Learning,

Rowe, Ryan (University of Washington), Singhal, Shivam (University of Washington), Yi, Daqing (University of Washington), Bhattacharjee, Tapomayukh (University of Washington), Srinivasa, Siddhartha (University of Washington)

For robots to operate in a three dimensional world and interact with humans, learning spatial relationships among objects in the surrounding is necessary. Reasoning about the state of the world requires inputs from many different sensory modalities including vision and haptics. We examine the problem of desk organization: learning how humans spatially position different objects on a planar surface according to organizational ``preference''. We model this problem by examining how humans position objects given multiple features received from vision and haptic modalities. However, organizational habits vary greatly between people both in structure and adherence. To deal with user organizational preferences, we add an additional modality, ``utility'', which informs on a particular human's perceived usefulness of a given object. Models were trained as generalized (over many different people) or tailored (per person). We use two types of models: random forests, which focus on precise multi-task classification, and Markov logic networks, which provide an easily interpretable insight into organizational habits. The models were applied to both synthetic data, which proved to be learnable when using fixed organizational constraints, and human-study data, on which the random forest achieved over 90% accuracy. Over all combinations of modalities, utility + vision and all of them combined were the most informative for organization. In a follow-up study, we gauged participants preference of desk organizations by a generalized random forest organization vs. by a random model. On average, participants rated the random forest models as 4.15 on a 5-point Likert scale compared to 1.84 for the random model.

13:15-13:30 TuBT4.2

Audio-Visual SLAM towards Human Tracking and Human-Robot Interaction in Indoor Environments,

Chau, Aaron (University of Calgary), Sekiguchi, Kouhei (Kyoto University), Nugraha, Aditya Arie (RIKEN AIP), Yoshii, Kazuyoshi (Kyoto University), Funakoshi, Kotaro (Honda Research Inst. Japan Co., Ltd)

We propose a novel audio-visual simultaneous and localization (SLAM) framework that exploits human pose and acoustic speech of human sound sources to allow a robot equipped with a microphone array and a monocular camera to track, map, and interact with human partners in an indoor environment. Since human interaction is characterized by features perceived in not only the visual modality, but the acoustic modality as well, SLAM systems must utilize information from both modalities. Using a state-of-the-art beam-forming technique, we obtain sound components correspondent to speech and noise; and estimate the Direction-of-Arrival (DoA) estimates of active sound sources as useful representations of observed features in the acoustic modality. Through estimated human pose by a monocular camera, we obtain the relative positions of humans as representation of observed features in the visual modality. Using these techniques, we attempt to eliminate restrictions imposed by intermittent speech, noisy periods, reverberant periods, triangulation of sound-source range, and limited visual field-of-views; and subsequently perform early fusion on these representations. We develop a system that allows for complimentary action between audio-visual sensor modalities in the simultaneous mapping of multiple human sound sources and the localization of observer position.

13:30-13:45 TuBT4.3

Teaching a Robot How to Spatially Arrange Objects: Representation and Recognition Issues,

Buoncompagni, Luca (University of Genoa), Mastrogiovanni, Fulvio (University of Genoa)

This paper introduces a technique to teach robots how to represent and qualitatively interpret perceived scenes in tabletop scenarios. To this aim, we envisage a 3-step human-robot interaction process, in which (i) a human shows a scene to a robot, (ii) the robot memorises a symbolic scene representation (in terms of objects and their spatial arrangement), and (iii) the human can revise such a representation, if necessary, by further interacting with the robot; here, we focus on steps i and ii. Scene classification occurs at a symbolic level, using ontology-based instance checking and subsumption algorithms. Experiments showcase the main properties of the approach, i.e., detecting whether a new scene belongs to a scene class already represented by the robot, or otherwise creating a new representation with a one shot learning approach, and correlating scenes from a qualitative standpoint to detect similarities and differences in order to build a scene hierarchy.

13:45-14:00 TuBT4.4

Simple, Inexpensive, Accurate Calibration of 9 Axis Inertial Motion Unit,

Das, Shome S (Indian Institute of Science, Bangalore)

Absolute orientation estimation is crucial for navigation of robots, drones, unmanned vehicles. It is also needed in bio-metrics, virtual reality, human robot interaction systems and in devices like cell phone, smart watch etc. Nine axis MEMS inertial motion unit(hereafter called IMU) consisting of accelerometer, gyroscope and magnetometer is used widely to obtain absolute orientation. Sensor fusion is used to combine the readings of the individual sensors to obtain correct estimate of the absolute orientation. However MEMS devices are noisy and correct calibration is needed for the sensor fusion to work. Existing libraries on nine axis sensor fusion fail to give accurate drift free orientation estimate as they either don't use accurate calibration algorithms or don't prescribe a way to collect good calibration data. Also it is difficult and time consuming for a hobbyist or a researcher working on bio-metrics or SLAM to implement complex calibration algorithms or to design good calibration rigs. We propose a new calibration setup which consists of some easy to implement calibration algorithms along with a new calibration rig. Our calibration framework attains better accuracy and drift free estimate of absolute orientation than the current state of art libraries.

14:00-14:15 TuBT4.5

Towards a Driver Monitoring System for Estimating Driver Situational Awareness,

Hijaz, Alaaldin (Oakland University), Louie, Wing-Yue Geoffrey (Oakland University), Mansour, Iyad (Dura Automotive)

Abstract— Autonomous vehicle technology is rapidly developing but the current state-of-the-art still has limitations and requires frequent human intervention. However, handovers from an autonomous vehicle to a human driver are challenging because a human operator may be unaware of the vehicle surroundings during a handover which can lead to dangerous driving outcomes. There is presently an urgent need to develop advanced driver-assistance systems capable of monitoring driver situational awareness within an autonomous vehicle and intelligently handing-over control to a human driver in emergency situations. Towards this goal, in this paper we present the development and evaluation of a vision-based system that identifies visual cues of a driver's situational awareness including their: head pose, eye pupil position, average head movement rate and visual focus of attention.

14:15-14:30 TuBT4.6

Automatic Speech-Gesture Mapping and Engagement Evaluation in Human Robot Interaction,

Ghosh, Bishal (Indian Institute of Technology Ropar), Dhall, Abhinav (Indian Institute of Technology Ropar), Singla, Ekta (Indian Institute of Technology Ropar)

In this paper, we present an end-to-end system for enhancing the effectiveness of non-verbal gestures in human robot interaction. We identify prominently used gestures in performances by TED talk speakers and map them to their corresponding speech context and modulated speech based upon the attention of the listener. Gestures are localised with convolution neural networks based approach. Dominant gestures of TED speakers are used for learning the gesture-to-speech mapping. We evaluated the engagement of the robot with people by conducting a social survey. The effectiveness of the performance was monitored by the robot and it self-improvised its speech pattern on the basis of the attention level of the audience, which was calculated using visual feedback from the camera. The effectiveness of interaction as well as the decisions made during improvisation was further evaluated based on the head-pose detection and an interaction survey.

TuBS1 Room T5

Social and Affective Robots (Special Session)

Chair: Sgorbissa, Antonio University of Genova

Co-Chair: Cominelli, Lorenzo E. Piaggio Research Center

13:00-13:15 TuBS1.1

Designing an Experimental and a Reference Robot to Test and Evaluate the Impact of Cultural Competence in Socially Assistive Robotics,

Recchiuto, Carmine Tommaso (University of Genova), Papadopoulos, Chris (University of Bedfordshire), Hill, Tetiana (University of Bedfordshire, Vicarage St, Luton LU13JU, UK), Castro, Nina (Advinia Healthcare, 314 Regents Park Rd, London N32JX, UK), Bruno, Barbara (University of Genova), Papadopoulos, Irena (Middlesex University Higher Education Corporation), Sgorbissa, Antonio (University of Genova)

The article focusses on the work performed in preparation for an experimental trial aimed at evaluating the impact of a culturally competent robot for care home assistance. Indeed, it has been estabilished that the user's cultural identity plays an important role during the interaction with a robotic system and cultural competence may be one of the key elements for increasing capabilities of socially assistive robots.
Specifically, the paper describes part of the work carried out for the definition and implementation of two different robotic systems for the care of older adults: a culturally competent robot, that shows its awareness of the user's cultural identity, and a reference robot, non culturally competent, but with the same functionalities of the former. The design of both robots is here described in detail, together with the key elements that make a socially assistive robot culturally competent, which should be absent in the non-culturally competent counterpart. Examples of the experimental phase of the CARESSES project, with a fictional user are reported, giving a hint of the validness of the proposed approach.

13:15-13:30 TuBS1.2

Using Socially Expressive Mixed Reality Arms for Enhancing Low-Expressivity Robots,

Groechel, Thomas (Univeristy of Southern California), Shi, Zhonghao (Univeristy of Southern California), Pakkar, Roxanna (University of Southern California), Mataric, Maja (University of

Southern California)

Expressivity--the use of multiple modalities to convey internal state and intent of a robot--is critical for interaction. Yet, due to cost, safety, and other constraints, many robots lack high degrees of physical expressivity. This paper explores using mixed reality to enhance a robot with limited expressivity by adding virtual arms that extend the robot's expressiveness. The arms, capable of a range of non-physically-constrained gestures, were evaluated in a between-subject study ($n=34$) where participants engaged in a mixed reality mathematics task with a socially assistive robot. The study results indicate that the virtual arms added a higher degree of perceived emotion, helpfulness, and physical presence to the robot. Users who reported a higher perceived physical presence also found the robot to have a higher degree of social presence, ease of use, usefulness, and had a positive attitude toward using the robot with mixed reality. The results also demonstrate the users' ability to distinguish the virtual gestures' valence and intent.

13:30-13:45 TuBS1.3

Wearable Affective Robot That Detects Human Emotions from Brain Signals by Using Deep Multi-Spectrogram Convolutional Neural Networks (Deep MS-CNN),

Wang, Ker-Jiun (University of Pittsburgh), Zheng, Caroline Yan (Royal College of Art)

Wearable robot that constantly monitors, adapts and reacts to human's need is a promising potential for technology to facilitate stress alleviation and contribute to mental health. Current means to help with mental health include counseling, drug medications, and relaxation techniques such as meditation or breathing exercises to improve mental status. The theory of human touch that causes the body to release hormone oxytocin to effectively alleviate anxiety shed light on a potential alternative to assist existing methods. Wearable robots that generate affective touch have the potential to improve social bonds and regulate emotion and cognitive functions. In this study, we used a wearable robotic tactile stimulation device, AffectNodes2, to mimic human affective touch. The touch-stimulated brain waves were captured from 4 EEG electrodes placed on the parietal, prefrontal and left and right temporal lobe regions of the brain. The novel Deep MS-CNN with emotion polling structure had been developed to extract Affective touch, Non-affective touch and Relaxation stimuli with over 95% accuracy, which allows the robot to grasp the current human affective status. This sensing and decoding structure is our first step towards developing a self-adaptive robot to adjust its touch stimulation patterns to help regulate affective status.

13:45-14:00 TuBS1.4

Real-Time Gazed Object Identification with a Variable Point of View Using a Mobile Service Robot,

Yuguchi, Akishige (Nara Institute of Science and Technology), Inoue, Tomoaki (Nara Institute of Science and Technology), Garcia Ricardez, Gustavo Alfonso (Nara Institute of Science and Techonology (NAIST)), Ding, Ming (Nara Institute of Science and Technology), Takamatsu, Jun (Nara Institute of Science and Technology), Ogasawara, Tsukasa (Nara Institute of Science and Technology)

As sensing and image recognition technologies advance, the environments where service robots operate expand into human-centered environments. Since the roles of service robots depend on the user situations, it is important for the robots to understand human intentions. Gaze information, such as gazed objects (i.e., the objects humans are looking at) can help to understand the users' intentions. In this paper, we propose a real-time gazed object identification method from RGB-D images captured by a camera mounted on a mobile service robot. First, we search for the candidate gazed objects using state-of-the-art, real-time object detection. Second, we estimate the human face direction using facial landmarks extracted by a real-time face detection tool. Then, by searching for an object along the estimated face direction, we identify the gazed object. If the gazed object identification fails even though a user is looking at an object, i.e., has a fixed gaze direction, the robot can determine whether the object is inside or outside the robot's view based on the face direction, and, then, change its point of view to improve the identification. Finally, through multiple evaluation experiments with the mobile service robot Pepper, we verified the effectiveness of the proposed identification and the improvement of the identification accuracy by changing the robot's point of view.

14:00-14:15 TuBS1.5

A Reinforcement-Learning Approach for Adaptive and Comfortable Assistive Robot Monitoring Behaviors,

Raggioli, Luca (University of Naples Federico II), Rossi, Silvia (Universita' Di Napoli Federico II)

Companion robots used in the field of elderly assistive care can be of great value in monitoring their everyday activities and well-being. However, in order to be accepted by the user, their behavior, while monitoring them, should not provide discomfort: robots must take into account the activity the user is performing and not be a distraction for them. In this paper, we propose a Reinforcement Learning approach to adaptively decide a monitoring distance and an approaching direction starting from an estimation of the current activity obtained by the use of a wearable device. Our goal is to improve user activity recognition performance without making the robot's presence uncomfortable for the monitored person. Results show that the proposed approach is promising for real scenario deployment, succeeding in accomplishing the task in more than 80% of episodes run.

14:15-14:30 TuBS1.6

Proposing Human-Robot Trust Assessment through Tracking Physical Apprehension Signals in Close-Proximity Human-Robot Collaboration,

Hald, Kasper (Aalborg University), Rehm, Matthias (Aalborg University), Moeslund, Thomas B. (Aalborg University)

We propose a method of human-robot trust assessment in close-proximity human-robot collaboration involving body tracking for recognition of physical signs of apprehension. We tested this by performing skeleton tracking on 30 participant while they repeated a shared task with a Sawyer robot while reporting trust between tasks. We tested different robot velocity and environment conditions with an unannounced increase in velocity midway through to provoke a dip trust. Initial analysis show significant effect for the test conditions on participant movements and reported trust as well as linear correlations between tracked signs of apprehension and reported trust.

TuCT1 Room T8

Cognitive Skills and Mental Models (Regular Session)

Chair: Lewis, Michael University of Pittsburgh

Co-Chair: Schulz, Trenton University of Oslo

15:00-15:15 TuCT1.1

Ontologenius : A Long-Term Semantic Memory for Robotic Agents,

Sarthou, Guillaume (LAAS-CNRS), Clodic, Aurélie (Laas - Cnrs), Alami, Rachid (CNRS)

In this paper we present Ontologenius, a semantic knowledge storage and reasoning framework for autonomous robots. More than a classic

ontology software to query a knowledge base and a first-order internal logic as it can be done for web-semantics, we propose with Ontologenius features adapted to a robotic use including human-robot interaction setting. Designed to be integrated in a complete robotic architecture we introduce the ability to modify the knowledge base during execution, whether through dialogue or geometric reasoning, and keep these changes even after the robot is powered off. Because Ontologenius was inspired by human behaviors and developed to be used in applications interacting with humans, we propose the possibility to estimate the semantic memory of a partner thus allowing to use the principles of theory of the mind in addition to the ability to estimate new knowledge through a generalization process.
This article presents the architecture of this software and its features, as well as examples of use in robotics applications.

15:15-15:30 TuCT1.2

Mind Perception and Causal Attribution for Failure in a Game with a Robot,

Miyake, Tomohito (Osaka University), Kawai, Yuji (Osaka University), Park, Jihoon (Osaka University), Shimaya, Jiro (Osaka University), Takahashi, Hideyuki (Osaka University), Asada, Minoru (Osaka University)

It is unclear how a human attributes the cause of failure to the robot in a human-robot interaction. We aim to identify the relationship between causal attribution and mind perception in a repeated game with an agent. We investigated causal attribution of the participant to the agent: which decision of the participant or the partner agent caused the unexpectedly small amount of the reward. We conducted experiments with three agent conditions: a human, robot, and computer. The results showed that the agency score negatively correlated with the degree of causal attribution to the partner agent. In particular, correlations of scores of "thought," "memory," "planning," and "self-control" that are sub-items of agency were significant. This implied the impression that ``the agent acted to succeed'' might reduce causal attribution. In addition, we found that decrease in the scores of mind perception correlated with the degree of causal attribution to the partner agent. This suggests that a sense of betrayal of the prior expectation by the partner agent through the game might lead to causal attribution to the partner agent.

15:30-15:45 TuCT1.3

Designing Child-Robot Interaction with Robotito,

Ewelina, Bakała (Facultad De Ingeniería, Universidad De La República, Montevideo), Visca, Jorge (Facultad De Ingeniería, Universidad De La República, Montevideo), Tejera López, Gonzalo Daniel (Universidad De La Republica, Facultad De Ingeniería, Instituto D), Seré, Andrés (Facultad De Ingeniería, Universidad De La República, Montevideo), Amorin, Guillermo (Facultad De Ingeniería, Universidad De La República, Montevideo), Gómez-Sena, Leonel (Laboratorio De Neurociencias, Facultad De Ciencias, Universidad)

Computational thinking is a skill that is considered essential for the future generations. Because of this it should be incorporated into the curricula as soon as possible. An interesting option to work on computational thinking with children is by means of robots. Here, we present Robotito, a robot that can be programmed by arranging its environment, intended to help the development of computational thinking in preschool children. We describe its hardware and software environment, and hierarchical state machines used to implement two modes of interaction with environment- first based on color detection and the second sensible to the surrounding objects. We also present activities that we developed to work on abstraction, generalization, decomposition, algorithmic thinking, and debugging- skills related to computational thinking.

15:45-16:00 TuCT1.4

Conflict Mediation in Human-Machine Teaming: Using a Virtual Agent to Support Mission Planning and Debriefing,

Haring, Kerstin Sophie (University of Denver), Tobias, Jessica (United States Air Force Academy), Waligora, Justin (United States Air Force Academy), Phillips, Elizabeth (Brown University), Tenhundfeld, Nathan (University of Alabama in Huntsville), Gale, Lucas (University of Southern California), De Visser, Ewart (George Mason University), Jonathan, Gratch (University of Southern California), Tossell, Chad (USAF Academy)

Socially intelligent artificial agents and robots are anticipated to become ubiquitous in home, work, and military environments. With the addition of such agents to human teams it is crucial to evaluate their role in the planning, decision making, and conflict mediation processes. We conducted a study to evaluate the utility of a virtual agent that provided mission planning support in a three-person human team during a military strategic mission planning scenario. The team consisted of a human team lead who made the final decisions and three supporting roles, two humans and the artificial agent. The mission outcome was experimentally designed to fail and introduced a conflict between the human team members and the leader. This conflict was mediated by the artificial agent during the debriefing process through discuss or debate and open communication strategies of conflict resolution [1]. Our results showed that our teams experienced conflict. The teams also responded socially to the virtual agent, although they did not find the agent beneficial to the mediation process. Finally, teams collaborated well together and perceived task proficiency increased for team leaders. Socially intelligent agents show potential for conflict mediation, but need careful design and implementation to improve team processes and collaboration.

16:00-16:15 TuCT1.5

Towards Automatic Visual Fault Detection in Highly Expressive Human-Like Animatronic Faces with Soft Skin,

Mayet, Ralf (Hanson Robotics), Diprose, James (Hanson Robotics), Pandey, Amit Kumar (Hanson Robotics)

Designing reliable, humanoid social robots with highly expressive human-like faces is a challenging problem. Their construction requires complex mechanical assemblies, large numbers of actuators and involves soft material. When deploying these robots in the field they face problems of wear and tear and mechanical abuse. Mechanical defects of such faces can be hard to analyze automatically or by manual visual inspection. We propose a method of automatic visual calibration and actuator fault detection for complex animatronic faces. We use our approach to scan three expressive animatronic faces, and analyze the data. Our findings indicate that our approach is able to detect faulty actuators even when they contribute to the overall expression of the face only marginally, and are hard to spot visually.

16:15-16:30 TuCT1.6

Differences of Human Perceptions of a Robot Moving Using Linear or Slow In, Slow Out Velocity Profiles When Performing a Cleaning Task,

Schulz, Trenton (University of Oslo), Holthaus, Patrick (University of Hertfordshire), Amirabdollahian, Farshid (The University of Hertfordshire), Koay, Kheng Lee (University of Hertfordshire), Torresen, Jim (University of Oslo), Herstad, Jo (University of Oslo)

We investigated how a robot moving with different velocity profiles affects a person's perception of it when working together on a task. The two profiles are the standard linear profile and a profile based on the animation principles of slow in, slow out. The investigation was

accomplished by running an experiment in a home context where people and the robot cooperated on a clean-up task. We used the Godspeed series of questionnaires to gather people's perception of the robot. Average scores for each series appear not to be different enough to reject the null hypotheses, but looking at the component items provides paths to future areas of research. We also discuss the scenario for the experiment and how it may be used for future research into using animation techniques for moving robots and improving the legibility of a robot's locomotion.

TuCT2	Room T2
HRI and Collaboration in Manufacturing Environment (Regular Session)	
Chair: Penders, Jacques	Sheffield Hallam University
Co-Chair: Beran, Vitezslav	Brno University of Technology

15:00-15:15 TuCT2.1

Combining Interactive Spatial Augmented Reality with Head-Mounted Display for End-User Collaborative Robot Programming,

Bambusek, Daniel (Brno University of Technology, Faculty of Information Technology), Materna, Zdenek (Faculty of Information Technology, Brno University of Technology), Kapinus, Michal (Brno University of Technology, Faculty of Information Technology), Beran, Vitezslav (Brno University of Technology), Smrz, Pavel (Brno University of Technology)

This paper proposes an intuitive approach for collaborative robot end-user programming using a combination of interactive spatial augmented reality (ISAR) and head-mounted display (HMD). It aims to reduce user's workload and to let the user program the robot faster than in classical approaches (e.g. kinesthetic teaching). The proposed approach, where user is using a mixed-reality HMD - Microsoft HoloLens - and touch-enabled table with SAR projected interface as input devices, is compared to a baseline approach, where robot's arms and a touch-enabled table are used as input devices. Main advantages of the proposed approach are the possibility to program the collaborative workspace without the presence of the robot, its speed in comparison to the kinesthetic teaching and an ability to quickly visualize learned program instructions, in form of virtual objects, to enhance the users' orientation within those programs. The approach was evaluated on a set of 20 users using the within-subject experiment design. Evaluation consisted of two pick and place tasks, where users had to start from the scratch as well as to update the existing program. Based on the experiment results, the proposed approach is better in qualitative measures by 33.84% and by 28.46% in quantitative measures over the baseline approach for both tasks.

15:15-15:30 TuCT2.2

Modulating Human Input for Shared Autonomy in Dynamic Environments,

Mower, Christopher Edwin (University of Edinburgh), Moura, Joao (Heriot-Watt University), Davies, Aled (Costain Group PLC), Vijayakumar, Sethu (University of Edinburgh)

Many robotic tasks require human interaction through teleoperation to achieve high performance. However, in industrial applications these methods often require high levels of concentration and manual dexterity leading to high cognitive loads and dangerous working conditions. Shared autonomy attempts to address these issues by blending human and autonomous reasoning, relieving the burden of precise motor control, tracking, and localization. In this paper we propose an optimization-based representation for shared autonomy in dynamic environments. We ensure real-time tractability by modulating the human input with the information of the changing environment in the same task space, instead of adding it to the optimization cost or constraints. We illustrate the method with two real world applications: grasping objects in a cluttered environment, and a spraying task requiring sprayed linings with greater homogeneity. Finally we use a 7 degree of freedom KUKA LWR arm to simulate the grasping and spraying experiments.

15:30-15:45 TuCT2.3

Seamless Manual-To-Autopilot Transition: An Intuitive Programming Approach to Robotic Welding,

Eto, Haruhiko (Massachusetts Institute of Technology), Asada, Harry (MIT)

An intuitive on-site robot programming method for small-lot robotic welding is presented. In current robotic welding, a human operator has to input numerous parameters, including feedrate, swing width, and frequency, by using a teach pendant or a control panel before executing the task. This traditional approach is suitable for mass production, but requires tedious, time-consuming programming, which does not fit low-volume manufacturing, such as shipbuilding. In this paper, a method is developed for acquiring those parameters directly from an on-site human demonstration and seamlessly transitioning from manual operation to automatic control. With this method, a welding worker can directly execute a welding task, and the motion of a welding torch is observed, from which key parameters are identified and the machine performs the rest of the task autonomously. No tedious parameter input is required, but the worker can jump-start the task. The motion of a welding torch is represented as a combination of sinusoidal and linear functions. Discrete Fourier Transform (DFT) and Recursive Least Squares (RLS) estimates are used for identifying the parametric model in real time. Furthermore, an algorithm is developed for determining whether an appropriate estimation result has been obtained and when to switch from manual operation to autonomous control. The method is implemented on a virtual teleoperation system and seamless control transition is demonstrated.

15:45-16:00 TuCT2.4

Teaching Method for Robot's Gripper Posture with a Laser Sensor on a Pan-Tilt Actuator: A Method for Specifying Posture Feature Curves and Posture Feature Point,

Ishihata, Kenji (Hiroshima City University), Sato, Kenjiro (Hiroshima City University), Fukui, Yuta (Hiroshima City Univercity), Iwaki, Satoshi (Hiroshima City University), Ikeda, Tetsushi (Hiroshima City University)

Recently a lot of robots have been developed for supporting our daily life or patient care. In order to instruct such a support robot that can work in such cluttered environments, we have conventionally developed an intuitive robot teaching interface using a TOF laser sensor on a pan-tilt actuator driven by a user. This interface enables us to control the direction of the laser spot to “click” a real object and instruct a robot to manipulate it by drag-and-drop operation throughout a PC world and a real world. In our conventional system, however, the success rates of grasping object was very low because only the position of the object can be taught, not the orientation of the object. To cope with the problem, in this paper we propose a system to easily grasp an object of arbitrary posture by measuring the locus of the laser spot using our real world click system. Some grasping experiments on various daily objects showed the effectiveness of the proposed method.

16:00-16:15 TuCT2.5

Model Checking Human-Agent Collectives for Responsible AI,

Abeywickrama, Dhaminda (University of Southampton), Cirstea, Corina (Electronics and Computer Science, University of

Southampton), Ramchurn, Sarvapali (University of Southampton)

Humans and agents often need to work together and agree on collective decisions. Ensuring that autonomous systems work responsibly is complex especially when encountering dilemmas. This paper proposes a novel, systematic model checking approach to responsible decision making by a human-agent collective to ensure it is safe, controllable and ethical. Our approach, which is based on the MCMAS model checker, verifies the permissibility of an agent's actions by checking the decision-making behaviour against the logical formulae specified for safety, controllability and ethical behaviour. The verification results through counterexamples and simulation results can provide a judgement, and an explanation to the AI engineer of the reasons actions are refused or allowed.

16:15-16:30 TuCT2.6

IoT Based Submersible ROV for Pisciculture,

Rohit, Mehboob Hasan (North South University), Barua, Sailanjan (North South University), Akter, Irin (North South University), Karim, S M Mujibul (North South University), Akter, Sharmin (North South University), Elahi, M. M. Lutfe (North South University)

Pisciculture refers to the controlled commercial breeding and raising fish in tanks or enclosures such as fish ponds. An automated IOT based system for fish farming has been developed which actually reduces the human effort required and maximize fish production. Our system can be placed in the center of a submersible ROV and explore underwater for real-time monitoring of fishes and water quality parameters. Multiple sensors are integrated into the system to record essential data that sends these data to the user through Message Queuing Telemetry Transport (MQTT) protocol. A Single Board Computer is used for processing images such as fish counting and fish size measurement. The user can also control different aqua tools and calibrate the sensors via IOT. The system can closely monitor for any changes in the fish environment and notify the user and take necessary actions to reestablish a suitable environment.

TuCT3 Room T3

Social Robots III (Regular Session)

Chair: Suri, Venkata Ratnadeep — Indraprasta Institute of Information Technology, Delhi, (IIIT-Delhi)

Co-Chair: Zibetti, Elisabetta — CHART-LUTIN

15:00-15:15 TuCT3.1

Teaching Pepper Robot to Recognize Emotions of Traumatic Brain Injured Patients Using Deep Neural Networks,

Ilyas, Chaudhary Muhammad (Aalborg University), Schmuck, Viktor (Aalborg University, Denmark), Haque, Mohammad Ahsanul (Aalborg University), Nasrollahi, Kamal (Aalborg University), Rehm, Matthias (Aalborg University), Moeslund, Thomas B. (Aalborg University)

Social signal extraction from the facial analysis is a popular research area in human-robot interaction. However, recognition of emotional signals from Traumatic Brain Injured (TBI) patients with the help of robots and non-intrusive sensors is yet to be explored. Existing robots have limited abilities to automatically identify human emotions and respond accordingly. Their interaction with TBI patients could be even more challenging and complex due to unique, unusual and diverse ways of expressing their emotions. To tackle the disparity in a TBI patient's Facial Expressions (FEs), a specialized deep-trained model for automatic detection of TBI patients' emotions and FE (TBI-FER model) is designed, for robot-assisted rehabilitation activities. In addition, the Pepper robot's built-in model for FE is investigated on TBI patients as well as on healthy people. Variance in their emotional expressions is determined by comparative studies. It is observed that the customized trained system is highly essential for the deployment of Pepper robot as a Socially Assistive Robot (SAR).

15:15-15:30 TuCT3.2

Mood Estimation As a Social Profile Predictor in an Autonomous, Multi-Session, Emotional Support Robot for Children,

Gamborino, Edwinn (National Taiwan University), Yueh, Hsiu-Ping (National Taiwan University), Lin, Weijane (National Taiwan University), Yeh, Su-Ling (National Taiwan University), Fu, Li-Chen (National Taiwan University)

In this work, we created an end-to-end autonomous robotic platform to give emotional support to children in long-term, multi-session interactions. Using a mood estimation algorithm based on visual cues of the user's behaviors through their facial expressions and body posture, a multi-dimensional model predicts a qualitative measure of the subject's affective state. Using a novel Interactive Reinforcement Learning algorithm, the robot is able to learn over several sessions the social profile of the user, adjusting its behavior to match their preferences. Although the robot is completely autonomous, a third party can optionally provide feedback to the robot through an additional UI to accelerate its learning of the user's preferences. To validate the proposed methodology, we evaluated the impact of the robot on elementary school aged children in a long-term, multi-session interaction setting. Our findings show that using this methodology, the robot is able to learn the social profile of the users over a number of sessions, either with or without external feedback as well as maintain the user in a positive mood, as shown by the consistently positive rewards received by the robot using our proposed learning algorithm.

15:30-15:45 TuCT3.3

Mapping Robotic Affordances with Pre-Requisite Learning Interventions for Children with Autism Spectrum Disorder,

Shukla, Jainendra (Indraprastha Institute of Information Technology, Delhi), Suri, Venkata Ratnadeep (Indraprasta Institute of Information Technology, Delhi, (IIIT-De), Garg, Jatin (Indraprastha Institute of Information Technology Delhi), Verma, Krit (Indraprastha Institute of Information Technology Delhi), Kansal, Prarthana (IIIT Delhi)

For children with Autism Spectrum Disease (ASD), pre-requisite learning (PRL) skills are particularly important because they form the basis for acquiring other advanced cognitive skills. Globally, researchers have shown that robot-assisted therapy (RAT) can have several positive effects on children with ASD. However, previous researches have failed in clearly mapping the PRL skill training tasks and strategies to robot affordances. In this research, we foster a better understanding of the objectives of the PRL skills required for children with ASD and provide a mapping with robot affordances to execute PRL training activities. In-depth interviews and focus group discussions (N=25) with paediatricians, ASD therapists, and educators from three nonprofit organisations were conducted to understand the clinical practices for teaching PRL skills among children with ASD. Naturalistic observations were used to understand the exercise and training protocols implemented for improving PRL skills among children with ASD. Finally, clinical literature on robotic therapy and technical documents provided by the manufacturers were analysed for identifying commercially available robots and evaluating their features and affordances. Our analysis revealed that affordances offered by several commercially available robots could be effectively leveraged to develop Robot-Assisted Therapies (RATs) to improve PRL skills in children with ASD. Strategies and implications for developing RATs to improve PRL skills among children with ASD are discussed.

15:45-16:00 TuCT3.4

Health Counseling by Robots: Modalities for Breastfeeding Promotion,

Murali, Prasanth (Khoury College of Computer Science), O'Leary, Teresa (Khoury College of Computer and Information Science), Shamekhi, Ameneh (Northeastern University), Bickmore, Timothy (Northeastern University)

Conversational humanoid robots are being increasingly used for health education and counseling. Prior research provides mixed indications regarding the best modalities to use for these systems, including user inputs spanning completely constrained multiple choice options vs. unconstrained speech, and embodiments of humanoid robots vs. virtual agents, especially for potentially sensitive health topics such as breastfeeding. We report results from an experiment comparing five different interface modalities, finding that all result in significant increases in user knowledge and intent to adhere to recommendations, with few differences among them. Users are equally satisfied with constrained (multiple choice) touch screen input and unconstrained speech input, but are relatively unsatisfied with constrained speech input. Women find conversational robots are an effective, safe, and non-judgmental medium for obtaining information about breastfeeding.

16:00-16:15 TuCT3.5

Persuasive ChairBots: A (Mostly) Robot-Recruited Experiment,

Agnihotri, Abhijeet (Oregon State University), Knight, Heather (Oregon State University)

Robot furniture is a growing area of robotics research, as people easily anthropomorphize these simple robots and they fit in easily to many human environments. Could they also be of service in recruiting people to play chess? Prior work has found motion gestures to aid in persuasion, but this work has mostly occurred in in-lab studies and has not yet been applied to robot furniture. This paper assessed the efficacy of four motion strategies in persuading passerbyers to participate in a ChairBot Chess Tournament, which consisted of a table with a chessboard and two ChairBots -- one for the white team, and another for the black team. The study occurred over a six-week period, seeking passersby to play chess in the atrium of our Computer Science building for an hour each Friday. Forward-Back motion was the most effective strategy in getting people to come to the table and play chess, while Spinning was the worst. Overall, people found the ChairBots to be friendly and somewhat dog-like. In-the-wild studies are challenging, but produce data that is highly likely to be replicable in future versions of the system. The results also support the potential of future robots to recruit participants to activities that they might already enjoy.

16:15-16:30 TuCT3.6

Robot-Assisted Therapy for Children with Delayed Speech Development: A Pilot Study,

Zhanatkyzy, Aida (Nazarbayev University), Turarova, Aizada (Nazarbayev University), Telisheva, Zhansaule (Nazarbayev University), Abylkasymova, Galiya (Republican Children's Rehabilitation Center), Sandygulova, Anara (Nazarbayev University)

This paper presents a study that aims to investigate the effects of Robot-Assisted Therapy (RAT) on children who have a form of verbal and mental development retardation disability. To this end, we developed a number of applications for a humanoid robot NAO with the aim to engage children during RAT sessions. We conducted an evaluation of these applications with children with Delayed Speech Development (DSD) who interacted with the robot on a few occasions. Our findings demonstrate the utility of such applications for the therapy of DSD children which was both engaging and entertaining. Similar approach could be utilized for the therapy of children with Autism Spectrum Disorder and Attention Deficit Hyperactivity Disorder.

TuCT4 Room T4

Visual Perception and Autonomous Robots (Regular Session)

Chair: Hayashi, Kotaro — Toyohashi University of Technology

Co-Chair: Chemori, Ahmed — Lirmm - Cnrs

15:00-15:15 TuCT4.1

Grasping of Novel Objects for Robotic Pick and Place Applications,

Vohra, Mohit (Indian Institute of Technology, Kanpur), Prakash, Ravi (Indian Institute of Technology, Kanpur), Behera, Laxmidhar (IIT Kanpur)

Grasping of novel objects in pick and place applications is a fundamental and challenging problem in robotics, specifically for complex-shaped objects. It is observed that the well-known strategies like i) grasping from the centroid of object and ii) grasping along the major axis of the object often fails for complex-shaped objects. In this paper, a real-time grasp pose estimation strategy for novel objects in robotic pick and place applications is proposed. The proposed technique estimates the object contour in the point cloud and predicts the grasp pose along with the object skeleton in the image plane. The technique is tested for the objects like ball container, hand weight, tennis ball and even for complex shape objects like blower (non-convex shape). It is observed that the proposed strategy performs very well for complex shaped objects and predicts the valid grasp configurations in comparison with the above strategies. The experimental validation of the proposed grasping technique is tested in two scenarios, when the objects are placed distinctly and when the objects are placed in dense clutter. A grasp accuracy of 88.16% and 77.03% respectively are reported. All the experiments are performed with a real UR10 robot manipulator along with WSG-50 two-finger gripper for grasping of objects.

15:15-15:30 TuCT4.2

A Novel Image-Based Path Planning Algorithm for Eye-In-Hand Visual Servoing of a Redundant Manipulator in a Human Centered Environment,

Raina, Deepak (TCS Robotics Innovation Lab), P, Mithun (International Institute of Information Technology Hyderabad), Shah, Suril Vijaykumar (Indian Institute of Technology Jodhpur), Swagat, Kumar (Tata Consultancy Services)

This paper presents a novel image-based path-planning and execution framework for vision-based control of a robot in a human centered environment. The proposed method involves applying Rapidly-exploring Random Tree (RRT) exploration to perform Image-Based Visual Servoing (IBVS) while satisfying multiple task constraints by exploiting robot redundancy. The methodology incorporates data-set of robot's workspace images for path-planning and design a controller based on visual servoing framework. This method is generic enough to include constraints like Field-of-View (FoV) limits, joint limits, obstacles, various singularities, occlusions etc. in the planning stage itself using task function approach and thereby avoiding them during the execution. The use of path-planning eliminates many of the inherent limitations of IBVS with eye-in-hand configuration and makes the use of visual servoing practical for dynamic and complex environments. Several experiments have been performed on a UR5 robotic manipulator to demonstrate that it is an effective and robust way to guide a robot in such environments.

15:30-15:45 TuCT4.3

A Novel Geometry-Based Algorithm for Robust Grasping in Extreme Clutter Environment,

Kundu, Olyvia (TCS Innovation Labs), Swagat, Kumar (Tata Consultancy Services)

This paper looks into the problem of grasping unknown objects in a cluttered environment using a 3D point cloud data obtained from a range sensor or an RGBD sensor. The objective is to identify graspable regions and detect suitable grasp poses from a single view, possibly, partial 3D point cloud without any apriori knowledge of the object geometry. The problem is solved in two steps - first, identifying and segmenting various object surfaces and second, searching for suitable grasping handles on these surfaces by applying geometric constraints of the physical gripper. The first step is solved by using a modified version of region growing algorithm that uses a pair of thresholds for the smoothness constraint on local surface normals to find natural boundaries of object surfaces. In this process, a novel concept of edge point is introduced that allows us to segment between different surfaces of the same object. The second step is solved by converting a 6D pose detection problem into a 1D linear search problem by projecting 3D cloud points onto the principal axes of the surface segment obtained in the first step. The graspable handles are then localized by applying physical constraints of the gripper. The resulting method allows us to grasp all kinds of objects including rectangular or box-type objects with flat surfaces which is otherwise considered to be difficult in the grasping literature. The proposed method is simple and can be implemented in real-time and does not require any off-line training phase for computing these affordances. The improvements achieved is demonstrated through comparison with another state-of-the-art grasping algorithm on various publicly-available datasets. We also contribute a new grasping dataset for extreme clutter situations.

15:45-16:00 TuCT4.4

Fatigue Estimation Using Facial Expression Features and Remote-PPG Signal,

Hasegawa, Masaki (Toyohash University of Technology), Hayashi, Kotaro (Toyohashi University of Technology), Miura, Jun (Toyohashi University of Technology)

Currently, research and development of lifestyle support robots in daily life is being actively conducted. Healthcase is one such function robots. In this research, we develop a fatigue estimation system using a camera that can easily be mounted on robots. Measurements taken in a real environment have to be consider noises caused by changes in light and the subject's movement. This fatigue estimation system is based on a robust feature extraction method. As an indicator of fatigue, LF/HF-ratio was calculated from the power spectrum of RR interval in the electrocardiogram or the blood volume pulse (BVP). The BVP can be detected from the fingertip by using the photoplethysmography (PPG). In this study, we used a contactless PPG: remote-PPG (rPPG) detected by the luminance change of the face image. Some studies show facial expression features extracted from facial video are also useful for fatigue estimation. dimension reduction of past method using LLE spoiled the information in the large dimention of feature. We also developed a fatigue estimation method with such features using a camera for the healthcare robots. It used facial landmark points, line-of-sight vector, and size of the ellipse fitted with eyes and mouth landmark points. Therefore, proposed method simply use time-varying shape information of face like size of eyes, or gaze direction. We verified the performance of proposed features by the fatigue state classification using Support Vector Machine (SVM).

16:00-16:15 TuCT4.5

Model & Feature Agnostic Eye-In-Hand Visual Servoing Using Deep Reinforcement Learning with Prioritized Experience Reply,

Singh, Prerna (Tata Consultancy Services), Singh, Virender (TCS), Dutta, Samrat (TCS Research and Innovation), Swagat, Kumar (Tata Consultancy Services)

This paper presents a feature agnostic and model- free visual servoing (VS) technique using deep reinforcement learning (DRL) which exploits two new architectures of ex- perience replay buffer in deep deterministic policy gradient (DDPG). The proposed architectures are significantly fast and converge in a few numbers of steps. We use the proposed method to learn an end-to-end VS with eye-in-hand configuration. In traditional DDPG, the experience replay memory is randomly sampled for training the actor-critic network. This results in a loss of useful experiences when the buffer contains very few successful examples. We solve this problem by proposing two new replay buffer architectures: (a) min- heap DDPG (mH-DDPG) and (b) dual replay buffer DDPG (dR-DDPG). The former uses a min-heap data structure to implement the replay buffer whereas the latter uses two buffers to separate “good” examples from the “bad” examples. The training data for the actor-critic network is created as a weighted combination of the two buffers. The proposed algorithms are validated in simulation with the UR5 robotic manipulator model. It is observed that as the number of good experiences increases in the training data, the convergence time decreases. We find 27.25% and 43.25% improvements in the rate of convergence respectively by mH-DDPG and dR-DDPG over state-of-the-art DDPG.

16:15-16:30 TuCT4.6

Reasoning on Shared Visual Perspective to Improve Route Directions,

Waldhart, Jules (LAAS-CNRS), Clodic, Aurélie (Laas - Cnrs), Alami, Rachid (CNRS)

We claim that providing route directions can be best dealt with as a joint task where not only the robot as a direction provider but also the human as listener must be modeled and taken into account for planning. Moreover, we claim that in some cases, the robot should go with the human to reach a different perspective of the environment that allows the explanations to be more efficient. As a first step toward implementing such a system, we propose the SVP (Shared Visual Perspective) planner that searches for the right placements both for the robot and the human to enable efficient visual perspective sharing needed for providing route direction and enables to choose the best landmark when several are available. The shared perspective is chosen taking into account not only the visibility of the landmarks, but most importantly the whole guiding task. We use the SVP planner to produce solutions to the guiding problem showing the influence of the choice of the perspective on the qualitative quality of the route direction providing task.

TuCS1 Room T5

Social Human Robot Interaction of Service Robots (Special Session)

Chair: Ahn, Ho Seok — The University of Auckland, Auckland

Co-Chair: Jang, Minsu — Electronics & Telecommunications Research Institute

15:00-15:15 TuCS1.1

Human Interaction and Improving Knowledge through Collaborative Tour Guide Robots,

Velentza, Anna Maria (University of Birmingham, University of Macedonia), Heinke, Dietmar (University of Birmingham), Wyatt, Jeremy (University of Birmingham)

In the coming years tour guide robots will be widely used in museums

and exhibitions. Therefore, it is important to identify how these new museum guides can optimally interact with visitors. In this paper, we introduce the idea of two collaborative tour guide robots. We have been inspired by evidence from cognitive studies stating that people remember more when they receive information from two different human speakers. Our collaborative tour guides were benchmarked against single robot guides. Our study initially proved, through real-world experiments, previous proposals stating that the personality of the robot affects the human learning process; our results demonstrate that people remember significantly more information when they are guided by a cheerful robot than when their guide is a serious one. Moreover, another important outcome of our study is that our visitors tend to like more our collaborative robots, than any referenced single robot, as demonstrated by the higher scores in the aesthetic-related questions. Hence our results suggest that a cheerful robot is more suitable for learning purposes while two robots are more suitable for entertainment purposes.

15:15-15:30 TuCS1.2

Identity, Gender, and Age Recognition Convergence System for Robot Environments,

Jang, Jaeyoon (ETRI)

This paper proposes a new identity, gender, and age recognition convergence system for robot environments. In a robot environment, it is difficult to apply deep learning based methods because of various limitations. To overcome the limitations, we propose a shallow deep-learning fusion model that can calculate identity, gender, and age at once, and a technique for improving recognition performance. Using convergence network, we can obtain three pieces of information from a single input through a single operation. In addition, we propose a 2D / 3D augmentation method to generate virtual additional datasets for learning data. The proposed method has a smaller model size and faster computation time than existing methods and uses a very small number of parameters. Through the proposed method, we finally achieved 99.35%, 90.0%, and 60.9% / 94.5% of performance in identity recognition, gender recognition, and age recognition. In all experiments, we did not exceed the state-of-the-art results, but compared to other studies, we obtained performance similar to the previous study using only less than 10% parameters. In some experiments, we also achieved state-of-the-art result.

15:30-15:45 TuCS1.3

Hospital Receptionist Robot V2: Design for Enhancing Verbal Interaction with Social Skills,

Ahn, Ho Seok (The University of Auckland, Auckland), Lim, Jong Yoon (University of Auckland), Ahn, Byeong-Kyu (Sungkyunkwan University), Johanson, Deborah (The University of Auckland), Hwang, Eui Jun (The University of Auckland), Lee, Min Ho (University of Auckland), Broadbent, Elizabeth (University of Auckland), MacDonald, Bruce (University of Auckland)

This paper presents a new version of robot receptionist system for healthcare facility environment. Our HealthBots consists of three subsystems: a receptionist robot system, a nurse assistant robot system, and a medical server. Our first version of receptionist robot, interacts with human at hospital reception, gives instructions to human verbally, but cannot understand what human says, so it uses a touch screen to get the response from human. In this paper, we design a receptionist robot that recognizes human face as well as speech, which enhances verbal interaction skill of robot. In addition, we design a reaction generation engine to generate appropriate reactive motions and speech. Moreover, we study which social skills are important to a hospital receptionist robot to enhance social interaction, such as friendliness and attention. We implemented perception modules, decision-making modules, and reaction modules to our HealthBots architecture, and did two case studies to find essential social skills for hospital receptionist robots.

15:45-16:00 TuCS1.4

Developing a Questionnaire to Evaluate Customers' Perception in the Smart City Robotic Challenge,

Wang, Lun (Sapienza University of Rome), Iocchi, Luca (Sapienza University of Roma), Marrella, Andrea (Sapienza University of Rome, Italy), Nardi, Daniele (Sapienza University of Rome)

In this paper, we present an approach to develop a new type of questionnaire for evaluating customers' perceptions in the upcoming Smart CIty RObotic Challenge (SciRoc). The approach consists of two steps. First, it relies on interviewing experts on Human-Robot Interaction (HRI) to understand which robot's behaviours can potentially affect the users' perceptions during a HRI task. Then, it leverages a user survey to filter out those robot's behaviours that are not significantly relevant from the end user perspective. We concretely enacted our approach over a specific scenario developed in the context of SciRoc, which instructs a robot to take an elevator of a shopping mall asking support to the customers of the mall. The results of the survey have allowed us to derive a final list of 17 behaviours to be captured in the questionnaire, which has been finally developed relying on a 5-point Likert-scale.

16:00-16:15 TuCS1.5

TeachMe: Three-Phase Learning Framework for Robotic Motion Imitation Based on Interactive Teaching and Reinforcement Learning,

Kim, Taewoo (University of Science and Technology), Lee, Joo-Haeng (ETRI)

Motion imitation is a fundamental communication skill for a robot specially as a nonverbal interaction with human. Due to kinematic configuration differences between human and robot, however, it is still challenging to find a proper mapping between two pose domains. Moreover, technical limitations of extracting 3D motion details such as a wrist joint from human motion videos makes motion retargeting more difficult. Explicit mapping over different motion domains could be a very inefficient solution. To solve these problems, we propose a three-phase reinforcement learning scheme to make a NAO robot to learn motions from human pose skeletons extracted from video inputs. Our learning scheme consists of three phases: (i) phase one for learning preparation, (ii) phase two for a simulation-based reinforcement learning, and (iii) phase three for a human-in-the-loop reinforcement learning. In phase one, embeddings of human skeleton and robot motions are learnt by AutoEncoder. In phase two, NAO robot can learn a rough imitation skill using reinforcement learning that translates learned embeddings. In the last phase, it learns motion details which are not considered in the previous phases by interactively setting rewards based on direct teaching over the policy of the previous phase. Especially, it is notable that relatively smaller number of interactive inputs are required for motion details in phase three, compared with the large volume of training sets for overall imitation in phase two. Experimental results show that the proposed method improves imitation skills efficiently for hand waving and salute motions from NTU-DB.

16:15-16:30 TuCS1.6

Lindsey the Tour Guide Robot - Usage Patterns in a Museum Long-Term Deployment,

Del Duchetto, Francesco (University of Lincoln), Baxter, Paul Edward (University of Lincoln), Hanheide, Marc (University of Lincoln)

The long-term deployment of autonomous robots co-located with

humans in real-world scenarios remains a challenging problem. In this paper, we present the ``Lindsey'' tour guide robot system in which we attempt to increase the social capability of current state-of-the-art robotic technologies. The robot is currently deployed at a museum displaying local archaeology where it is providing guided tours and information to visitors. The robot is operating autonomously daily, navigating around the museum and engaging with the public, with on-site assistance from roboticists only in cases of hardware/software malfunctions. In a deployment lasting seven months up to now, it has travelled nearly 300km and has delivered more than 2300 guided tours. First, we describe the robot framework and the management interfaces implemented. We then analyse the data collected up to now with the goal of understanding and modelling the visitors' behavior in terms of their engagement with the technology. These data suggest that while short-term engagement is readily gained, continued engagement with the robot tour guide is likely to require more refined and robust socially interactive behaviours. The deployed system presents us with an opportunity to empirically address these issues.

Technical Program for Wednesday October 16, 2019

WeAT1	Room T8
Machine Learning and Adaptation (Regular Session)	
Chair: Gupta, Kamal	Simon Fraser University
Co-Chair: Busch, Baptiste	EPFL

10:30-10:45 WeAT1.1

HiFI: A Hierarchical Framework for Incremental Learning Using Deep Feature Representation,

Raj, Ankita (IIT Delhi), Majumder, Anima (Tata Consultancy Services), Swagat, Kumar (Tata Consultancy Services)

The presented work focuses on automatic recognition of object classes while ensuring near real-time training required for recognizing a new object not seen previously. This is achieved by proposing a two-stage hierarchical deep learning framework which first learns object categories using a Nearest Class Mean (NCM) classifier applied directly to CNN features and then, uses a two-layer artificial neural network to learn the object labels within each category. In order to recognize a new object not seen earlier, the category is identified first and then the second stage neural network is incrementally trained with the features of the new object without forgetting previously learnt labels. The proposed hierarchical framework is shown to provide comparable recognition accuracy with significant reduction in overall computational time in recognizing new objects compared to methods that use end-to-end re-training. The efficacy of the approach is demonstrated through comparison with existing state-of-the-art methods on the publicly available CORe50 dataset.

10:45-11:00 WeAT1.2

Reinforcement Learning Motion Planning for an EOG-Centered Robot Assisted Navigation in a Virtual Environment,

Garrote, Luís Carlos (Institute of Systems and Robotics), Perdiz, João (University of Coimbra), Pires, Gabriel (University of Coimbra), Nunes, Urbano J. (Instituto De Sistemas E Robotica)

This paper presents a new collaborative approach for robot motion planning of an assistive robotic platform that takes into account the intentions of the user provided through Electrooculographic (EOG) signals, as well as obstacles surrounding the robotic platform. In order to increase human confidence in the operation of robotic platforms with some degree of navigational autonomy, the intent of the user must be included in the decision process. In our system, the human-robot interface works through ocular movements (saccades and blinks), which are acquired as EOG signals and classified using a Convolutional Neural Network. In our proposed approach, a model-free Reinforcement Learning (RL) layer is used to provide commands to a virtual robotic platform. The RL layer is constantly being updated with the inputs from the user's intent, environment perception and previous machine-based decisions. In order to prevent collisions, machine-based perception using the proposed RL motion planning approach will assist the user by selecting suitable actions while learning from prior driving behaviors. The approach was validated by a set of tests that consisted of driving a robotic platform in an in-house 3D virtual model of our Research Center (ISR-UC). The experimental results show a better performance of the proposed approach with RL when compared to the version without the RL-based motion planning component. Results show that the approach is a promising step in the concept put forward for collaborative Human-Robotic Interaction (HRI), and opens a path for future research.

11:00-11:15 WeAT1.3

Identifying Multiple Interaction Events from Tactile Data During Robot-Human Object Transfer,

Davari, Mohammad-Javad (Simon Fraser University), Hegedus, Michael James (Simon Fraser University), Gupta, Kamal (Simon Fraser University), Mehrandezh, Mehran (University of Regina)

During a robot to human object handover task, several intended or unintended events may occur with the object - it may be pulled, pushed, bumped or simply held - by the human receiver. We show that it is possible to differentiate between these events solely via tactile sensors. Training data from tactile sensors were recorded during interaction of human subjects with the object held by a 3-finger robotic hand. A Bag of Words approach was used to automatically extract effective features from the tactile data. A Support Vector Machine was used to distinguish between the four events with over 95 percent average accuracy.

11:15-11:30 WeAT1.4

Accuracy Improvement of Facial Expression Recognition in Speech Acts: Confirmation of Effectiveness of Information Around a Mouth and GAN-Based Data Augmentation,

Song, KyuSeob (KAIST (Korea Advanced Institute of Science and Technology)), Kwon, Dong-Soo (KAIST)

With the growth of the social robot market, much research has been undertaken on facial expression recognition, which is an important function of a social robot. Facial expression recognition models have shown good performance in a facial expression image dataset that expresses emotion without considering speaking effect. However, in reality, humans often express emotions by speaking and moving the muscles around the mouth. Therefore, the lack of consideration of speech leads to unsatisfactory emotion recognition results. In this paper, we investigated two points to be considered in learning a facial expression recognition model. First, we confirmed whether the information around a mouth induces the recognition model in speech act to misrecognition like the case of a facial expression recognition in non-speech acts or it has valid information for facial expression recognition. Second, Generative Adversarial Network (GAN)-based data augmentation has been performed to cover the problem in which the accuracy of the recognition model in speech acts is low because of the relatively small variance about the subject in RML dataset. The results showed that the information around the mouth made facial expression recognition in speech acts exhibit higher performance, unlike the case of facial expression recognition in non-speech acts. In addition, the GAN-based data augmentation alleviated the accuracy degradation in facial expression recognition because of the low

variance of the dataset.

11:30-11:45 WeAT1.5

An Empirical Study of Person Re-Identification with Attributes,

Shree, Vikram (Cornell University), Chao, Wei-Lun (Cornell University), Campbell, Mark (Cornell University)

Person re-identification aims to identify a person from an image collection, given one image of that person as the query. There is, however, a plethora of real-life scenarios where we may not have a priori library of query images and therefore must rely on information from other modalities. In this paper, an attribute-based approach is proposed where the person of interest (POI) is described by a set of visual attributes, which are used to perform the search. We compare multiple algorithms and analyze how the quality of attributes impacts the performance. While prior work mostly relies on high precision attributes annotated by experts, we conduct a human-subject study and reveal that certain visual attributes could not be consistently described by human observers, making them less reliable in real applications. A key conclusion is that the performance achieved by non-expert attributes, instead of expert-annotated ones, is a more faithful indicator of the status quo of attribute-based approaches for person re-identification.

11:45-12:00 WeAT1.6

Q-Learning Based Navigation of a Quadrotor Using Non-Singular Terminal Sliding Mode Control,

Yogi, Subhash Chand (Indian Institute of Technology - Kanpur), Tripathi, Vibhu Kumar (Indian Institute of Technology, Kanpur), Kamath, Archit Krishna (Indian Institute of Technology, Kanpur), Behera, Laxmidhar (IIT Kanpur)

This paper demonstrates an hybrid methodology of quadrotor navigation and control in an environment with obstacles by combining a Q-learning strategy for navigation with a non-linear sliding mode control scheme for position and altitude control of the quadrotor. In an unknown environment, an optimal safe path is estimated using the Q-learning scheme by considering the environment as a 3D grid world. Furthermore, a non-singular terminal sliding mode control (NTSMC) is employed to navigate the quadrotor through the planned trajectories. The NTSMC that is employed for trajectory tracking ensures robustness towards bounded disturbances as well as parametric uncertainties. In addition, it ensures finite time convergence of the tracking error and avoids issues that arise due to singularities in the dynamics. The effectiveness of the proposed navigation and control scheme are validated using numerical simulations wherein a quadrotor is required to pass through a window.

WeAT2 Room T2

Imitation Learning (Regular Session)

Chair: Wachs, Juan — Purdue University

Co-Chair: Di Nuovo, Alessandro — Sheffield Hallam University

10:30-10:45 WeAT2.1

SMAK-Net: Self Supervised Multi-Level Spatial Attention Network for Knowledge Representation towards Imitation Learning,

Ramachandruni, Kartik (TCS Innovation Labs), Vankadari, Madhu Babu (TCS), Majumder, Anima (Tata Consultancy Services), Dutta, Samrat (TCS Research and Innovation), Swagat, Kumar (Tata Consultancy Services)

In this paper, we propose an end-to-end self-supervised feature representation network for imitation learning. The proposed network incorporates a novel multi-level spatial attention module to amplify the relevant and suppress the irrelevant information while learning task-specific feature embeddings. The multi-level attention module takes multiple intermediate feature maps of the input image at different stages of the CNN pipeline and results a 2D matrix of compatibility scores for each feature map with respect to the given task. The weighted combination of the feature vectors with the scores estimated from attention modules leads to a more task specific feature representation of the input images. We thus name the proposed network as SMAK-Net, abbreviated from Self-supervised Multi-level spatial Attention Knowledge representation Network. We have trained the network using a metric learning loss which aims to decrease the distance between the feature representations of simultaneous frames from multiple view points and increases the distance between the neighboring frames of the same view point. The experiments are performed on the publicly available Multi-View pouring dataset [1]. The outputs of the attention module are demonstrated to highlight the task specific objects while suppressing the rest of the background in the input image. The proposed method is validated by qualitative and quantitative comparisons with the state-of-the art technique TCN [1] along with intensive ablation studies. This method is shown to significantly outperform TCN by 6.5% in the temporal alignment error metric while reducing the total number of training steps by 155K.

10:45-11:00 WeAT2.2

Extending Policy from One-Shot Learning through Coaching,

Balakuntala Srinivasa Murthy, Mythra Varun (Purdue University), Venkatesh, L.N Vishnunandan (Purdue University), Padmakumar Bindu, Jyothsna (Purdue University), Voyles, Richard (Purdue University), Wachs, Juan (Purdue University)

Humans generally teach their fellow collaborators to perform tasks through a small number of demonstrations, often followed by episodes of coaching that tune and refine the execution during practice. Adopting a similar framework for teaching robots through demonstrations makes teaching tasks highly intuitive and imitating the refinement of complex tasks through coaching improves the efficacy. Unlike traditional Learning from Demonstration (LfD) approaches which rely on multiple demonstrations to train a task, we present a novel one-shot learning from demonstration approach, augmented by coaching, to transfer the task from task expert to robot. The demonstration is automatically segmented into a sequence of textit{a priori} skills (the task policy) parametrized to match task goals. During practice, the robotic skills self-evaluate their performances and refine the task policy to locally optimize cumulative performance. Then, human coaching further refines the task policy to explore and globally optimize the net performance. Both the self-evaluation and coaching are implemented using reinforcement learning (RL) methods. The proposed approach is evaluated using the task of scooping and unscooping granular media. The self-evaluator of the scooping skill uses the real-time force signature and resistive force theory to minimize scooping resistance similar to how humans scoop. Coaching feedback focuses modificatioins to sub-domains of the task policy whjile RL adjusts parameters. Thus, the proposed method provides a framework for learning tasks from one demonstration and generalizing it using human feedback through coaching.

11:00-11:15 WeAT2.3

DeepMoTIon: Learning to Navigate Like Humans,

Hamandi, Mahmoud (INSA Toulouse), D'Arcy, Michael (Northwestern University), Fazli, Pooyan (San Francisco State University)

We present a novel human-aware navigation approach, where the robot learns to mimic humans to navigate safely in crowds. The presented model, referred to as DeepMoTIon, is trained with

pedestrian surveillance data to predict human velocity in the environment. The robot processes LiDAR scans via the trained network to navigate to the target location. We conduct extensive experiments to assess the components of our network and prove their necessity to imitate humans. Our experiments show that DeepMoTIion outperforms all the benchmarks in terms of human imitation, achieving a 24% reduction in time series-based path deviation over the next best approach. In addition, while many other approaches often failed to reach the target, our method reached the target in 100% of the test cases while complying with social norms and ensuring human safety.

11:15-11:30 WeAT2.4

Learning Active Spine Behaviors for Dynamic and Efficient Locomotion in Quadruped Robots,

Bhattacharya, Shounak (Indian Institute of Science), Singla, Abhik (Indian Institute of Science (IISc), Bangalore), Singh, Abhimanyu (BITS Pilani K K Birla Goa Campus), Dholakiya, Dhaivat (Indian Institute of Science), Bhatnagar, Shalabh (Indian Institute of Science, Bangalore), Amrutur, Bharadwaj (Indian Institute of Science), Ghosal, Ashitava (India Institute of Science (IISc), Nadubettu Yadukumar, Shishir (Indian Institute of Science)

In this work, we provide a simulation framework to perform systematic studies on the effects of spinal joint compliance and actuation on bounding performance of a 16-DOF quadruped spined robot Stoch 2. Fast quadrupedal locomotion with active spine is an extremely hard problem, and involves a complex coordination between the various degrees of freedom. Therefore, past attempts at addressing this problem have not seen much success. Deep-Reinforcement Learning seems to be a promising approach, after its recent success in a variety of robot platforms, and the goal of this paper is to use this approach to realize the aforementioned behaviors. With this learning framework, the robot reached a bounding speed of 2.1 m/s with a maximum Froude number of 2. Simulation results also show that use of active spine, indeed, increased the stride length, improved the cost of transport, and also reduced the natural frequency to more realistic values.

11:30-11:45 WeAT2.5

Trajectory Based Deep Policy Search for Quadrupedal Walking,

Nadubettu Yadukumar, Shishir (Indian Institute of Science), Joglekar, Ashish (Robert Bosch Center for Cyber Physical Systems, Indian Institute), Shetty, Suhan (IISc), Dholakiya, Dhaivat (Indian Institute of Science), Singh, Abhimanyu (BITS Pilani K K Birla Goa Campus), Sagi, Aditya Varma (Indian Institute of Science), Bhattacharya, Shounak (Indian Institute of Science), Singla, Abhik (Indian Institute of Science (IISc), Bangalore), Bhatnagar, Shalabh (Indian Institute of Science, Bangalore), Ghosal, Ashitava (India Institute of Science (IISc), Amrutur, Bharadwaj (Indian Institute of Science)

In this paper, we explore a specific form of deep reinforcement learning (D-RL) technique for quadrupedal walking---trajectory based policy search via deep policy networks. Existing approaches determine optimal policies for each time step, whereas we propose to determine an optimal policy for each walking step. We justify our approach based on the fact that animals including humans use ``low" dimensional trajectories at the joint level to realize walking. We will construct these trajectories by using Bezier polynomials, with the coefficients being determined by a parameterized policy. In order to maintain smoothness of the trajectories during step transitions, hybrid invariance conditions are also applied. The action is computed at the beginning of every step, and a linear PD control law is applied to track at the individual joints. After each step, reward is computed, which is then used to update the new policy parameters for the next step. After learning an optimal policy, i.e., an optimal walking gait for each step, we then successfully play them in a custom built quadruped robot, Stoch 2, thereby validating our approach.

11:45-12:00 WeAT2.6

Natural Language Interface for Programming Sensory-Enabled Scenarios for Human-Robot Interaction,

Buchina, Nina (Eindhoven University of Techniligy), Sterkenburg, Paula (Free University of Amsterdam), Lourens, Tino (TiViPE), Barakova, Emilia I. (Eindhoven University of Technology)

Previous research has shown that robot-mediated therapy may be effective in different mental or physical conditions, but this effectiveness strongly depends on how well the therapy can be translated to robot training. The goal of this study is to assist the end-users such as occupational and rehabilitation therapists to create without help of technical professional therapy-specific and sensory-enabled scenarios for the robotic assistant for use in an unstructured environment. The Cognitive Dimension of Notations framework was applied to assess the usability of the programming interface and the Cyclomatic complexity method was used to evaluate the complexity of the created robot scenarios. Eleven therapists with a mean age of 39 years working in the care for persons with visual-and-intellectual disabilities participated. The results show good usability of the interface, as measured via the CDN framework and the cyclomatic complexity analysis showed an increased complexity of the created by the occupational and rehabilitation therapist's scenarios. The participants did not request for very specifically defined behaviors for the robot, and therefore descriptions in natural text can be successfully used for robot programming.

WeAT3 Room T3

Motion Planning, Navigation, and Control in Human Centered Environment (Regular Session)

Chair: Behera, Laxmidhar IIT Kanpur

Co-Chair: Krishna, Madhava IIIT Hyderabad

10:30-10:45 WeAT3.1

PIVO: Probabilistic Inverse Velocity Obstacle for Navigation under Uncertainty,

Poonganam, SriSai Naga Jyotish (IIIT Hyderabad), Goel, Yash (IIIT Hyderabad), Avula, Venkata Seetharama Sai Bhargav Kumar (International Institute of Information Technology, Hyderabad), Krishna, Madhava (IIIT Hyderabad)

In this paper, we present an algorithmic framework which computes the collision-free velocities for the robot in a human shared dynamic and uncertain environment. We extend the concept of Inverse Velocity Obstacle (IVO) to a probabilistic variant to handle the state estimation and motion uncertainties that arise due to the other participants of the environment. These uncertainties are modeled as non-parametric probability distributions. In our PIVO: Probabilistic Inverse Velocity Obstacle, we propose the collision-free navigation as an optimization problem by reformulating the velocity conditions of IVO as chance constraints that takes the uncertainty into account. The space of collision-free velocities that result from the presented optimization scheme are associated to a confidence measure as a specified probability. We demonstrate the efficacy of our PIVO through numerical simulations and demonstrating its ability to generate safe trajectories under highly uncertain environments.

10:45-11:00 WeAT3.2

Trajectory Advancement During Human-Robot Collaboration,

Tirupachuri, Yeshasvi (Italian Institute of Technology), Nava, Gabriele (Istituto Italiano Di Tecnologia), Rapetti, Lorenzo (IIT),

Latella, Claudia (Istituto Italiano Di Tecnologia), Pucci, Daniele (Italian Institute of Technology)

As technology advances, the barriers between the co-existence of humans and robots are slowly coming down. The prominence of physical interactions for collaboration and cooperation between humans and robots will be an undeniable fact. Rather than exhibiting simple reactive behaviors to human interactions, it is desirable to endow robots with augmented capabilities of exploiting human interactions for successful task completion. Towards that goal, in this paper, we propose a trajectory advancement approach in which we mathematically derive the conditions that facilitate advancing along a reference trajectory by leveraging assistance from helpful interaction wrench present during human-robot collaboration. We validate our approach through experiments conducted with the iCub humanoid robot both in simulation and on the real robot.

11:00-11:15 WeAT3.3

Vision-Based Fast-Terminal Sliding Mode Super Twisting Controller for Autonomous Landing of a Quadrotor on a Static Platform,

Kamath, Archit Krishna (Indian Institute of Technology, Kanpur), Tripathi, Vibhu Kumar (Indian Institute of Technology, Kanpur), Yogi, Subhash Chand (Indian Institute of Technology - Kanpur), Behera, Laxmidhar (IIT Kanpur)

This paper proposes a vision-based sliding mode control technique for autonomous landing of a quadrotor over the static platform. The proposed vision algorithm estimates the quadrotor's position relative to an ArUco marker placed on a static platform using an on-board monocular camera. The relative position is provided as an input to a Fast-terminal Sliding Mode Super Twisting Controller (FTSMSTC) which ensures finite time convergence of the relative position between the landing pad marker and the quadrotor. In addition, the proposed controller attenuates chattering phenomena and guarantees robustness towards bounded external disturbances and modelling uncertainties. The proposed vision-based control scheme is implemented using numerical simulations and validated in real-time on the DJI Matrice 100.

11:15-11:30 WeAT3.4

Vision-Based Fractional Order Sliding Mode Control for Autonomous Vehicle Tracking by a Quadrotor UAV,

Maurya, Heera Lal (Indian Institute of Technology - Kanpur), Kamath, Archit Krishna (Indian Institute of Technology, Kanpur), Behera, Laxmidhar (IIT Kanpur), Verma, Nishchal K. (Indian Institute of Technology, Kanpur)

This paper proposes a vision-based sliding mode control technique for autonomous tracking of a moving vehicle by a quadrotor. The proposed vision algorithm estimates the quadrotor's position relative to moving vehicle using an on-board monocular camera. The relative position is provided as an input to a Fractional Order Sliding mode Controller (FOSMC) which ensures the convergence of the relative position between the moving vehicle and the quadrotor thereby enabling it to track the vehicle effectively. In addition, the proposed controller guarantees robustness towards bounded external disturbances and modelling uncertainties. The proposed vision-based control scheme is implemented using numerical simulations and validated in real-time on the DJI Matrice 100. Theses validations help in gaining into the maximum allowable speed of the moving target for the quadrotor to successfully track the object. This plays a vital role in surveillance operations and intruder chase.

11:30-11:45 WeAT3.5

End-User Programming of Low and High-Level Actions for Robotic Task Planning,

Liang, Ying Siu (Université Grenoble Alpes), Pellier, Damien (Laboratoire d'Informatique De Grenoble - CNRS), Fiorino, Humbert (University Grenoble Alpes - Laboratoire d'Informatique De Grenob), Pesty, Sylvie (University of Grenoble-Alps)

Programming robots for general purpose applications is extremely challenging due to the great diversity of end-user tasks ranging from manufacturing environments to personal homes. Recent work has focused on enabling end-users to program robots using Programming by Demonstration. However, teaching robots new actions from scratch that can be reused for unseen tasks remains a difficult challenge and is generally left up to robotic experts. We propose iRoPro, an interactive Robot Programming framework that allows end-users to teach robots new actions from scratch and reuse them with a task planner. In this work we provide a system implementation on a two-armed Baxter robot that (i) allows simultaneous teaching of low- and high-level actions by demonstration, (ii) includes a user interface for action creation with condition inference and modification, and (iii) allows creating and solving previously unseen problems using a task planner for the robot to execute in real-time. We evaluate the generalisation power of the system on six benchmark tasks and show how taught actions can be easily reused for complex tasks. We further demonstrate the system's usability with a user study (N=21), where users completed eight tasks to teach the robot new actions and execute plans in real-time. The study demonstrates that users with any programming level and educational background can easily learn and use the system.

11:45-12:00 WeAT3.6

Human Perception of Gait Styles on a Compass Walker in Variable Contexts Via Descriptive versus Emotive Labels,

Lambert, Jacey (University of Illinois at Urbana-Champaign), Huzaifa, Umer (University of Illinois at Urbana-Champaign), Rizvi, Wali (University of Illinois at Urbana Champaign), LaViers, Amy (University of Illinois at Urbana-Champaign)

The behavior and aesthetics of robots can impact perception by human viewers, and prior work has shown that context influences this judgement. This paper presents an experiment to better understand what sort of gait label can best explain human estimate of an internal state based on external changes, despite effects of variable context on the perception of gait. The study analyzes how a user's perception of movement in a simple two degree-of-freedom mechanism changes through the use of varying environments via more emotive or more descriptive labels. Specifically, five bipedal gaits were overlaid onto illustrated backgrounds that were created to reflect various affective inclinations and given labels with and without emotive implications. Users were then asked to rate the accuracy of the descriptive or emotive labels of these videos, and the differences between their ratings were compared throughout the multiple backgrounds. It was found that while both sets of labels scored well, emotive labels were slightly preferred overall. However, although the addition of an environment positively affected the user perceptions in rating the suggested descriptive labels, it was more likely to negatively affect the ratings of emotive labels. The results of this analysis suggest that lay end-users prefer to make judgements about motion behavior in an emotive space but that descriptive labels may be more stable identifiers across various contexts for robot designers. These results highlight the emotional connection that humans make with motion and the role the context plays in helping to create this experience.

WeAT4 Room T4

Medical Robotics (Regular Session)

Chair: Sgorbissa, Antonio University of Genova

Co-Chair: Xie, Le — Shanghai Jiao Tong University

10:30-10:45 — WeAT4.1

Master-Slave Guidewire and Catheter Robotic System for Cardiovascular Intervention,

Xiang, Yujia (Shanghai Jiao Tong University), Shen, Hao (Shanghai Jiao Tong University), Xie, Le (Shanghai Jiao Tong University), Wang, Hesheng (Shanghai Jiao Tong University)

Cardiovascular disease remains a primary cause of morbidity globally. Percutaneous coronary intervention plays a crucial role in the treatment. The radiation exposure of surgeons during the cardiovascular intervention can be avoided by master-slave surgical robots. This paper introduces a master-slave guidewire and catheter robotic system to protect the surgeons from X ray radiation to the most extent. And the jitters of master manipulators are mitigated by Kalman filtering algorithm. With two master manipulators, it helps to retain the surgeon's traditional operating habits. Also, a vascular model trial was conducted to validate that this interventional robotic system could complete the alternate progress and rotation of interventional guidewire and catheter.

10:45-11:00 — WeAT4.2

A Brief Review of the Electronics, Control System Architecture, and Human Interface for Commercial Lower Limb Medical Exoskeletons Stabilized by Aid of Crutches,

Tabti, Nahla (Université Paris-Sud), Kardofaki, Mohamad (UVSQ), Alfayad, Samer (LISV, BIA), Chitour, Yacine (University of Paris Sud), Ben Ouezdou, Fathi (University of Versailles St. Quentin), Dychus, Eric (Sandyc)

Research in the field of the powered orthosesor exoskeletons has expanded tremendously over the pastyears. Lower limb exoskeletons are widely used in roboticrehabilitation and are showing benefits in the patients qualityof life. Many engineering reviews have been published aboutthese devices and addressed general aspects. To the best of ourknowledge, no review has minutely discussed specifically thecontrol of the the most common used devices, particularly thealgorithms used to define the function state of the exoskeleton,such as walking, sit-to-stand, etc. In this contribution, thecontrol hardware and software, as well as the integrated sensorsfor the feedback are thoroughly analyzed. We will also discussthe importance of user-specific state definition and customizedcontrol architecture. Although there are many prototypesdeveloped nowadays, we chose to target medical lower limbexoskeletons that uses crutches to keep balance, and that areminimally actuated. These are the most common system thatare now being commercialized and used worldwide.Therefore, the outcome of such a review helps to have a practical insight in all of : the mechatronics design, system architecture, and control.

11:00-11:15 — WeAT4.3

Development of a Foldable Five-Finger Robotic Hand for Assisting Laparoscopic Surgery,

Anzai, Yuki (Yokohama National University), Sagara, Yuto (Yokohama National University), Kato, Ryu (Yokohama National University), Mukai, Masaya (Tokai University)

The purpose of this study is to develop a robotic hand that can be inserted from a small incision wound and can handle large organs in laparoscopic surgery. We have determined the requirements for the proposed hand from a surgeon's motions in HALS. We identified the basic 4 motions : "grasp", "pinch", "exclusion" and "spread". The proposed hand has the necessary DOFs for performing these behaviors, five fingers as in a human's hand, a palm that can be folded into a bellows when a surgeon inserts the hand into the abdominal cavity. We evaluated the proposed robot hand based on a performance test, and we confirmed that it can insert from 20mm incision wound and grasp the simulated organs.

11:15-11:30 — WeAT4.4

Effects of Flexible Surgery Robot on Endoscopic Procedure: Preliminary Bench-Top User Test,

Kim, Joonhwan (Korea Advanced Institute of Science and Technology(KAIST)), Hwang, Minho (Korea Advanced Institute of Science and Technology (KAIST)), Lee, Dong-Ho (Korea Advanced Institute of Science and Technology), Kim, Hansoul (Korea Advanced Institute of Science and Technology), Ahn, Jeongdo (Korea Advanced Institute of Science and Technology), You, Jae Min (Korea Advanced Institute of Science and Technology), Baek, DongHoon (KAIST), Kwon, Dong-Soo (KAIST)

Endoscopes are widely used for not only intraluminal diagnosis but also therapeutic procedures in the gastrointestinal area. However, conventional endoscopes present a few challenges such as nonintuitive manipulation, physical burden on the operator, and lack of dexterity. These challenges limit endoscope usage in complex surgical procedures. Moreover, endoscope operators undergo extensive and lengthy training to attain an adequate skill level. In this paper, we introduce a flexible surgery robot platform K-FLEX that facilitates teleoperation via an intuitive master interface and bimanual manipulation by means of two dexterous surgical robot arms. Its effects on endoscopic procedures, especially in terms of task performance, learning properties, and physical burden on the operator, are validated by conducting a user test. The experimental results demonstrate that the developed robotic assistant increases operation speed, especially for novices; simplifies the learning process; and reduces the workload on the operator compared to conventional endoscopes.

11:30-11:45 — WeAT4.5

Towards Securing the Sclera against Patient Involuntary Head Movement in Robotic Retinal Surgery,

Ebrahimi, Ali (Johns Hopkins University), Urias, Muller (Wilmer Eye Institute), He, Changyan (Beihang University), Patel, Niravkumar (Johns Hopkins University), Taylor, Russell H. (The Johns Hopkins University), Gehlbach, Peter (Johns Hopkins Medical Institute), Iordachita, Ioan Iulian (Johns Hopkins University)

Retinal surgery involves manipulating very delicate tissues within the confined area of eyeball. In such demanding practices, patient involuntary head movement might abruptly raise tool-to-eyeball interaction forces which would be detrimental to eye. This study is aimed at implementing different force control strategies and evaluating how they contribute to attaining sclera force safety while patient head drift is present. To simulate patient head movement, a piezoelectric-actuated linear stage is used to produce random motions in a single direction in random time intervals. Having an eye phantom attached to the linear stage then an experienced eye surgeon is asked to manipulate the eye and repeat a mock surgical task both with and without the assist of the Steady-Hand Eye Robot. For the freehand case, warning sounds were provided to the surgeon as auditory feedback to alert him about excessive slclra forces. For the robot-assisted experiments two variants of an adaptive sclera force control and a virtual fixture method were deployed to see how they can maintain eye safety under head drift circumstances.The results indicate that the developed robot control strategies are able to compensate for head drift and keep the sclera forces under safe levels as well as the free hand operation.

11:45-12:00 — WeAT4.6

Detecting Deception in HRI Using Minimally-Invasive and Noninvasive Techniques,

Iacob, David-Octavian (ENSTA-ParisTech), Tapus, Adriana (ENSTA-ParisTech)

Our work focuses on detecting deception in Human-Robot Interactions (HRI) by using measurement techniques that are appropriate for such interactions. In our previous research works, we obtained interesting results by using thermal and RGB-D cameras. In this paper, we approached this aspect from a different angle and used a lab-designed armband to accurately measure the participants' heart rate and skin conductance. We also developed a deception card game scenario that entices human participants to lie either to a robot or a human game partner, allowing us to monitor and understand the correlations between human physiological manifestations and their trustworthiness. Our results show the existence of statistically significant correlations between the participants' deceptive behaviour and their heart rate, skin conductance, face position, and face orientation. These results allow us to improve robots' ability to detect deception in HRI.

WeAT5	Room T5
Robotics for Rehabilitation (Special Session)	
Chair: Vashista, Vineet	Indian Institute of Technology Gandhinagar
Co-Chair: Fiorini, Laura	The BioRobotics Institute, Scuola Superiore Sant'Anna

10:30-10:45 WeAT5.1

Preliminary Evaluation of a Closed-Loop Social Robot for Reading Comprehension Testing,

Migovich, Miroslava (University of Tennessee), McCarthy, Jillian (University of Tennessee Health Science Center), Wade, Eric (University of Tennessee)

Reading comprehension in the United States has not shown significant improvement since 2007 [4]. Studies in comprehension improvement lack evidence and ease of implementation in and outside of the classroom [5] Our long-term study seeks to incorporate social robotics and reading comprehension activities to provide an option for in-home and in-school reading focused interventions. In the current study, we present an initial validation of a closed-loop social robotic system for reading comprehension testing. Results suggest our robot-based system is capable of recording and interpreting human responses and can provide contingent feedback to answers to evidence-derived reading comprehension questions. The system demonstrated few errors and was found to be acceptable, falling within the 3rd quartile range when compared to other studies, according to the System Usability Scale (SUS) [4]. These results demonstrate the potential utility of the system with the target population; additional testing with age-matched participants is needed to verify the relationship between errors and SUS scores. Keywords—Social Robotics, Reading Comprehension, System Usability, Deaf or Hard of Hearing

10:45-11:00 WeAT5.2

Evaluation of Physical Therapy through Analysis of Depth Images,

Kramer, Ivanna (University of Koblenz-Landau), Memmesheimer, Raphael (University of Koblenz-Landau), Schmidt, Niko (University of Koblenz-Landau), Paulus, Dietrich (Universtät Koblenz-Landau)

The support through robots in orthopaedic rehabilitation is an opportunity to relieve physiotherapists. However, to be able to provide a control in the robot-patient cooperation in the therapy process a certain standard in interpreting the exercise has to be established. In this paper we present an evaluation approach of the health subject performance in a tibiofemoral rehabilitation on the example of squat exercises. The proposed method utilizes only depth images for the performance evaluation and any human-robot interaction system for the performance correction. Thus, this method can be easily applied to a mobile service robot in the robot-aided physical therapy. The patient is observed while performing the exercise and the motion is evaluated and segmented using Motion History Images. Concrete, depth images are used to monitor local points of interest on the performer during the exercise. The proposed approach was evaluated on custom image sequences with a multitude of varying subjects and shows the suitable performance for assisting in the correctness of the exercise execution.

11:00-11:15 WeAT5.3

Optimal Feature Selection for EMG-Based Finger Force Estimation Using LightGBM Model,

Ye, Yuhang (South China University of Technology), Liu, Chao (LIRMM (UMR5506), CNRS, France), Zemiti, Nabil (LIRMM, Université Montpellier II - CNRS UMR 5506), Yang, Chenguang (University of the West of England)

Electromyogram (EMG) signal has been long used in human-robot interface in literature, especially in the area of rehabilitation. Recent rapid development in artificial intelligence (AI) has provided powerful machine learning tools to better explore the rich information embedded in EMG signals. For our specific application task in this work, i.e. estimate human finger force based on EMG signal, a LightGBM (Gradient Boosting Machine) model has been used. The main contribution of this study is the development of an automatic optimal feature selection algorithm that can minimize the number of features used in the LightGBM model in order to simplify implementation complexity, reduce computation burden and maintain comparable estimation performance to the one with full features. The performance of the LightGBM model with selected optimal features is compared with 4 other popular machine learning models in order to show the effectiveness of the developed feature selection method.

11:15-11:30 WeAT5.4

Learning Robot Policies Using a High-Level Abstraction Persona-Behaviour Simulator,

Andriella, Antonio (IRI, CSIC-UPC), Torras, Carme (Csic - Upc), Alenyà, Guillem (CSIC-UPC)

Collecting data in Human-Robot Interaction for training learning agents might be a hard task to accomplish. This is especially true when the target users are older adults with dementia since this usually requires hours of interactions and puts quite a lot of workload on the user.
This paper addresses the problem of importing the Personas technique from HRI to create fictional patients' profiles. We propose a Persona-Behaviour Simulator tool that provides, with high-level abstraction, user's actions during an HRI task, and we apply it to cognitive training exercises for older adults with dementia. It consists of a Persona Definition that characterizes a patient along four dimensions and a Task Engine that provides information regarding the task complexity. We build a simulated environment where the high-level user's actions are provided by the simulator and the robot initial policy is learned using a Q-learning algorithm. The results show that the current simulator provides a reasonable initial policy for a defined Persona profile. Moreover, the learned robot assistance has proved to be robust to potential changes in the user's behaviour. In this way, we can speed up the fine-tuning of the rough policy during the real interactions to tailor the assistance to the given user. We believe the presented approach can be easily extended to account for other types of HRI tasks; for example, when input data is required to train a learning algorithm, but data collection is very expensive or unfeasible. We advocate that simulation is a convenient tool in these cases.

11:30-11:45 WeAT5.5

Estimating the Effect of Robotic Intervention on Elbow Joint Motion,

Ghonasgi, Keya (The University of Texas at Austin), De Oliveira, Ana Christine (The University of Texas at Austin), Shafer, Anna (University of Texas at Austin), Rose, Chad (University of Texas at Austin), Deshpande, Ashish (University of Texas)

Much effort has been placed into the development of robotic devices to support, rehabilitate, and interact with humans. Despite these advances, reliably modeling the neuromuscular changes in human motion resulting from a robotic intervention remains difficult. This paper proposes a method to uncover the relationship between robotic intervention and human response by combining surface electromyography (sEMG), the musculoskeletal modeling platform OpenSim, and artificial neural networks (ANNs). To demonstrate the method, a one degree of freedom (DOF) elbow flexion-extension motion is performed and analyzed. Preliminary results show that while the robot provides assistance to the subject, it also appears to produce other unexpected responses in the movement. Further investigation using the new method reveals the neuromuscular effect of an unintended resistance to the subject's motion applied by the robot as it enforces a speed slower than the subject selects. The characterization of the differences in expected and actual interaction is enabled by the method presented in this paper. Thus, the method uncovers previously obscured aspects of human robot interaction, and creates possibilities for new training modalities.

11:45-12:00 WeAT5.6

Development and Applicability of a Cable-Driven Wearable Adaptive Rehabilitation Suit (WeARS),

Iyer, S. Srikesh (IIT Gandhinagar), V Joseph, Joel (Indian Institute of Technology Gandhinagar), Nakka, S S Sanjeevi (Indian Institute of Technology Gandhinagar), Singh, Yogesh (Indian Institute of Technology Gandhinagar), Vashista, Vineet (Indian Institute of Technology Gandhinagar)

Walking is one of the most relevant tasks that a person performs in his daily routine, which requires actuation and coordination of both inter and intra limb parameters of the lower extremity to adjust to the changing conditions of the environment like an unexpected perturbation or a change in terrain. Incidentally, with aging or due to an occurrence of a neuro-musculoskeletal disorder, human performance while walking degrades significantly. A major reason for the abnormal performance has been attributed to the observance of variability in the order and timing of muscle contraction in these individuals. In this work, we develop a Wearable Adaptive Rehabilitation Suit (WeARS) for lower extremity that uses externally actuated cables to resemble the role of agonist and antagonist muscles as in a biological system. WeARS also uses a subject-specific control strategy that is adaptive to the subject's gait. The focus of the current study is to use WeARS in applying resistive forces on the hip joint to study various gait abnormalities and to develop subject-specific gait rehabilitation paradigms.

WeBT1 Room T8

Human Robot Collaboration and Cooperation (Regular Session)

Chair: Lambrecht, Jens — Technische Universität Berlin

Co-Chair: Fazli, Pooyan — San Francisco State University

13:00-13:15 WeBT1.1

Can a Humanoid Robot Be Part of the Organizational Workforce? a User Study Leveraging Sentiment Analysis,

Mishra, Nidhi (Institute for Media Innovation, Nanyang Technological University), Ramanathan, Manoj (Institute for Media Innovation, Nanyang Technological University), Satapathy, Ranjan (Institute for Media Innovation, Nanyang Technological University), Cambria, Erik (Nanyang Technological University), Thalmann, Nadia Magnenat (Nanyang Technological University)

Hiring robots for the workplaces is a challenging task as robots have to cater to customer demands, follow organizational protocols and behave with social etiquette. In this study, we propose to have a humanoid social robot, Nadine, as a customer service agent in an open social work environment. The objective of this study is to analyze the effects of humanoid robots on customers in a work environment, and see if it can handle social scenarios. We propose to evaluate these objectives through two modes, namely: survey questionnaire and customer feedback. The survey questionnaires are analyzed based on the datapoints provided in the questionnaire. We propose a novel approach to analyze customer feedback data using sentic computing. Specifically, we employ aspect extraction and sentiment analysis to analyze the data. From our framework, we detect sentiment associated to the aspects that mainly concerned the customers during their interaction. This allows us to understand customers expectations and current limitations of robots as employees.

13:15-13:30 WeBT1.2

A Multi Modal People Tracker for Real Time Human Robot Interaction,

Wengefeld, Tim (Ilmenau University of Technology), Mueller, Steffen (Ilmenau University of Technology), Lewandowski, Benjamin (Ilmenau University of Technology), Gross, Horst-Michael (Ilmenau University of Technology)

Tracking people in the surroundings of interactive service robots is a topic of high interest. Even if image based detectors using deep learning techniques have improved the detection rate and accuracy a lot, for robotic applications it is necessary to integrate those detections over time and over the limited ranges of individual sensors into a global model. That data fusion enables a continuous state estimation of people and helps reducing the false decisions taken by individual detectors and increasing the overall range. In this paper we present a tracking framework with a new distance measure for data association and a proper consideration of individual sensors' accuracies. By means of that, we could deal with high false detection rates of laser-based leg detectors without introducing further heuristics like a background model. The proposed system is compared to other tracking approaches from the state of the art. Furthermore, we present a novel manually annotated benchmark dataset for multi sensor person tracking from a moving robot platform in a guide scenario.

13:30-13:45 WeBT1.3

Human Prediction for the Natural Instruction of Handovers in Human Robot Collaboration,

Lambrecht, Jens (Technische Universität Berlin), Nimpsch, Sebastian (GESTALT Robotics GmbH)

Human robot collaboration is aspiring to establish hybrid work environments in accordance with specific strengths of humans and robots. We present an approach of flexibly integrating robotic handover assistance into collaborative assembly tasks through the use of natural communication. For flexibly instructed handovers, we implement recent Convolutional Neural Networks in terms of object detection and grasping of arbitrary objects based on an RGB-D camera equipped to a robot following the eye-in-hand principle. In order to increase fluency and efficiency of the overall assembly process, we investigate the human ability to instruct the robot predictively with voice commands. We conduct a user study quantitatively and qualitatively evaluating the predictive instruction in order to achieve just-in-time handovers of tools needed for following subtasks. We compare our predictive strategy with a pure manual assembly having all tools in direct reach and a step-by-step reactive handover. The results reveal that the human is able to

predict the handover comparable to algorithm-based predictors. Nevertheless, human prediction does not rely on extensive prior knowledge and is thus suitable for more flexible usage. However, the cognitive workload for the worker is increased compared to manual or reactive assembly.

13:45-14:00 WeBT1.4

Evaluation of an Industrial Robotic Assistant in an Ecological Environment,

Busch, Baptiste (EPFL), Cotugno, Giuseppe (King's College London), Khoramshahi, Mahdi (EPFL), Skaltsas, Grigorios (University of Hertfordshire), Turchi, Dario (Ocado), Urbano, Leonardo (EPFL), Waechter, Mirko (Karlsruhe Institute of Technology (KIT)), Zhou, You (Karlsruhe Institute of Technology (KIT)), Asfour, Tamim (Karlsruhe Institute of Technology (KIT)), Deacon, Graham (OCADO - Robotics Research), Russell, Duncan (Ocado Technology), Billard, Aude (EPFL)

Social robotic assistants have been widely studied and deployed as telepresence tools or caregivers. Evaluating their design and impact on the people interacting with them is of prime importance. In this research, we evaluate the usability and impact of ARMAR-6, an industrial robotic assistant for maintenance tasks. For this evaluation, we have used a modified System Usability Scale (SUS) to assess the general usability of the robotic system and the Godspeed questionnaire series for the subjective perception of the coworker. We have also recorded the subjects' gaze fixation patterns and analyzed how they differ when working with the robot compared to a human partner.

14:00-14:15 WeBT1.5

Human Trust after Robot Mistakes: Study of the Effects of Different Forms of Robot Communication,

Ye, Sean (Georgia Institute of Technology), Neville, Glen (Georgia Institute of Technology), Schrum, Mariah (Georgia Institute of Technology), Gombolay, Matthew (Georgia Institute of Technology), Chernova, Sonia (Georgia Institute of Technology), Howard, Ayanna (Georgia Institute of Technology)

Collaborative robots that work alongside humans will experience service breakdowns and make mistakes. These robotic failures can cause a degradation of trust between the robot and the community being served. A loss of trust may impact whether a user continues to rely on the robot for assistance. In order to improve the teaming capabilities between humans and robots, forms of communication that aid in developing and maintaining trust need to be investigated. In our study, we identify four forms of communication which dictate the timing of information given and type of initiation used by a robot. We investigate the effect that these forms of communication have on trust with and without robot mistakes during a cooperative task. Participants played a memory task game with the help of a humanoid robot that was designed to make mistakes after a certain amount of time passed. The results showed that participants' trust in the robot was better preserved when that robot offered advice only upon request as opposed to when the robot took initiative to give advice.

14:15-14:30 WeBT1.6

Path Planning through Tight Spaces for Payload Transportation Using Multiple Mobile Manipulators,

Tallamraju, Rahul (International Institute of Information Technology, Hyderabad), Sripada, Venkatesh (Oregon State University, Corvallis, USA), Shah, Suril Vijaykumar (Indian Institute of Technology Jodhpur)

In this paper, the problem of path planning through tight spaces, for the task of spatial payload transportation, using a formation of mobile manipulators is addressed. Due to the high dimensional configuration space of the system, efficient and geometrically stable path planning through tight spaces is challenging. We resolve this by planning the path for the system in two phases. First, an obstacle-free trajectory in R3 for the payload being transported is determined using RRT. Next, near-energy optimal and quasi-statically stable paths are planned for the formation of robots along this trajectory using non-linear multi-objective optimization. We validate the proposed approach in simulation experiments and compare different multi-objective optimization algorithms to find energy optimal and geometrically stable robot path plans.

WeBT2 Room T2

Linguistic Communication and Dialogue (Regular Session)

Chair: Trovato, Gabriele — Waseda University

Co-Chair: Kirstein, Franziska — Blue Ocean Robotics

13:00-13:15 WeBT2.1

Autonomous Generation of Robust and Focused Explanations for Robot Policies,

Struckmeier, Oliver (Aalto University), Racca, Mattia (Aalto University), Kyrki, Ville (Aalto University)

Transparency of robot behaviors increases efficiency and quality of interactions with humans. To increase transparency of robot policies, we propose a method for generating robust and focused explanations that express why a robot chose a particular action. The proposed method examines the policy based on the state space in which an action was chosen and describes it in natural language. The method can generate focused explanations by leaving out irrelevant state dimensions, and avoid explanations that are sensitive to small perturbations or have ambiguous natural language concepts. Furthermore, the method is agnostic to the policy representation and only requires the policy to be evaluated at different samples of the state space. We conducted a user study with 18 participants to investigate the usability of the proposed method compared to a comprehensive method that generates explanations using all dimensions. We observed how focused explanations helped the subjects more reliably detect the irrelevant dimensions of the explained system and how preferences regarding explanation styles and their expected characteristics greatly differ among the participants.

13:15-13:30 WeBT2.2

A Robot's Expressive Language Affects Human Strategy and Perceptions in a Competitive Game,

Roth, Aaron M. (Carnegie Mellon University), Reig, Samantha (Carnegie Mellon University), Bhatt, Umang (Carnegie Mellon University), Shulgach, Jonathan (Carnegie Mellon University), Amin, Tamara (Independent), Doryab, Afsaneh (Carnegie Mellon University), Fang, Fei (Carnegie Mellon University), Veloso, Manuela (Carnegie Mellon University)

As robots are increasingly endowed with social and communicative capabilities, they will interact with humans in more settings, both collaborative and competitive. We explore human-robot relationships in the context of a competitive Stackelberg Security Game. We vary humanoid robot expressive language (in the form of “encouraging” or “discouraging” verbal commentary) and measure the impact on participants' rationality, strategy prioritization, mood, and perceptions of the robot. We learn that a robot opponent that makes discouraging comments causes a human to play a game less rationally and to perceive the robot more negatively. We also contribute a simple open source Natural Language Processing framework for generating expressive sentences, which was used to generate the speech of our autonomous social robot.

13:30-13:45 WeBT2.3

Walk the Talk! Exploring (Mis)Alignment of Words and Deeds by Robotic Teammates in a Public Goods Game,

Correia, Filipa (INESC-ID and Instituto Superior Técnico, Technical University Of), Chandra, Shruti (INESC-ID and Instituto Superior Técnico, TechnicalUniversity Of), Mascarenhas, Samuel (INESC-ID / Instituto Superior Técnico, University of Lisbon), Charles-Nicolas, Julien (Técnico Lisboa), Gally, Justin Philippe Roger Luc (INSA Lyon), Lopes, Diana (Instituto Superior Técnico), Santos, Fernando P. (Princeton University), Santos, Francisco C. (IST, Universidade De Lisboa, Portugal), Melo, Francisco S. (Instituto Superior Tecnico), Paiva, Ana (INESC-ID and Instituto Superior Técnico, TechnicalUniversity Of)

This paper explores how robotic teammates can enhance and promote cooperation in collaborative settings. It presents a user study in which participants engaged with two fully autonomous robotic partners to play a game together, named "For The Record", a variation of a public goods game. The game is played for a total of five rounds and in each of them, players face a social dilemma: to cooperate i.e., contributing towards the team's goal while compromising individual benefits, or to defect i.e., favouring individual benefits over the team's goal. Each participant collaborates with two robotic partners that adopt opposite strategies to play the game: one of them is an unconditional cooperator (the pro-social robot), and the other is an unconditional defector (the selfish robot). In a between-subjects design, we manipulated which of the two robots criticizes behaviours, which consists of condemning participants when they opt to defect, and it represents either an alignment or a misalignment of words and deeds by the robot. Two main findings should be highlighted (1) the misalignment of words and deeds may affect the level of discomfort perceived on a robotic partner; (2) the perception a human has of a robotic partner that criticizes him is not damaged as long as the robot displays an alignment of words and deeds.

13:45-14:00 WeBT2.4

Your Instruction May Be Crisp, but Not Clear to Me!,

Pramanick, Pradip (TCS Research & Innovation), Sarkar, Chayan (TCS Research & Innovation), Bhattacharya, Indrajit (TCS Research & Innovation)

The number of robots deployed in our daily surroundings is ever-increasing. Even in the industrial set-up, the use of coworker robots is increasing rapidly. These cohabitant robots perform various tasks as instructed by co-located human beings. Thus, a natural interaction mechanism plays a big role in the usability and acceptability of the robot, especially by a non-expert user. The recent development in natural language processing (NLP) has paved the way for chatbots to generate an automatic response for users' query. A robot can be equipped with such a dialogue system. However, the goal of human-robot interaction is not focused on generating a response to queries, but it often involves performing some tasks in the physical world. Thus, a system is required that can detect user intended task from the natural instruction along with the set of pre- and post-conditions. In this work, we develop a dialogue engine for a robot that can classify and map a task instruction to the robot's capability. If there is some ambiguity in the instructions or some required information is missing, which is often the case in natural conversation, it asks an appropriate question(s) to resolve it. The goal is to generate minimal and pin-pointed queries for the user to resolve an ambiguity. We evaluate our system for a telepresence scenario where a remote user instructs the robot for various tasks. Our study based on 12 individuals shows that the proposed dialogue strategy can help a novice user to effectively interact with a robot, leading to satisfactory user experience.

14:00-14:15 WeBT2.5

Building Language-Agnostic Grounded Language Learning Systems,

Kery, Caroline (University of Maryland, Baltimore County), Pillai, Nisha (UMBC), Matuszek, Cynthia (University of Maryland, Baltimore County), Ferraro, Francis (University of Maryland Baltimore County)

Learning the meaning of grounded language--language that references the robot's physical environment and perceptual data--is an important and increasingly widely studied problem in robotics and human-robot interaction. However, with a few exceptions, research in this area has focused on learning groundings for a single natural language pertaining to rich perceptual data. We present experiments on taking an existing natural language grounding system designed for English and applying it to a novel multilingual corpus of descriptions of objects paired with RGB-D perceptual data. We demonstrate that this specific approach transfers well to different languages, but also present possible design constraints to consider for grounded language learning systems that are intended for robots that will function in a variety of linguistic settings.

14:15-14:30 WeBT2.6

Let Me Show You Your New Home: Studying the Effect of Proxemic-Awareness of Robots on Users' First Impressions,

Petrak, Björn (Augsburg University), Weitz, Katharina (Augsburg University), Aslan, Ilhan (Augsburg University), Andre, Elisabeth (Augsburg University)

First impressions play an important part in social interactions, establishing the foundation of a person's opinion about their counterparts. Since interpersonal communication is essentially multimodal, people are judged during first encounters by both their verbal utterances and nonverbal behavior, such as how they utilize eye contact, body distance, and body orientation. In this paper, we argue that robots would provide better user experiences, including being perceived as more likable if they were able to make a good first impression when introduced to a new home. Moreover, we wanted to test if robots can improve their perceived impression by behaving in a proxemic-aware manner; i.e., by following established social norms, which prescribe, for example how far people should position themselves around other objects to improve the facilitation of social interactions. In order to test this hypothesis, we conducted a user study with 16 participants in a virtual reality setting, comparing the impression of two agents being introduced to their new homes by users. We found that the proxemic-aware agent was indeed perceived as significantly better considering multiple constructs, including perceived anthropomorphism and trustworthiness.

WeBT3 Room T3

Robot Companions (Regular Session)

Chair: Indurkhya, Bipin Jagiellonian University

Co-Chair: Michael, John Central European University

13:00-13:15 WeBT3.1

An Adaptive Robot Teacher Boosts a Human Partner's Learning Performance in Joint Action,

Vignolo, Alessia (Istituto Italiano Di Tecnologia), Powell, Henry (University of Glasgow), McEllin, Luke (Central European University), Rea, Francesco (Istituto Italiano Di Tecnologia), Sciutti, Alessandra (Italian Institute of Technology), Michael, John (Central European University)

One important challenge for roboticists in the coming years will be to design robots to teach humans new skills or to lead humans in activities

which require sustained motivation (e.g. physiotherapy, skills training). In the current study, we tested the hypothesis that if a robot teacher invests physical effort in adapting to a human learner in a context in which the robot is teaching the human a new skill, this would facilitate the human's learning. We also hypothesized that the robot teacher's effortful adaptation would lead the human learner to experience greater rapport in the interaction. To this end, we devised a scenario in which the iCub and a human participant alternated in teaching each other new skills. In the high effort condition, the iCub slowed down his movements when repeating a demonstration for the human learner, whereas in the low effort condition he sped the movements up when repeating the demonstration. The results indicate that participants indeed learned more effectively when the iCub adapted its demonstrations, and that the iCub's apparently effortful adaptation led participants to experience him as more helpful.

13:15-13:30 WeBT3.2

On the Role of Trust in Child-Robot Interaction,

Zguda, Paulina (Jagiellonian University), Kolota, Anna (Jagiellonian University), Jarosz, Mateusz (AGH University of Science and Technology), Sondej, Filip (AGH University of Science and Technology), Izui, Takamune (Tokyo University of Agriculture and Technology), Dziok, Maria (AGH University of Science and Technology), Belowska, Anna (AGH University of Science and Technology), Jędras, Wojciech (AGH University of Science), Venture, Gentiane (Tokyo University of Agriculture and Technology), Sniezynski, Bartlomiej (AGH University of Science and Technology), Indurkhya, Bipin (Jagiellonian University)

In child-robot interaction, the element of trust towards the robot is critical. This is particularly important the first time the child meets the robot, as the trust gained during this interaction can play a decisive role in future interactions. We present an in-the-wild study where Polish kindergartners interacted with a Pepper robot. The videos of this study were analyzed for the issues of trust, anthropomorphization, and reaction to malfunction, with the assumption that the last two factors influence the children's trust towards Pepper. Our results reveal children's interest in the robot performing tasks specific for humans, highlight the importance of the conversation scenario and the need for an extended library of answers provided by the robot about its abilities or origin and show how children tend to provoke the robot.

13:30-13:45 WeBT3.3

An Exploratory Study on Proxemics Preferences of Humans in Accordance with Attributes of Service Robots,

Samarakoon, Bhagya (University of Moratuwa), Muthugala Arachchige, Viraj Jagathpriya Muthugala (Singapore University of Technology and Design), Jayasekara, A.G.B.P. (University of Moratuwa), Elara, Mohan Rajesh (Singapore University of Technology and Design)

Service robots that possess social interactive capabilities are vital to cater to the demand in emerging domains of robotic applications. A service robot frequently needs to interact with users when performing service tasks. The comfortability of users depends on the human-robot proxemics during these interactions. Hence, a service robot should be capable of maintaining proper proxemics that improves the comfort of users. The proxemics preferences of users might depend on diverse attributes of a robot, such as emotional state, noise level, and physical appearance. Therefore, it is vital to gain a better understanding of a robot's attributes which influence human-robot proxemics behavior. This paper contributes to an exploratory study to analyze the effects on human-robot proxemics preferences due to a robot's attributes; facial and vocal emotions, level of internal noises, and the physical appearance. Four sub-studies have been conducted to gather the required human-robot proxemics data. The gathered data have been analyzed through statistical tests. The test statistics reveal that facial and vocal emotions, internal noise level, and the physical appearance of a robot have significant effects on proxemics preferences of humans. The outcomes of this exploratory study would be useful in designing and developing human-robot proxemics strategies of a service robot that would enhance social interaction.

13:45-14:00 WeBT3.4

Augmented Reality As a Medium for Human-Robot Collaborative Tasks,

Chacko, Sonia (NYU Tandon School of Engineering), Kapila, Vikram (NYU Tandon School of Engineering)

This paper presents a novel augmented reality (AR) interaction method that allows a robot to perform manipulation of unknown physical objects in a human-robot collaborative working environment. A mobile AR application is developed to determine and communicate, in real-time, the position, orientation, and dimension of any random object in a robot manipulator's workspace to perform pick-and-place operations. The proposed method is based on estimating the pose and size of the object by means of an AR virtual element superimposed on the live view of the real object. In particular, a semi-transparent AR element is created and manipulated through touch screen interactions to match with the pose and scale of the physical object to provide the information about that object. The resulting data is communicated to the robot manipulator to perform pick-and-place tasks. In this way, the AR virtual element acts as a medium of communication between a human and a robot. The performance of the proposed AR interface is assessed by conducting multiple trials with random objects, and it is observed that the robot successfully accomplishes tasks communicated through the AR virtual elements. The proposed interface is also tested with 20 users to determine the quality of user experience, followed by a post-study survey. The participants reported that the AR interface is intuitive and easy to operate for manipulating physical objects of various sizes and shapes.

14:00-14:15 WeBT3.5

Designing a Socially Assistive Robot for Long-Term In-Home Use for Children with Autism Spectrum Disorders,

Pakkar, Roxanna (University of Southern California), Clabaugh, Caitlyn (University of Southern California), Lee, Rhianna (University of Southern California), Deng, Eric (University of Southern California), Mataric, Maja (University of Southern California)

Socially assistive robotics (SAR) research has shown great potential for supplementing and augmenting therapy for children with autism spectrum disorders (ASD). However, the vast majority of SAR research has been limited to short-term studies in highly controlled environments. The design and development of a SAR system capable of interacting autonomously in situ for long periods of time involves many engineering and computing challenges. This paper presents the design of a fully autonomous SAR system for long-term, in-home use with children with ASD. We address design decisions based on robustness and adaptability needs, discuss the development of the robot's character and interactions, and provide insights from the month-long, in-home data collections with children with ASD. This work contributes to a larger research program that is exploring how SAR can be used for enhancing the social and cognitive development of children with ASD.

14:15-14:30 WeBT3.6

Proof of Concept of a Projection-Based Safety System for Human-Robot Collaborative Engine Assembly,

Hietanen, Antti Eerikki (Tampere University of Technology), Changizi, Alireza (Tampere University of Technology), Lanz, Minna (Department of Mechanical Engineering and Industrial Systems), Kamarainen, Joni-Kristian (Tampere University of Technology), Ganguly, Pallab (Tampere University), Pieters, Roel S. (Tampere University), Latokartano, Jyrki Matias (Tampere University of Technology)

In the past years human-robot collaboration has gained interest among industry and production environments. While there is interest towards the topic, there is a lack of industrially relevant cases utilizing novel methods and technologies. The feasibility of the implementation, worker safety and production efficiency are the key questions in the field. The aim of the proposed work is to provide a conceptual safety system for context-dependent, multi-modal communication in human-robot collaborative assembly, which will contribute to safety and efficiency of the collaboration. The approach we propose offers an addition to traditional interfaces like push buttons installed at fixed locations. We demonstrate an approach and corresponding technical implementation of the system with projected safety zones based on the dynamically updated depth map and a graphical user interface (GUI). The proposed interaction is a simplified two-way communication between human and the robot to allow both parties to notify each other, and for the human to coordinate the operations.

WeBT4	Room T4
Therapy and Rehabilitation (Regular Session)	
Chair: Cavallo, Filippo	Scuola Superiore Sant'Anna - Pisa
Co-Chair: Fiorini, Laura	The BioRobotics Institute, Scuola Superiore Sant'Anna

13:00-13:15 WeBT4.1

Linear Parameter-Varying Identification of the EMG–Force Relationship of the Human Arm,

Pesenti, Mattia (Department of Information and Bioengineering, Politecnico Di Mil), Alkhoury, Ziad (University of Strasbourg), Bednarczyk, Maciej (ICube Laboratory, University of Strasbourg, Strasbourg), Omran, Hassan (ICube Laboratory, University of Strasbourg, Strasbourg), Bayle, Bernard (University of Strasbourg)

In this paper, we present a novel identification approach to model the EMG–Force relationship of the human arm, reduced to a single degree of freedom (1-DoF) for simplic- ity. Specifically, we exploit the Linear Parameter Varying (LPV) framework. The inputs of the model are the electromyographic (EMG) signals acquired on two muscles of the upper arm, biceps brachii and triceps brachii, and two muscles of the forearm, brachioradialis and flexor carpi radialis. The output of the model is the force produced at the hand actuating the elbow. Because of the position-dependency of the system, the elbow angle is used as scheduling signal for the LPV model. Accurate modeling of the human arm with this approach opens new possibilities in terms of robot control for physical Human- Robot Interaction and rehabilitation robotics.

13:15-13:30 WeBT4.2

Co-Designing and Field-Testing Adaptable Robots for Triggering Positive Social Interactions for Adolescents with Cerebral Palsy,

Mariager, Casper Sloth (Aalborg University), Fischer, Daniel K. B. (Aalborg University), Kristiansen, Jakob (Aalborg University), Rehm, Matthias (Aalborg University)

Robots in the health care sector are often envisioned as a kind of social interaction partner. We suggest a different approach, where robots become adaptable tools for facilitating positive social interaction between and learning for special needs users. The paper presents the development and a series of field tests of a new robot game platform, which is envisioned to level the playing field for users with distinct motor and cognitive capacities by adapting the robots to their abilities. The series of field tests shows that the system is successful in triggering positive social interactions between the players.

13:30-13:45 WeBT4.3

Socially Assistive Robot's Behaviors Using Microservices,

Ercolano, Giovanni (University of Naples Federico II), Lambiase, Paolo D. (University of Naples Federico II), Leone, Enrico (University of Naples "Federico II"), Raggioli, Luca (University of Naples Federico II), Trepiccione, Davide (University of Naples Federico II), Rossi, Silvia (Universita' Di Napoli Federico II)

In this work, we introduce a set of robot's behavior aimed at being used for monitoring and interaction with elderly people affected by Alzheimer disease. Robot's behaviors for a low cost robotic device rely on the use of microservices running on a local server. A microservice is an independent, self-contained, self-scope and self-responsibility component of the robotic system proposed for decoupling the implemented functions linked to the complex robot behaviors. The services developed include navigation, interaction, and monitoring capabilities. The requests and the signals of the patients are handled and managed relying on real-time event-based communications between the system components. The use design patterns like this, increases the overall reliability of a service composition. The system is currently operating in a private house with an elderly couple.

13:45-14:00 WeBT4.4

A Robot-Mediated Assessment of Tinetti Balance Scale for Sarcopenia Evaluation in Frail Elderly,

Fiorini, Laura (The BioRobotics Institute, Scuola Superiore Sant'Anna), D'Onofrio, Grazia (Complex Unit of Geriatrics, Department of Medical Sciences, IRC), Rovini, Erika (Scuola Superiore Sant'Anna - Pisa), Sorrentino, Alessandra (Scuola Superiore Sant'Anna), Coviello, Luigi (The Biorobotics Institute, Scuola Superiore Sant'Anna), Limosani, Raffaele (Scuola Superiore Sant'Anna), Sancarlo, Daniele (Complex Unit of Geriatrics, Department of Medical Sciences, IRC), Cavallo, Filippo (Scuola Superiore Sant'Anna - Pisa)

Aging society is characterized by a high prevalence of sarcopenia, which is considered one of the most common health problems of the elderly population. Sarcopenia is due to the age-related loss of muscle mass and muscle strength. Recent literature findings highlight that the Tinetti Balance Assessment (TBA) scale is used to assess the sarcopenia in elderly people. In this context, this article proposes a model for sarcopenia assessment that is able to provide a quantitative assessment of TBA-gait motor parameters by means of a cloud robotics approach. The proposed system is composed of cloud resources, an assistive robot namely ASTRO and two inertial wearable sensors. Particularly, data from two inertial sensors (i.e., accelerometers and gyroscopes), placed on the patient's feet, and data from ASTRO laser sensor (position in the environment) were analyzed and combined to propose a set of motor features correspondent to the TBA gait domains. The system was preliminarily tested at the hospital of “Fondazione Casa Sollievo della Sofferenza” in Italy. The preliminary results suggest that the extracted set of features is able to describe the motor performance. In the future, these parameters could be used to support the clinicians in the assessment of sarcopenia, to monitoring the motor parameters over time and to propose personalized care-plan.

14:00-14:15 WeBT4.5

Stakeholder's Acceptance and Expectations of Robot-Assisted Therapy for Children with Autism Spectrum Disorder,

Oliver, Joan (Instituto De Robótica Para La Dependencia), Oliván, Rebeca (Instituto De Robótica Para La Dependencia), Shukla, Jainendra (Indraprastha Institute of Information Technology, Delhi), Folch, Annabel (Intellectual Disability and Developmental Disorders Research Uni), Martínez-Leal, Rafael (Intellectual Disability and Developmental Disorders Research Uni), Castellà, Mireia (Intellectual Disability and Developmental Disorders Research Uni), Puig, Domenec (Rovira I Virgili University)

Robot assisted therapy for children with Autism Spectrum Disorder (ASD) should take into account the stakeholders expectations about their potential benefits. Any disparity between the stakeholders expectations and the gained benefits may negatively impact the acceptance and adoption of the robot assisted therapy. In this research, we conducted an observational study with eleven parents and five clinical professionals related with the children with ASD who were pre-selected to undergo robot assisted therapeutic sessions. The aim was to investigate and identify the potential impact regarding the interventions delivered by the social robots during the interventions, roles of the social robots and benefit offered by them. Specifically, the social robot Cozmo was used for this study. Their opinions were collected using questionnaires and were analyzed quantitatively and qualitatively.

The results of the study confirm a positive attitude towards the adoption of these technologies, both among the caregivers and the professionals.

14:15-14:30 WeBT4.6

SHEBA: A Low-Cost Assistive Robot for Older Adults in the Developing World,

Motahar, Tamanna (North South University), Farden, Fahim (North South University), Sarkar, Dibya Prokash (North South University), Islam, Atiqul (North South University), Cabrera, Maria Eugenia (University of Washington), Cakmak, Maya (University of Washington)

Maintaining independence and dignity is a primary goal of successful aging for older adults around the globe. Robots can support this goal in various ways by assisting everyday tasks that become challenging due to aging-related deterioration in physical and mental abilities. While a growing body of research tackles challenges in creating such robots, most work has focused on older adults with high socio-economic status in the developed world. In most cases, the price of these robots alone prohibits their potential use in the developing world. Further, socio-cultural differences in the developing world will limit the usability and chance of adoption of a robot designed based on users in the developed world. Our work aims to close this gap. In this paper we present findings from the user-centered design and development process of a low-cost assistive robot for older adults in the developing world named SHEBA, which is a Bengali term for care. We first interviewed 37 older adults and 21 caregivers in assisted and independent living settings in Dhaka, Bangladesh to gather requirements and understand priorities. We then developed a prototype focused on medication management and delivery and we brought it to an assisted living center to interact with potential older adult users. We interviewed 23 older adults and 5 caregivers who interacted with or observed our prototype to gather feedback. We present quantitative and qualitative data obtained in these interviews, identifying key requirements for robots designed for older adults in the developing world.

WeBT5 Room T5

Medical Robotics and Intelligent Control Systems in the Indian Context (Special Session)

Chair: Maria Joseph, Felix Orlando — Indian Institute of Technology Roorkie

Co-Chair: Pradhan, PyariMohan — IIT Roorkee

13:00-13:15 WeBT5.1

Bondgraph Modelling for the Master-Slave Robotic Teleoperation System,

Saini, Sarvesh (Indian Institute of Technology Roorkee), Pathak, Pushparaj M. (Indian Institute of Technology Roorkee), Maria Joseph, Felix Orlando (Indian Institute of Technology Roorkee)

Teleoperation is required where the operator cannot directly access the actual workspace such as nuclear exploration, garbage treatment, surgical workspace in laparoscopic and Natural Orifice Transluminal Endoscopic Surgery (NOTES), etc. In master and slave robotic teleoperation system the force and velocity information exchange take place between master and slave robots. In this paper, the bondgraph modelling technique has been used for the modeling of master-slave robotic teleoperation system. Here, the elements of teleoperation system such as master robot (Phantom Omni haptic device), slave robot (miniature In-vivo robot), communication architecture and external environment are modeled in bondgraph. Simulation results for trajectory tracking (in unilateral teleoperation) and force feedback (in bilateral teleoperation) between master and slave are presented.

13:15-13:30 WeBT5.2

Simultaneously Concentrated PSWF-Based Synchrosqueezing S-Transform and Its Application to R Peak Detection in ECG Signal,

Singh, Neha (IIT Roorkee), Deora, Puneesh (IIT Roorkee), Pradhan, PyariMohan (IIT Roorkee)

Time-frequency (TF) analysis through well-known TF tool namely S-transform (ST) has been extensively used for QRS detection in Electrocardiogram (ECG) signals. However, Gaussian window-based conventional ST suffers from poor TF resolution due to the fixed scaling criterion and the long taper of the Gaussian window. Many variants of ST using different scaling criteria have been reported in literature for improving the accuracy in the detection of QRS complexes. This paper presents the usefulness of zero-order prolate spheroidal wave function (PSWF) as a window kernel in ST. PSWF has ability to concentrate maximum energy in narrow and finite time and frequency intervals, and provides more flexibility in changing window characteristics. Synchrosqueezing transform is a post processing method that improves the energy concentration in a TFR remarkably. This paper proposes a PSWF-based synchrosqueezing ST for detection of R peaks in ECG signals. The results show that the proposed method accurately detects R peaks with a sensitivity, positive predictivity and accuracy of \$99.96%\$, \$99.96%\$ and \$99.92%\$ respectively. It also improves upon on existing techniques in terms of the aforementioned metrics and the search back range.

13:30-13:45 WeBT5.3

Continuous Higher Order Sliding Mode Control of Bevel-Tip Needle for Percutaneous Interventions,

Maria Joseph, Felix Orlando (Indian Institute of Technology Roorkee)

The major challenge in percutaneous interventions involving rigid needles are to assure accuracy in target reaching and stability. Human factor such as breathing process and human errors along with image distortion during needle deformation process can lead to the abovementioned challenges. Thus, in this piece of work, a robust second order sliding mode controller called super twisting algorithm to ensure chattering free response of the bevel tip flexible needle motion is proposed. Through the kinematic model of the bevel tip needle, the

performance of the proposed controller is tested. Furthermore, the comparison study through extensive simulations are also performed with conventional sliding mode controller. From the results, it is observed that the stable maneuvering performance of the needle due to the proposed algorithm will be suitable for real-time clinical scenarios involving minimal invasive surgeries.

13:45-14:00 WeBT5.4

Development of an Intelligent Cane for Visually Impaired Human Subjects,

Maria Joseph, Felix Orlando (Indian Institute of Technology Roorkee)

People with visual disabilities are often dependent on external assistance which is provided by either humans, trained dogs, or other special electronic devices for decision making but there are certain limitations to these aids.Hence, an intelligent white cane is developed for visually challenged people which makes use of HR-SO4 ultrasonic sensors to detect any obstacle that lies in the range of the the sensor and determine its distance. The ultrasonic sensor has range up to 450 meters so that any object lying within this range can be easily detected and the warning signal is provided using the buzzer which gives beeping signals in order to alert the user for prompt action. Also, an intelligent technique of object detection and classification using the web camera which captures the image and hence classifies it is being used. The classification obtained is in the form of text which is further converted to audio signal using text-to-speech conversion which is implemented in Python using Espeak open source library.

14:00-14:15 WeBT5.5

Intention Detection and Gait Recognition (IDGR) System for Gait Assessment: A Pilot Study,

Singh, Yogesh (Indian Institute of Technology Gandhinagar), Kher, Manan (Institute of Technology, Nirma University), Vashista, Vineet (Indian Institute of Technology Gandhinagar)

Gait abnormality is the most significant symptom in the neurologically affected patients. To improve their quality of life, it is important to complement and further enhance the existing qualitative gait analysis protocol with a technically sound quantitative paradigm. In this paper, we present a pilot study and the development of a wearable intention detection and gait recognition (IDGR) system. This system comprises a well-established integrated network of microcontrollers and sensors which acts as a diagnostic tool for gait correction. IDGR system provides real-time feedback of the temporal gait parameter on a user interface. Furthermore, this system classifies the subject's intention - standing still, walking or ascending the stairs using simple logic inherent to an individual's walking style. It offers reliable tools for functional assessment of the patient's progress by measuring physical parameters. We conducted an experiment on a healthy participant as a validation of our approach and proof-of-concept.

14:15-14:30 WeBT5.6

Transferring Dexterous Surgical Skill Knowledge between Robots for Semi-Autonomous Teleoperation,

Rahman, Md Masudur (Purdue University - West Lafayette), Sanchez-Tamayo, Natalia (Purdue University), Gonzalez, Glebys (Purdue University), Agarwal, Mridul (Purdue University), Vaneet, Aggarwal (Purdue University), Voyles, Richard (Purdue University), Xue, Yexiang (Purdue University), Wachs, Juan (Purdue University)

In the future, deployable, teleoperated surgical robots can save the lives of critically injured patients in battlefield environments. These robotic systems will need to have autonomous capabilities to deal with communication delays and unexpected environmental conditions during critical phases of the procedure. Understanding and predicting the next surgical actions (referred as “surgemes”) is essential for autonomous surgery. Most approaches for surgeme recognition cannot cope with the high variability associated with austere environments and thereby cannot “transfer” well to field robotics. We propose a methodology that uses compact image representations with kinematic features for surgeme recognition in the DESK dataset. This dataset offers samples for surgical procedures over different robotic platforms with a high variability in the setup. We performed surgeme classification in two setups: 1) No transfer, 2) Transfer from a simulated scenario to two real deployable robots. Then, the results were compared with recognition accuracies using only kinematic data with the same experimental setup. The results show that our approach improves the recognition performance over kinematic data across different domains. The proposed approach produced a transfer accuracy gain up to 20% between the simulated and the real robot, and up to 31% between the simulated robot and a different robot. A transfer accuracy gain was observed for all cases, even those already above 90%.

WeCT1 Room T8

Poster Slot 1 (Poster Session)

Chair: Behera, Laxmidhar IIT Kanpur

15:00-17:00 WeCT1.1

Learning by Collaborative Teaching : An Engaging Multi-Party CoWriter Activity,

El Hamamsy, Laila (EPFL), Johal, Wafa (École Polytechnique Fédérale De Lausanne), Asselborn, Thibault (EPFL), Nasir, Jauwairia (EPFL), Dillenbourg, Pierre (EPFL)

This paper presents the design of a novel and engaging collaborative learning activity for handwriting where a group of participants simultaneously tutor a Nao robot. This activity was intended to take advantage of both collaborative learning and the learning by teaching paradigm to improve children's meta-cognition (perception of their own skills). Multiple engagement probes were integrated into the activity as a first step towards fostering long term interactions. As a lot of research targets social interactions, the goal here was to determine whether an engagement strategy focused on the task could be as, or more efficient than one focused on social interactions and participants' introspection. To that effect, two engagement strategies were implemented. They differed in content but used the same multi-modal design in order to increase participants' meta-cognitive reflection, once on the task and performances, and once on participants' enjoyment and emotions. Both strategies were compared to a baseline by probing and assessing engagement at the individual and group level, along the behavioural, emotional and cognitive dimensions, in a between subject experiment with 12 groups of children. The experiments showed that the collaborative task pushed the children to adapt their manner of writing to the group, even though the adopted solution was not always correct. Furthermore, there was no significant difference between the strategies in terms of behaviour on task (behavioural engagement), satisfaction (emotional engagement) or performance (cognitive engagement) as the group dynamics had a stronger impact on the outcome of the collaborative teaching task. Therefore, the task and social engagement strategies can be considered as efficient in the context of collaboration.

15:00-17:00 WeCT1.2

Trajectory Optimization of Continuum Arm Robots,

Yadav, Ritesh (BITS Pilani), Rout, Bijay Kumar (Birla Institute of Technology and Science, Pilani, India)

Rigid manipulators are applicable for a very structured environment and standard applications. For real world applications, continuum manipulators are used which has required high degrees of freedom, and compliance. The current work focus on the trajectory optimization of continuum robot for a specified application to minimize energy usage. To achieve this task Lagrangian mechanics is used to develop the mathematical model of the continuum robot with the payload. In this case the trajectory optimization has been carried out by treating the problem as a nested optimization problem. The outer optimization task is to optimize the trajectory using minimization of input force as primary goal where initial and final configurations of the arm are already available. Here, Genetic Algorithm is used as the optimizer for the selected tasks. The purpose of inner optimization loop is to find the feasible inverse solution for the manipulator that is required to calculate input forces which is further required to optimize the trajectory of the arm. A constrained non-linear optimization algorithm is used for the task. The optimization results show 30-80 % decrease in the input force required for the specified trajectories of the arm. The current paper shows that various tasks can be optimized using the formulated strategy to save the energy required by the arm to execute specified task.

15:00-17:00 WeCT1.3

Playful Interaction with Humanoid Robots for Social Development in Autistic Children: A Pilot Study,

Cervera, Enric (Jaume-I University), del Pobil, Angel P. (Jaume-I University), Cabezudo, Maria-Isabel (Hospital De Manises)

Children with a diagnosis of Autism Spectrum Disorder (ASD) have serious difficulties in the development of their communicative and social skills. In recent years, robots have been tested in the therapy of autistic children as a promising tool for increasing their interest and motivation in the activities. In this paper we present the results of a pilot study with playful robot-child interaction developed for the therapy of diagnosed children aged between 3 and 5. The children were separated into an intervention and a control group. Their progress in development was measured before and after the intervention. Although the experience was unanimously considered as positive by parents and caregivers, we have found no significative differences between the intervention and control groups. Some observed trends demand more caution and additional studies for identifying not only the advantages but also the possible pitfalls of the use of robots in the therapy of autistic children.

15:00-17:00 WeCT1.4

Formulating User Requirements for Designing Collaborative Robots,

Macovetchi, Ana Maria (Blue Ocean Robotics), Shahabeddini Parizi, Mohammad (Blue Ocean Robotics), Kirstein, Franziska (Blue Ocean Robotics)

This paper is concerned with a methodology for gathering user requirements (URs) to inform a later design process of industrial collaborative robots. The methodology is applied to four use cases from CoLLaboratE, which is a European project focusing on how industrial robots learn to cooperate with human workers in performing new manufacturing tasks. The project follows a User-Centered Design (UCD) approach by involving end-users in the development process. The user requirements (URs) are gathered using a mixed methodology, with the purpose of formulating a list of case specific requirements, which can be also generalized. The results presented in this paper consist of the list of user requirements, which will serve as a basis in establishing scenarios and system requirements for later design of a Human-Robot Collaboration (HRC) system. The described methodology contributes to the field of design of HRC systems by taking a UCD approach. The methodology is aimed at improving the solution performance and users' acceptance of the technology, by early involvement of the users in the design process. It can also be adaptable to other development projects, where users play an essential role in creating Human-Robot Collaboration solutions.

15:00-17:00 WeCT1.5

Dark-Room Exchange: Human Supervision of Decentralized Multi-Robot Systems Using Distributed Ledgers and Network Mapping,

Krishnamoorthy, Sai-Prasanth (NYU Tandon School of Engineering), Go, Albert (Massachusetts Institute of Technology), Tiwari, Ashlee (Indian Institute of Technology, Kanpur), Kapila, Vikram (NYU Tandon School of Engineering)

This paper develops a distributed technique to populate the network graph of a decentralized multi-robot system (MRS) by employing a consensus protocol for extracting the identities and states of each robot's neighbors in the MRS. A dark-room exchange (DRE) technique is proposed wherein each robot uses its on-board 2D LiDAR for range sensing and peer-to-peer communication to identify and track neighboring objects. The resulting information is utilized to build and maintain a distributed ledger populated with the information of the MRS network graph structure to facilitate supervision by human operators. The system is tested in a simulated environment consisting of TurtleBot3 robots scattered in a 2D plane. Using the results of simulation, an analysis of the speed and performance of the DRE technique is conducted that illustrates high reliability and fast response times. The paper concludes with a discussion of the future scope of this research for multi-robot/swarm applications.

15:00-17:00 WeCT1.6

Communicating with SanTO – the First Catholic Robot,

Trovato, Gabriele (Waseda University), Pariasca, Franco (Pontificia Universidad Catolica Del Peru), Ramirez, Renzo (Pontificia Universidad Católica Del Perú), Cerna, Javier (Pontificia Universidad Catolica Del Peru), Reutskiy, Vadim (Innopolis University), Rodriguez, Laureano (Pontificia Universidad Católica Del Perú), Cuellar, Francisco (Pontificia Universidad Catolica Del Peru)

In the 1560s Philip II of Spain commissioned the realisation of a "mechanical monk", a small humanoid automaton with the ability to move and walk. Centuries later, we present a Catholic humanoid robot. With the appearance of a statue of a saint and some interactive features, it is designed for Christian Catholic users for a variety of purposes. Its creation offers new insights on the concept of sacredness applied to a robot and the role of automation in religion. In this paper we present its concept, its functioning, and a preliminary test. A dialogue system, integrated within the multimodal communication consisting of vision, touch, voice and lights, drives the interaction with the users. We collected the first responses, particularly focused on the impression of sacredness of the robot, during an experiment that took place in a church in Peru.

15:00-17:00 WeCT1.7

Quantitative Evaluation of Clothing Assistance Using Whole-Body Robotic Simulator of the Elderly,

Joshi, Ravi Prakash (Graduate School of Life Science and Systems Engineering, Kyushu), Shibata, Tomohiro (Kyushu Institute of Technology), Ogata, Kunihiro (National Institute of Advanced Industrial Science and Technology), Matsumoto, Yoshio (AIST)

The recent demographic trend across developed nations shows a dramatic increase in the aging population, fallen fertility rates and a shortage of caregivers. Robotic solutions to clothing assistance can significantly improve the Activity of Daily Living (ADL) for the elderly

and disabled. We have developed a clothing assistance robot using dual arms and conducted many successful demonstrations with healthy people. It was, however, impossible to systematically evaluate its performance because human arms are not visible due to occlusion from a shirt and robot during dressing. To address this problem, we propose to use another robot, Whole-Body Robotic Simulator of the Elderly that can mimic the posture and movement of the elderly persons during the dressing task. The dressing task is accomplished by utilizing Dynamic Movement Primitives (DMP) wherein the control points of DMP are determined by applying forward kinematics on the robotic simulator. The experimental results show the plausibility of our approach.

15:00-17:00 WeCT1.8

Impression Change on Nonverbal Non-Humanoid Robot by Interaction with Humanoid Robot,

Ueno, Azumi (Tokyo University of Agriculture and Technology), Mizuuchi, Ikuo (Tokyo University of Agriculture and Technology), Hayashi, Kotaro (Toyohashi University of Technology)

Even if a robot is not designed with a specific impression, if there is a means that can add an impression later to the robot, it will be useful for social robot design, we considered. In particular, anthropomorphism seems to be an important impression of designing social interaction between humans and robots. In the movie, ”STAR WARS,” there is a non-humanoid robot, called R2-D2, which communicates mainly by sounds. A humanoid interpreter robot, called C- 3PO, responds to the sound of R2-D2 with natural language and gesture. And the audience finds the personality in R2-D2 richer than the personality which is based on the information which R2-D2's sounds have. that it might be possible to change the impression of a non-humanoid robot emitting simple sounds by communication with a humanoid robot that speaks a natural language and make gestures. We conducted an impression evaluation experiment. In the condition where robots are inter- acting, the observer evaluated anthropomorphism of the non- humanoid robot more than in the non-interacting condition. There were also some other impressions that have changed.

15:00-17:00 WeCT1.9

MobiKa - Low-Cost Mobile Robot for Human-Robot Interaction,

Graf, Florenz (Fraunhofer IPA), Odabasi, Cagatay (Fraunhofer IPA), Jacobs, Theo (Fraunhofer IPA), Graf, Birgit (Fraunhofer IPA), Födisch, Thomas (BruderhausDiakonie)

One way to allow elderly people to stay longer in their homes is to use of service robots to support them with everyday tasks. With this goal, we design, develop and evaluate a low-cost mobile robot to communicate with elderly people. The main idea is to create an affordable communication assistant robot which is optimized for multimodal Human-Robot Interaction (HRI). Our robot can navigate autonomously through dynamic environments using a new algorithm to calculate poses for approaching persons. The robot was tested in a real life scenario in an elderly care home.

15:00-17:00 WeCT1.10

Design and Evaluation of Expressive Turn-Taking Hardware for a Telepresence Robot,

Fitter, Naomi T. (University of Southern California), Joung, Youngseok (University of Southern California), Demeter, Marton (University of Southern California), Hu, Zijian (University of Southern California), Mataric, Maja (University of Southern California)

Although nonverbal expressive abilities are an essential element of human-to-human communication, telepresence robots support only select nonverbal behaviors. As a result, telepresence users can experience difficulties taking turns in conversation and using various cues to obtain the attention of others. To expand telepresence robot users' abilities to hold the floor during conversation, this work proposes and evaluates new types of expressive telepresence robot hardware. The described within-subjects study compared robot user and co-present person experiences during teamwork activity conditions involving basic robot functions, expressive LED lights, and an expressive robot arm. We found that among participants who preferred the arm-based expressiveness, individuals in both study roles felt the robot operator to be more in control of the robot during the arm condition, and participants co-located with the robot felt closer to their teammate during the arm phase. Participants also noted advantages of the LED lights for notification-type information and advantages of the arm for increasing perceptions of the robot as a human-like entity. Overall, these findings can inform future work on augmenting the nonverbal expressiveness of telepresence robots.

15:00-17:00 WeCT1.11

Study of Empathy on Robot Expression Based on Emotion Estimated from Facial Expression and Biological Signals,

Sripian, Peeraya (Shibaura Institute of Technology), Kurono, Yuya (Shibaura Institute of Technology), Yoshida, Reiji (Shibaura Institute of Technology), Sugaya, Midori (Shibaura Institute of Technology)

Empathy, the ability to share the other's feeling, is one of the effective elements in promoting mutual reliability and construction of a good relationship. In order to create empathy between human-robot, a robot must be able to estimate the emotion of human and reflect the same emotion on its expression. In general, emotion can be estimated based on observable expressions such as facial expression, or unobservable expressions such as biological signals. Although there are many methods for measuring emotion from both facial expression and biological signals, few studies have been done on the comparison of estimated emotion. In this paper, we investigate whether emotion estimated from facial expression or biological signals could lead to empathy toward a robot. Using our proposed emotion estimation system, we performed two experiments and found that higher impression was rated on sociability elements with significant when the reflected emotion is estimated from uncontrollable emotion.

WeCT2 Room T2

Poster Slot 2 (Poster Session)

Chair: Behera, Laxmidhar IIT Kanpur

15:00-17:00 WeCT2.1

Does a Friendly Robot Make You Feel Better?,

Ruijten, Peter (Eindhoven University of Technology), Cuijpers, Raymond (Eindhoven University of Technology)

As robots are taking a more prominent role in our daily lives, it becomes increasingly important to consider how their presence influences us. Several studies have investigated effects of robot behavior on the extent to which that robot is positively evaluated. Likewise, studies have shown that the emotions a robot shows tend to be contagious: a happy robot makes us feel happy as well. It is unknown, however, whether the affect that people experience while interacting with a robot also influences their evaluation of the robot. This study aims to discover whether people's affective and evaluative responses to a social robot are related. Results show that affective responses and evaluations are related, and that these effects are strongest when a robot shows meaningful motions. These results are consistent with earlier findings in terms of how people evaluate social robots.

15:00-17:00 WeCT2.2

Brand Recognition with Partial Visible Image in the Bottle Random Picking Task Based on Inception V3,

Zhu, Chen (Waseda University), Matsumaru, Takafumi (Waseda University)

In the brand-wise random-ordered drinking PET bottles picking task, the overlapping and viewing angle problem makes a low accuracy of the brand recognition. In this paper, we set the problem to increase the brand recognition accuracy and try to find out how the overlapping rate infects on the recognition accuracy. By using a stepping motor and transparent fixture, the training images were taken automatically from the bottles under 360 degrees to simulate a picture taken from viewing angle. After that, the images are augmented with random cropping and rotating to simulate the overlapping and rotation in a real application. By using the automatically constructed dataset, the Inception V3, which was transferred learning from ImageNet, is trained for brand recognition. By generating a random mask with a specific overlapping rate on the original image, the Inception V3 can give 80% accuracy when 45% of the object in the image is visible or 86% accuracy when the overlapping rate is lower than 30%.

15:00-17:00 WeCT2.3

A Conditional Adversarial Network for Scene Flow Estimation,

Thakur, Ravi Kumar (Indian Institute of Information Technology Sri City, Chittoor), Mukherjee, Snehasis (Indian Institute of Information Technology Sri City, Chittoor)

The problem of Scene flow estimation in depth videos has been attracting attention of researchers of robot vision, due to its potential application in various areas of robotics. The conventional scene flow methods are difficult to use in real-life applications due to their long computational overhead. We propose a conditional adversarial network SceneFlowGAN for scene flow estimation. The proposed SceneFlowGAN uses loss function at two ends: both generator and descriptor ends. The proposed network is the first attempt to estimate scene flow using generative adversarial networks, and is able to estimate both the optical flow and disparity from the input stereo images simultaneously. The proposed method is experimented on a huge RGB-D benchmark sceneflow dataset.

15:00-17:00 WeCT2.4

Evaluating Imitation of Human Eye Contact and Blinking Behavior Using an Android for Human-Like Communication,

Tetsuya, Sano (Nara Institute of Science and Technology), Yuguchi, Akishige (Nara Institute of Science and Technology), Garcia Ricardez, Gustavo Alfonso (Nara Institute of Science and Techonology (NAIST)), Takamatsu, Jun (Nara Institute of Science and Technology), Nakazawa, Atsushi (Kyoto University), Ogasawara, Tsukasa (Nara Institute of Science and Technology)

The appearance of android robots is very similar to that of human beings. From their appearance, we expect that androids might provide us with high-level communication. The imitation of human behavior gives us the feeling of natural behavior even if we do not know what drives high-level communication. In this paper, we evaluate the imitation of human eye behavior by an android. We consider that the android imitates human eye behavior while explaining some research topic and a person acts as a listener. Then, we construct a method to imitate the eye behavior obtained from eye trackers. For the evaluation, we asked seventeen male subjects for their subjective evaluation and compared the imitation with an android that controlled eye-contact duration and eyeblinks by editing the imitation or programming rule-based behavior. From the results, we found out that 1) the rule-based behaviors kept human-likeness, 2) 3-second eye contact obtained better scores regardless of the imitation-based or rule-based eye behavior, and 3) the subjects might regard the longer eyeblinks as voluntary eyeblinks, with the intention to break eye contacts.

15:00-17:00 WeCT2.5

Deep-Pack: A Vision-Based 2D Online Bin Packing Algorithm with Deep Reinforcement Learning,

Kundu, Olyvia (TCS Innovation Labs), Dutta, Samrat (TCS Research and Innovation), Swagat, Kumar (Tata Consultancy Services)

This paper looks into the problem of online 2D bin packing where the objective is to place an incoming object in a way so as to maximize the overall packing density inside the bin. Unlike off-line methods, the online methods do not make use of information about the sequence of future objects that are going to arrive and hence, are comparatively difficult to solve. A deep reinforcement learning framework based on Double DQN is proposed to solve this problem that takes an image showing the current state of the bin as input and gives out the pixel location where the incoming object needs to be placed as the output. The reward function is defined in such a way so that the system learns to place an incoming object adjacent to the already placed items so that the maximum grouped empty area is retained for future placement. The resulting approach is shown to outperform existing state-of-the-art-method for 2D online packing and can easily be extended to 3D online bin packing problems.

15:00-17:00 WeCT2.6

Collaborative Transportation of Cable-Suspended Payload Using Two Quadcopter with Human in the Loop,

Prajapati, Pratik (Indian Institute of Technology Gandhinagar), Parekh, Sagar (Institute of Technology, Nirma University), Vashista, Vineet (Indian Institute of Technology Gandhinagar)

We study the problem of collaborative transportation of cable-suspended payload using two quadcopters. While previous works on transportation using quadcopters emphasize more on autonomous control and generating complex trajectory, in this paper a master-slave strategy is implemented where the master quadcopter is controlled by human and the slave quadcopter tries to stabilize the oscillations of the payload. Two quadcopters with a cable-suspended payload system is under-actuated with coupled dynamics and hence, manual control is difficult. We use Lagrangian mechanics on a manifold for deriving equations of motion and apply variation based linearization to linearize the system. We designed a Lyapunov based controller to minimize the oscillations of the payload while transportation, leading to an easier manual control of master quadcopter.

15:00-17:00 WeCT2.7

Effective Human-Robot Collaboration in Near Symmetry Collision Scenarios,

da Silva Filho, José Grimaldo (University Grenoble Alpes - INRIA), Olivier, Anne-Hélène (Univ Rennes, M2S Lab, Inria, MimeTIC), Crétual, Armel (M2S Lab, University Rennes 2), Pettre, Julien (Inria - Irisa), Fraichard, Thierry (INRIA)

Recent works in the domain of Human-Robot Motion (HRM) attempt to plan collision avoidance behavior that accounts for cooperation between agents. This is important as effective cooperation requires, among several factors, predicting whether

the person will attempt to avoid collision as first or last crosser. The robot should be able to replicate this decision making process in order to allow for effective collaboration during collision avoidance. However, whenever situations arise in which the choice crossing order is not consistent for people, the robot is forced to account for the possibility that both agents will assume the same role ie{} a decision detrimental to collision avoidance. Thus, in our work we evaluate the boundary that separates the decision to avoid collision as first or last crosser. By approximating the uncertainty around this boundary, we developed a collision avoidance strategy to address this problem. Our approach is based on the insight that the robot should plan its collision avoidance motion in such a way that, even if agents, at first, incorrectly choose the same crossing order, they would be able to unambiguously perceive their crossing order on their following collision avoidance action.

15:00-17:00 WeCT2.8

Establishing Human-Robot Trust through Music-Driven Robotic Emotion Prosody and Gesture,

Savery, Richard (Georgia Inst. of Technology), Weinberg, Gil (Georgia Inst. of Technology), Rose, Ryan (Georgia Inst. of Technology)

As human-robot collaboration opportunities continue to expand, trust becomes ever more important for full engagement and utilization of robots. Affective trust, built on emotional relationship and interpersonal bonds is particularly critical as it is more resilient to mistakes and increases the willingness to collaborate. In this paper we present a novel model built on music-driven emotional prosody and gestures that encourages the perception of a robotic identity, designed to avoid uncanny valley. Symbolic musical phrases were generated and tagged with emotional information by human musicians. These phrases controlled a synthesis engine playing back pre-rendered audio samples generated through interpolation of phonemes and electronic instruments. Gestures were also driven by the symbolic phrases, encoding the emotion from the musical phrase to low degree-of-freedom movements. Through a user study we showed that our system was able to accurately portray a range of emotions to the user. We also showed with a significant result that our non-linguistic audio generation achieved an 8% higher mean of average trust than using a state-of-the-art text-to-speech system.

15:00-17:00 WeCT2.9

Effectiveness of Robot Communication Level on Likeability, Understandability and Comfortability,

Chatterji, Nupur (Georgia Institute of Technology), Allen, Courtney (Georgia Institute of Technology), Chernova, Sonia (Georgia Institute of Technology)

The proliferation of commercially available social robots is undeniable. As humans and robots interact more closely and frequently, it brings to light issues surrounding how the human feels and perceives when dealing with robots - how much do they like the way the interaction occurs, how well do they understand what the robot is trying to communicate, and how comfortable do they feel? Much of this is intertwined within the communication level that the robot uses. In this paper, we evaluate the effect of different robot communication levels -- voice only, sound only, or voice and sound -- when applied to robots designed with differing levels of anthropomorphism and different purposes, evaluating the resulting impact on human-robot interaction with respect to likeability, understandability and comfort. We evaluate these factors on 13 commercially designed robots. Our results show that in almost all cases, survey responders showed a preference for robots that incorporate more spoken interaction than currently deployed systems.

15:00-17:00 WeCT2.10

Trip Recommendation Robot Agent,

Matsui, Tetsuya (Seikei University), Yamada, Seiji (National Institute of Informatics)

In this paper, we suggest a design method for constructing trip recommendation agents. We focused on two factors for the agents: appearance and whether the agents expressed an opinion or not. We constructed two kinds of appearance for the agents: human-like and robot-like. Also, we constructed two types of recommendation text: with the agents' opinion and without. We conducted an experiment on the web to verify these two factors on the recommendation effect. As a result, we revealed that the robot-like agent was more effective than the human-like agent in trip recommendation.

15:00-17:00 WeCT2.11

Tracking Control Incorporating Friction Estimation of a Cleaning Robot with a Scrubbing Brush,

Nemoto, Takuma (Singapore University of Technology and Design), Mohan, Rajesh Elara (Singapore University of Technology and Design)

This paper proposes an improved controller with a friction estimator for the path tracking of a cleaning robot having a scrubbing brush, motivated by the presence of the positive influence of brush friction on robot propulsion. For the controller and the estimator, the dynamics of a cleaning robot with a scrubbing brush is represented by a model incorporating the LuGre dynamic friction model. This dynamic robot model is transformed into appropriate forms in controller and estimator design. The controller employs a sliding mode control (SMC) law improved to exploit the friction for achieving a control target. The estimator provides estimates of the state and parameters of the dynamic model in an unscented Kalman filter (UKF) framework to calculate the friction force. The performance of the proposed controller with the estimator is tested through numerical simulations. The simulation results illustrate that the proposed approach is effective for the path tracking of cleaning robots with less input torque.

WeCT3 Room T3

Poster Slot 3 (Poster Session)

Chair: Behera, Laxmidhar IIT Kanpur

15:00-17:00 WeCT3.1

Evaluation of Robots That Signals a Pedestrian Using Face Orientation Based on Moving Trajectory Analysis,

Yamashita, Shohei (Hiroshima City University), Ikeda, Tetsushi (Hiroshima City University), Shinozawa, Kazuhiko (Advanced Telecommunications Research Institute), Iwaki, Satoshi (Hiroshima City University)

Robots that share daily environments with us are required to behave in a socially acceptable manner. There are two important approaches to this purpose: 1) robots model human behavior, understand it properly and behave appropriately 2) robots present their understanding and future behavior to surrounding people. In this paper, considering people present various cues to other people around them using gaze and face direction, we focus on the latter approach and propose a robot that presents cues to an opposing pedestrian by turning face. Another problem with the conventional research is that the evaluation of the

pedestrian's ease of passing with the robot depends only on the subjective impression, so it was difficult to design the robot's behavior based on the temporal change of the ease of walking. In this paper, we evaluate the fluctuation of the pedestrian's moving velocity vector as an index of the ease of walking and analyze the temporal change. We have conducted preliminary experiments in which 12 subjects passed by the robot and compared the three types of presentation methods using the face. By presenting information using a face, we confirmed that the subjects tended to have better impressions of walking based on subjective evaluation and that the walking was relatively easy to walk for several seconds while approaching the robot based on analyzing the fluctuation of the moving speed vector.

15:00-17:00 WeCT3.2

Augmented Robotics for Learners: A Case Study on Optics,

Johal, Wafa (École Polytechnique Fédérale De Lausanne), Robu, Olguta (EPFL), Dame, Amaury (Oxford University), Magnenat, Stéphane (EPFL), Mondada, Francesco (EPFL)

In recent years, robots have been surfing on a trendy wave as standard devices for teaching programming. The tangibility of robotics platforms allows for collaborative and interactive learning. Moreover, with these robot platforms, we also observe the occurrence of a shift of visual attention from the screen (on which the programming is done) to the physical environments (i.e. the robot). In this paper, we describe an experiment aiming at studying the effect of using augmented reality (AR) representations of sensor data in a robotic learning activity. We designed an AR system able to display in real-time the data of the InfraRed sensors of the Thymio robot. In order to evaluate the impact of AR on the learners' understanding on how these sensors worked, we designed a pedagogical lesson that can run with or without the AR rendering.

Two different age groups of students participated in this between-subject experiment, counting a total of 74 children. The tests were the same for the experimental (AR) and control group (NOAR). The exercises differed only through the use of AR. Our results show that AR was worth being used for younger groups dealing with difficult concepts. We discuss our findings and propose future works to establish guidelines for designing AR robotic learning sessions.

15:00-17:00 WeCT3.3

Incremental Estimation of Users' Expertise Level,

Carreno, Pamela (University of Waterloo), Dahiya, Abhinav (University of Waterloo), Smith, Stephen L. (University of Waterloo), Kulic, Dana (University of Waterloo)

Estimating a user's expertise level based on observations of their actions will result in better human-robot collaboration, by enabling the robot to adjust its behaviour and the assistance it provides according to the skills of the particular user it's interacting with. This paper details an approach to incrementally and continually estimate the expertise of a user whose goal is to optimally complete a given task. The user's expertise level, here represented as a scalar parameter, is estimated by evaluating how far their actions are from optimal; the closer to optimal the user's choices are, the more expert the user is considered to be. The proposed approach was tested using data from an online study where participants were asked to complete various instances of a simulated kitting task. An optimal planner was used to estimate the ``goodness'' of all available actions at any given task state. We found that our expertise level estimates correlate strongly with observed after-task performance metrics and that it is possible to differentiate novices from experts after observing, in average, 33% of the errors made by the novices.

15:00-17:00 WeCT3.4

Autonomous Chess Playing Robot,

Rath, Prabin Kumar (NIT Rourkela), Mahapatro, Neelam (NIT Rourkela), Nath, Prasanmit (NIT Rourkela), Dash, Ratnakar (National Institute of Technology Rourkela)

Chess is an ancient strategy board game that is played on an 8x8 board. Although digital games have become attractive today, chess still retains its popularity in the onscreen version of the game. There has also been considerable development in the chess game engines to play against a human counterpart. The objective of this work is to integrate these chess engines with an actual board game experience and create an autonomous chess player. The system is designed around the use of an open source chess engine and a computer numeric control (CNC) controlled magnetic moving mechanism for moving around the chess pieces. The moves from the human counterpart are taken through an overhead computer vision system. The robot makes the game much more interactive and builds a link between the human and computer system.

15:00-17:00 WeCT3.5

Human-Robot Team: Effects of Communication in Analyzing Trust,

Ciocirlan, Stefan-Dan (University Politehnica of Bucharest), Agrigoroaie, Roxana (ENSTA-ParisTech), Tapus, Adriana (ENSTA-ParisTech)

Trust is related to the performance of human teams, making it a significant characteristic, which needs to be analyzed inside human-robot teams. Trust was researched for a long time in other domains like social sciences, psychology, and economics. Building trust within a team is formed through common tasks and it depends on team performance and communication. By applying an online game based tasks for human-robot teams, the effects of three communication conditions (communication without text and verbal interaction, communication with text and verbal interaction related/not related to the task) on trust are analyzed. Additionally, we found that the participants' background is linked to the trust in the interaction with the robot. The results show that in a human-robot team the human trust will increase more over time when he/she is working with a robot that uses text and verbal interaction communication related to the task. They further suggest that human trust will decrease to a lower extent when the robot fails in doing the tasks if it uses text and verbal communication with the human. with the human.

15:00-17:00 WeCT3.6

Probabilistic Obstacle Avoidance and Object Following: An Overlap of Gaussians Approach,

Bhatt, Dhaivat (IIIT-Hyderabad), Garg, Akash (Delhi Technological University), Gopalakrishnan, Bharath (IIIT HYDERABAD), Krishna, Madhava (IIIT Hyderabad)

Autonomous navigation and obstacle avoidance are core capabilities that enable robots to execute tasks in the real world. We propose a new approach to collision avoidance that accounts for uncertainty in the states of the agent and the obstacles. We first demonstrate that measures of entropy— used in current approaches for uncertainty-aware obstacle avoidance—are an inappropriate design choice. We then pro- pose an algorithm that solves an optimal control sequence with a guaranteed risk bound, using a measure of overlap between the two distributions that represent the state of the robot and the obstacle, respectively. Furthermore, we provide closed form expressions that can characterize the overlap as a function of the control input. The proposed approach enables model- predictive control framework to generate bounded-confidence control commands. An extensive set of simulations have been conducted in various constrained environments in order to demonstrate the efficacy of the proposed approach over the prior art. We demonstrate the usefulness of the proposed scheme under tight spaces where computing risk-sensitive control maneuvers is vital. We also show how this framework generalizes to other problems, such as

object-following.

15:00-17:00 WeCT3.7

Improving Robot Tutoring Interactions through Help-Seeking Behaviors,

Jordan, Kristin (University of Southern California), Pakkar, Roxanna (University of Southern California), Mataric, Maja (University of Southern California)

Robot tutors have great potential for supporting personalized learning, in both home and classroom settings. To be effective, robot tutors must encourage users to seek help as needed during the learning process. We conducted a between-subjects study with N = 45 participants to compare different types of learner help-seeking behaviors–pressing an on-screen button, pressing a physical button, and raising a hand–and assess how help-seeking behavior preferences relate to perceptions of the robot tutor. The results indicate that hand raising was seen as the hardest method for a user to perform but the most useful and beneficial, with positive trends in students' intention to use a robot.

15:00-17:00 WeCT3.8

Coupling of Arm Movements During Human-Robot Interaction: The Handover Case,

Ferreira Duarte, Nuno (Instituto Superior Técnico, Lisbon), Rakovic, Mirko (University of Novi Sad, Faculty of Technical Sciences), Santos-Victor, José (Instituto Superior Técnico - Lisbon)

Collaboration involves understanding the action of others, as well as acting in a way that can be understood by others. One of those tasks is the handover. In this paper, we study the behaviour of humans during the handover and design the mechanisms allowing a robot to learn from that behaviour. We analyse and model the arm movements of humans while handing over objects to one another. The contributions of this paper are the following: (i) a computational model that captures the behaviour of the “giver” and “receiver” of the object, by coupling the arm motion; (ii) discuss this approach amidst a previous coupling strategy; and (iii) embedded the model in the iCub robot for human to robot handovers . Our results show that: (i) the robot can coordinate with the human to timely and safely receive the object; (ii) the robot behaves in a “human-like” manner while receiving the object; and (iii) our approach has significant advantages to the previous approach.

15:00-17:00 WeCT3.9

Towards Situational Awareness from Robotic Group Motion,

Levillain, Florent (Ensadlab-Reflective Interaction), St-Onge, David (Ecole De Technologie Superieure), Beltrame, Giovanni (Ecole Polytechnique De Montreal), Zibetti, Elisabetta (CHART-LUTIN)

The control of multiple robots in the context of tele-exploration tasks is often attentionally taxing, resulting in a loss of situational awareness for operators. Unmanned aerial vehicle swarms require significantly more multitasking than controlling a plane, thus making it necessary to devise intuitive feedback sources and control methods for these robots. The purpose of this article is to examine a swarm's nonverbal behaviour as a possible way to increase situational awareness and reduce the operator's cognitive load by soliciting intuitions about the swarm's behaviour. To progress on the definition of a database of nonverbal expressions for robot swarms, we first define categories of communicative intents based on spontaneous descriptions of common swarm behaviours. The obtained typology confirms that the first two levels (as defined by Endsley: elements of environment and comprehension of the situation) can be shared through swarms motion-based communication. We then investigate group motion parameters potentially connected to these communicative intents. Results are that synchronized movement and tendency to form figures help convey meaningful information to the operator. We then discuss how this can be applied to realistic scenarios for the intuitive command of remote robotic teams.

15:00-17:00 WeCT3.10

Analysis of Factors Influencing the Impression of Speaker Individuality in Android Robots,

Mikata, Ryusuke (ATR), Ishi, Carlos Toshinori (ATR), Minato, Takashi (ATR), Ishiguro, Hiroshi (Osaka University)

Humans use not only verbal information but also non-verbal information in daily communication. Among the non-verbal information, we have proposed methods for automatically generating hand gestures in android robots, with the purpose of generating natural human-like motion. In this study, we investigate the effects of hand gesture models trained/designed for different speakers on the impression of the individuality through android robots. We consider that it is possible to express individuality in the robot, by creating hand motion that are unique to that individual. Three factors were taken into account: the appearance of the robot, the voice, and the hand motion. Subjective evaluation experiments were conducted by comparing motions generated in two android robots, two speaker voices, and two motion types, to evaluate how each modality affects the impression of the speaker individuality. Evaluation results indicated that all these three factors affect the impression of speaker individuality, while different trends were found depending on whether or not the android is copy of an existent person.

15:00-17:00 WeCT3.11

Synthesizing Unnatural Grasping in Humanoid Robots Using Fuzzy Logic,

Dayal, Udai, Arun (Birla Institute of Technology), Biswas, Shiladitya (Birla Institute of Technology), Penisetty, Sree Aslesh (Birla Institute of Technology, Mesra, Ranchi)

This paper presents a whole body grasping algorithm using fuzzy logic. Firstly, a comprehensive analysis of the human body was performed by decomposing it into a simplistic stick diagram and examining all types of grasps possible. The theory of combinations namely, Enumerative Combinatorics was used in order to calculate the total number of grasps possible by the human body. The paper focuses largely upon the grasps which can be physically accomplished by the NAO humanoid robot developed by Aldebaran Robotics. Finally, a fuzzy logic based algorithm was implemented to assign grasping weightage to the body parts, i.e. arms, torso, head, etc. of the robot depending upon the position of the object to be grasped.

WeCT4 Room T4

Poster Slot 4 (Poster Session)

Chair: Behera, Laxmidhar IIT Kanpur

15:00-17:00 WeCT4.1

Classroom Group Formation Model Based on Socion Theory Considering Communication in Social Networking Services,

Naito, Kosuke (Nagoya Institute of Technology), Kato, Shohei (Nagoya Institute of Technology)

In recent years, Social Networking Services (SNS) have become popular among young people. Unfortunately, as SNS usage has increased, cyberbullying has also increased and has become a social problem. Several previous studies have employed multi-agent simulation, which can be used to analyze human relationships, to identify bullying mechanisms. In this study, we model SNSs in a classroom and apply multi-agent simulation to analyze the influence of

SNSs on classroom friendships. We focus on junior high school students as our research object. In the proposed model, which is based on socion theory, an agent can communicate with other agents using two types of networks: a classroom network and SNS networks, via a network which recognized by each individual (in socion theory, people have mental networks that reflect society). Agents communicate face to face (FTF) in the classroom and using SNS in their SNS groups. In addition, agents have social skills and are categorized based on these social skills. In this study, we simulate friendship relations considering SNSs and discuss the influence of SNSs on classroom relationships based on the simulation results. We performed two simulations; one only involved FTF communication and the others involved both FTF and SNS communication. We compare the two simulations and discuss the results. We found that, compared to FTF communication, the average likability rating of agents increased with SNS communication. On the other hand, we also found that specific agents were rejected. We consider that sharing information over SNSs is related to increased bullying. In conclusion, we discuss applying to educational robots from results.

15:00-17:00 WeCT4.2

Design of an Integrated Gripper with a Suction System for Grasping in Cluttered Environment,

Kang, Long (Hanyang University), Seo, Jong-Tae (Hanyang University), Kim, Sang-Hwa (Hanyang University), Yi, Byung-Ju (Hanyang University)

Development of an integrated gripping system for grasping various objects in different work environments is very useful in many practical applications, such as warehouse automation. In this paper, we propose a linkage-driven underactuated gripper combined with a suction mechanism. This underactuated gripper has two fingers which can be controlled independently and each finger is constructed by stacking one five-bar mechanism over one double parallelogram. The special architecture allows for installing all of the actuators on the base. The suction mechanism is used to grasp objects in narrow space and enhance the grasp stability. The ability of grasping various objects is confirmed through practical grasping experiment on a commercial robot arm.

15:00-17:00 WeCT4.3

A Robust Position Estimation Algorithm under Unusual Large Range Errors,

Kim, Moonki (Korean Institute of Science and Technology), Lee, Ji Yang (Korean Institute of Science and Technology), Kim, Jung-Hee (Korea Institute of Science and Technology), Hassen, Nigatu (Korean Institute of Science and Technology), Kim, Doik (KIST)

This paper provides a robust fusion algorithm for accurate position estimation under uncertain large errors in range measurements. Many researchers have studied UWB, IMU, odometry integration algorithms for estimating position, velocity, attitude and IMU biases. However, the fused results of these conventional algorithms are likely to be affected by the unusual ranging measurement errors. Therefore, in order to improve the positioning accuracy under the large errors of the UWB range, a robust fusion algorithm is required. In this paper, instead of using the range directly, the estimated range that the errors is reduced is used. Reducing the errors is possible by using the odometry velocity that is relatively accurate and is independent of range measurement. The robustness and accuracy of the proposed algorithm is verified by a mobile robot with real-time positioning and trajectory control under large range errors which are occurred randomly.

15:00-17:00 WeCT4.4

Factors Influencing the Human Preferred Interaction Distance,

Rajamohan, Vineeth (University of Nevada, Reno), Scully-Allison, Connor (University of Nevada, Reno), Dascalu, Sergiu (University of Nevada, Reno), Feil-Seifer, David (University of Nevada, Reno)

Nonverbal interactions are a key component of human communication. Since robots have become significant by trying to get close to human beings, it is important that they follow social rules governing the use of space. Prior research has conceptualized personal space as physical zones which are based on static distances. This work examined how preferred interaction distance can change given different interaction scenarios. We conducted a user study using three different robot heights. We also examined the difference in preferred interaction distance when a robot approaches a human and, conversely, when a human approaches a robot. Factors included in quantitative analysis are the participants' gender, robot's height, and method of approach. Subjective measures included human comfort and perceived safety. The results obtained through this study shows that robot height, participant gender and method of approach were significant factors influencing measured proxemic zones and accordingly participant comfort. Subjective data showed that experiment respondents regarded robots in a more favorable light following their participation in this study. Furthermore, the NAO was perceived most positively by respondents according to various metrics and the PR2 Tall, most negatively.

15:00-17:00 WeCT4.5

Perception of Social Intelligence in Robots Performing False-Belief Tasks,

Sturgeon, Stephanie (University of Nevada, Reno), Palmer, Andrew (University of Nevada, Reno), Blankenburg, Janelle (University of Nevada, Reno), Feil-Seifer, David (University of Nevada, Reno)

This study evaluated how a robot demonstrating a Theory of Mind (ToM) influenced human perception of social intelligence and animacy in a human-robot interaction. Data was gathered through an online survey where participants watched a video depicting a NAO robot either failing or passing the Sally-Anne false-belief task. Participants (N = 60) were randomly assigned to either the Pass or Fail condition. A Perceived Social Intelligence Survey and the perceived intelligence and animacy subsections of the Godspeed Questionnaire Series (GQS) were used as measures. The GQS was given before viewing the task to measure participant expectations, and again after to test changes in opinion. Our findings show that robots demonstrating ToM significantly increase perceived social intelligence, while robots demonstrating ToM deficiencies are perceived as less socially intelligent.

15:00-17:00 WeCT4.6

Dynamic Calibration between a Mobile Robot and SLAM Device for Navigation,

Ishikawa, Ryoichi (The University of Tokyo), Oishi, Takeshi (The University of Tokyo), Ikeuchi, Katsushi (Microsoft)

In this paper, we propose a dynamic calibration between a mobile robot and a device using simultaneous localization and mapping (SLAM) technology, which we termed as the SLAM device, for a robot navigation system. The navigation framework assumes loose mounting of SLAM device for easy use and requires an online adjustment to remove localization errors. The online adjustment method dynamically corrects not only the calibration errors between the SLAM device and the part of the robot to which the device is attached but also the robot encoder errors by calibrating the whole body of the robot. The online adjustment assumes that the information of the external environment and shape information of the robot are consistent. In addition to the online adjustment, we also present an

offline calibration between a robot and device. The offline calibration is motion-based and we clarify the most efficient method based on the number of degrees-of-freedom of the robot movement. Our method can be easily used for various types of robots with sufficiently precise localization for navigation. In the experiments, we confirm the parameters obtained via two types of offline calibration based on the degree of freedom of robot movement. We also validate the effectiveness of the online adjustment method by plotting localized position errors during a robot's intense movement. Finally, we demonstrate the navigation using a SLAM device.

15:00-17:00 WeCT4.7

Development of a Teach Pendant for Humanoid Robotics with Cartesian and Joint-Space Control Modalities,

Otarbay, Zhenis (Nazarbayev University), Assylgali, Iliyas (Nazarbayev University), Yskak, Asset (Nazarbayev University), Folgheraiter, Michele (Nazarbayev University)

This paper presents the design, the construction and testing of a teach pendant for humanoid robotics applications. The system is equipped with a touch-based Graphical User Interface (GUI) from which the robot's joints and the robot's end-effectors can be easily controlled in the joint and Cartesian space respectively. A visual representation of the legs pose were integrated in the interface allowing the operator to test the motion of the limbs before their actual execution on the real robot. The forward and inverse kinematic models were formalized according to the Denavit-Hartenberg convention and implemented in Python 3 with the support of the Tkinter, NumPy and Matplotlib libraries. The chassis of the teach-pendant was designed using SolidWorks software to accommodate a 9-inch display with a touch sensor, a 5000 mAh battery, a Raspberry pi 3, and an ATmega168 microcontroller. On the frontal panel, rotary encoders and different buttons are present to access the menu and precisely tune the control variables.

15:00-17:00 WeCT4.8

Influencing Hand-Washing Behaviour with a Social Robot: HRI Study with School Children in Rural India,

Deshmukh, Amol (University of Glasgow), K Babu, Sooraj (AMMACHI Labs, Amrita Vishwa Vidyapeetham, Amritapuri, India), Radhakrishnan, Unnikrishnan (Amrita University), Ramesh, Shanker (AMMACHI Labs, Amrita Vishwa Vidyapeetham, Amritapuri, India), A, Parameswari (Ammachilabs, Amrita Vishwa Vidyapeetham, Amritapuri, India), Rao R, Bhavani (Amrita Vishwa Vidyapeetham University)

The work presented in this paper reports the influence of a social robot on hand washing behaviour on school children in rural India with a significant presence of indigenous tribes. We describe the design choices of our social robot to cater the requirements of the intervention. The custom built wall mounted social robot encouraged 100 children to wash their hand at appropriate time (before meal and after toilet) using the correct handwashing technique via a poster on a wall. The results indicate that the intervention using the robot was found to be effective (40% rise) at increasing levels of hand washing with soap and with a better handwashing technique in ecologically valid settings.

15:00-17:00 WeCT4.9

Aggressive Bee: A New Vision for Missile Guidance Applications,

Jada, Chakravarthi (RGUKT-NUZVID), Urlana, Ashok (RGUKT-NUZVID), Baswani, Pavan (RGUKT-NUZVID), Shaik, Gouse Basha (RGUKT-NUZVID)

This paper presents the idea of inspiration from aggressive bee for target tracking and extremely quick attack.The experimental setup made ready and multiple target movements are given using various aggravators and for each movement, the bee-target motion episode is recorded. The bee-target position tuple is generated for all points, all trajectories, and all episodes. Three approaches namely the kinematic model, error based model and an energy-based approach are implemented to derive the bee tracking and attacking behaviour. All the approaches are explained step by step and conclusions are given with prospective works and future applications are mentioned at the end.

15:00-17:00 WeCT4.10

Chasing and Aiming of a Moving Target,

Agarwal, Suryansh (IIT Kanpur), Hanchinal, Suraj Veerabhadra (IIT Kanpur), Chaudhary, Ashok Kumar (IIT Kanpur), Behera, Laxmidhar (IIT Kanpur)

This paper proposes an approximate solution for accurate pitch calculation countering the effect of air resistance, chasing algorithm dynamic pipeline integrated using Behavior Tree so that an

autonomous robot can follow, target and aim with shooting precision on a moving target. The air resistance is taken into account for achieving shooting precision through linear as well as polynomial functions of distance of target from the robot, for which the effectiveness is checked using simulations as well as theoretical derivations. The stability and effectiveness of the chasing algorithm is based on the fact that robot tracks the pose of the target in real time and its tri-vision module helps it in localising better. The reactivity of the proposed pipeline is maintained through behavior tree intelligence, which structures as well as dynamically make decisions. The above has been experimentally validated using the standard DJI robot as a proof of utility in real-time applications.

15:00-17:00 WeCT4.11

Investigations on Gesture Holding Durations at Speech Interruptions in Dialogue Robots,

Ishi, Carlos Toshinori (ATR), Mikata, Ryusuke (ATR), Minato, Takashi (ATR), Ishiguro, Hiroshi (Osaka University)

Hand gestures commonly occur in daily dialogue interactions, and have important functions in human-human as well as human-robot communication. In this study, we consider one issue regarding speech interruptions by the dialogue partner in an android robot dialogue system. Specifically, we conducted a subjective experiment to evaluate the effects of holding duration control after speech interruptions, in our android robot. Evaluation results indicated that gesture holding durations around 0.5 to 2 seconds after an interruption look natural, while longer durations may cause impression of displeasure by the robot.

WeCT5 Room T5

Poster Slot 5 (Poster Session)

Chair: Behera, Laxmidhar IIT Kanpur

15:00-17:00 WeCT5.1

Human-Robot Handovers with Signal Temporal Logic Specifications,

Kshirsagar, Alap (Cornell University), Kress-Gazit, Hadas (Cornell University), Hoffman, Guy (Cornell University)

We present a formal methods based approach to human-robot handovers. Specifically, we use the automatic synthesis of a robot controller from specifications in Signal Temporal Logic (STL). This allows users to specify and dynamically change the robot's behaviors using high-level abstractions of goals and constraints rather than by tuning controller parameters. Also, in contrast to existing controllers, this controller can provide guarantees on the timing of each of the

handover phases. We replicate the behavior of existing handover strategies from the literature to illustrate the proposed approach. We are currently implementing this approach on a collaborative robot arm and we will evaluate it's usability through human-participant experiments.

15:00-17:00 WeCT5.2

Development and Performance Evaluation of Onboard Auto-Pilot System for an Aerial Vehicle,

Kumar, Abhinay (IIT Jodhpur), Comandur, Venkatesan (IIT-Jodhpur)

Design of hover capable unmanned aerial vehicles has been an active area of research for the past several years. The stabilization of these unstable vehicles require estimation of orientation, velocity, position, external wind speed etc. and providing appropriate control signal to the actuators so that the vehicle can perform the desired tasks. This paper presents the key aspects that need to be addressed to design an onboard flight control system for a multi-rotor vehicle. Several test rigs were developed to estimate the parameters of the propulsion system, and tuning of gains for autonomous stabilization, prior to free flight. The performance of the vehicle in free flight was tested for control inputs in orientation and altitude. It is observed that the tracking in orientation is fairly accurate for small angle inputs, i.e., less than 5 deg. but deviates more with higher angle set points.

15:00-17:00 WeCT5.3

A Body Contact-Driven Pupil Response Pet-Robot for Enhancing Familiarity,

Sejima, Yoshihiro (Kansai University), Kawamoto, Hiroki (Okayama Prefectural University), Sato, Yoichiro (Okayama Prefectural University), Watanabe, Tomio (Okayama Prefectural University)

Pupil response is closely related to human affect and interest. Focusing on the pupil response in human-robot interaction, we have developed a pupil response system using hemisphere displays and confirmed that the pupil response is effective for enhancing affective conveyance in human-robot interaction. In this study, for the basic research of realizing a friendly communication during embodied interaction between human and robot, we developed a body contact-driven pupil response pet-robot for enhancing familiarity in human-robot interaction. This robot generates the pupil response based on the body contact using small displays in which the 3D models of pupil and iris are represented. Then, we carried out an evaluation experiment by using a sensory evaluation with the pet-robot. The results demonstrated that the pet-robot with the pupil response is effective for enhancing familiarity strongly in human-robot interaction.

15:00-17:00 WeCT5.4

Development of a Finger Rehabilitation System Considering Motion Sense and Vision Based on Mirror Therapy,

Ota, Shunsuke (University of Toyama), Jindai, Mitsuru (University of Toyama), Yasuda, Toshiyuki (University of Toyama)

Mirror therapy has been undertaken as one of rehabilitation for symptoms such as hemiplegia. In this rehabilitation, it is effective to support the movement of the finger on the paralyzed side at the same time as the movement of the finger on the healthy side in the mirror. Furthermore, effective rehabilitation can be expected by improving a difference between vision and motion sense. Therefore, in this paper, we develop a finger rehabilitation system considering motion sense and vision based on mirror therapy. Furthermore, the rehabilitation movement preferred by humans is considered by sensory evaluation experiment, and the effectiveness of the developed finger rehabilitation system is demonstrated.

15:00-17:00 WeCT5.5

Extended Hybrid Code Network for Hospital Receptionist Robot,

Hwang, Eui Jun (The University of Auckland), Ahn, Byeong-Kyu (Sungkyunkwan University), MacDonald, Bruce (University of Auckland), Ahn, Ho Seok (The University of Auckland, Auckland)

Task-oriented dialogue system has a vital role in service robots. This paper introduces a preliminary result for a robot dialogue system in the context of hospital receptionist. The system includes Hybrid Code Network (HCN) which is an RNN based end-to-end dialogue system and an RNN based gesture selection module that select gesture according to robot utterance. The proposed system has been applied to a real robot platform NAO and tested based on sample hospital receptionist scenario.

15:00-17:00 WeCT5.6

Investigating the Understandability and Efficiency of Directional Cues in Robot Navigation,

Neggers, Margot (Eindhoven University of Technology), Ruijten, Peter (Eindhoven University of Technology), Cuijpers, Raymond (Eindhoven University of Technology), IJsselsteijn, Wijnand (Technische Universiteit Eindhoven)

Understanding a robot's directional cues not only depends on their clarity but also on how people perceive them. In the current study the effectiveness of three directional cues (LEDs, Speech and Movement) is tested in three scenarios where a robot and a person cross paths. Participants had to reach a target in a grid in as few moves as possible, without colliding with the robot. We measured Perceived Message Understanding of the cues, interaction time to measure efficiency and asked participant to rate their subjective perception of the cues. Results showed that the LEDs cue was rated lowest in terms of Perceived Message Understanding, the Speech cue was evaluated as the most friendly and the Movement cue was the most efficient as shown by faster interaction times.

15:00-17:00 WeCT5.7

Multi-Robot Formation Control Using Reinforcement Learning,

Rawat, Abhay (International Institute of Information Technology, Hyderabad), Karlapalem, Kamalakar (IIIT-Hyderabad)

In this paper, we present a machine learning approach to move a group of robots in a formation. We model the problem as a multi-agent reinforcement learning problem. Our aim is to design a control policy for maintaining the desired formation among a number of agents (robots) while moving towards the desired goal. This is achieved by training our agents to track two agents of the group and maintain the formation with respect to those agents. We consider all agents to be homogeneous and model them as unicycle [1]. In contrast to the leader-follower approach, where each agent has an independent goal, our approach aims to train the agents to be cooperative and work towards the common goal. Our motivation to use this method is to make a fully decentralized multi-agent formation system and scalable for a number of agents.

15:00-17:00 WeCT5.8

A Pilot Study for a Robot-Mediated Listening Comprehension Intervention for Children with ASD,

Louie, Wing-Yue Geoffrey (Oakland University), Abbas, Ibrahim (Oakland University), Korneder, Jessica (Oakland University,)

Autism spectrum disorder (ASD) is a life-long developmental condition which affects an individual's ability to communicate and relate to others. Despite such challenges, early intervention during childhood development has shown to have positive long-term benefits for individuals with ASD. Namely, early childhood development of communicative speech skills has shown to improve future literacy and academic achievement. However, the delivery of such interventions is often time-consuming. Socially assistive robots are a potential strategic technology which could help support intervention delivery for children with ASD and increase the number of individuals that healthcare professionals can positively impact. In this work, we present a pilot study to evaluate the efficacy of a robot-mediated listening comprehension intervention for children with ASD.

15:00-17:00 WeCT5.9

Contextual Non-Verbal Behaviour Generation for Humanoid Robot Using Text Sentiment,

Deshmukh, Amol (University of Glasgow), Foster, Mary Ellen (University of Glasgow), Mazel, Alexandre (Aldebaran-Robotics)

This paper describes an approach to synthesise non-verbal behaviours for a humanoid robot Pepper using spoken text. Our approach takes into account the sentiment of the spoken text and maps the appropriate gesture and sound relevant to that text in a parameterised manner. This work forms a basis for our planned user study where we will evaluate this approach.

15:00-17:00 WeCT5.10

Towards Automatic Synthesis and Instantiation of Proactive Behaviour,

Buyukgoz, Sera (SoftBank Robotics Europe, Sorbonne University), Chetouani, Mohamed (Sorbonne University), Pandey, Amit Kumar (Hanson Robotics)

This paper contributes to the research efforts for designing a unified framework of proactive behaviour. Despite existing definitions of proactive behaviours in variety of different fields, no such unified framework is available. We propose a framework that considers different aspects of proactivity, such as anticipating user needs, improvement in knowledge, interacting and engagement, and considering user's actions and feelings. Our proactive framework is based on Markov Decision Processes (MDP). Moreover, the probability of state transitions are computed according to past actions of both the robot and the user. The architecture is illustrated by a memory card game task, where the robot and the user try to solve the task together.

15:00-17:00 WeCT5.11

An Agent Model Introducing Interpersonal Sentiments for Enhancement of Friendliness,

Fukuta, Kazuaki (Nagoya Institute of Technology), Kato, Shohei (Nagoya Institute of Technology)

We frequently communicate interactively with robots and there is considerable demand for friendly communication agents to make such interactions smooth, low- stress, and enjoyable. Thus, we propose an agent model with interpersonal sentiments. The interpersonal sentiments make the agent behave consistently and produce lasting changes by accumulating experiences. The proposed agent also adapts its behavior to suit individual users. The proposed model has an emotion, a mood, and a sentiment. We conduct experiments to verify that the proposed model is effective relative to enhancing agent friendliness. Participants had conversations with the agents. We analyze the participants' evaluation of them using the Semantic Differential to confirm whether our proposed method is effective for agents' friendliness enhancement.

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AUTHOR INDEX

&	
イシイ, ユウキ	TuAT4.4
A	
A, Parameswari	TuBT1.5
	WeCT4.8
Abbas, Ibrahim	WeCT5.8
Abeywickrama, Dhaminda	TuCT2.5
Abylkasymova, Galiya	TuCT3.6
Agarwal, Akshat	TuAT1.2
Agarwal, Mridul	WeBT5.6
Agarwal, Suryansh	WeCT4.10
Agnihotri, Abhijeet	TuCT3.5
Agrawal, Shrey	TuBT2.4
Agrigoroaie, Roxana	WeCT3.5
Ahn, Byeong-Kyu	TuCS1.3
	WeCT5.5
Ahn, Ho Seok	TuCS1
	TuCS1.3
	WeCT5.5
Ahn, Jeongdo	WeAT4.4
Akter, Irin	TuCT2.6
Akter, Sharmin	TuCT2.6
Alami, Rachid	TuCT1.1
	TuCT4.6
Alenyà, Guillem	WeAT5.4
Alfayad, Samer	WeAT4.2
Alhaddad, Ahmad Yaser	TuAT3.4
Alkhoury, Ziad	WeBT4.1
Allen, Courtney	WeCT2.9
Amin, Tamara	WeBT2.2
Amirabdollahian, Farshid	TuCT1.6
Amorin, Guillermo	TuCT1.3
Amrutur, Bharadwaj	WeAT2.4
	WeAT2.5
Andre, Elisabeth	WeBT2.6
Andriella, Antonio	WeAT5.4
Anzai, Yuki	WeAT4.3
Asada, Harry	TuCT2.3
Asada, Minoru	TuCT1.2
Asfour, Tamim	WeBT1.4
Aslan, Ilhan	WeBT2.6
Asselborn, Thibault	TuBT1.4
	WeCT1.1
Assylgali, Iliyas	WeCT4.7
Avula, Venkata Seetharama Sai Bhargav Kumar	WeAT3.1
Axelsson, Minja	TuBT1.1
B	
Baek, DongHoon	WeAT4.4
Balakuntala Srinivasa Murthy, Mythra Varun	WeAT2.2
Bambusek, Daniel	TuAT2.5
	TuCT2.1
Banks, Jaime	TuAT2.2
	TuAT3.1
Barakova, Emilia I.	WeAT2.6
Barco, Alex	TuBT3.6
Barua, Sailanjan	TuCT2.6
Baswani, Pavan	WeCT4.9
Baxter, Paul Edward	TuCS1.6
Bayle, Bernard	WeBT4.1
Bednarczyk, Maciej	WeBT4.1
Begum, Momotaz	TuAT1.6
Behera, Laxmidhar	TuAT1
	TuAT1.1
	TuCT4.1
	WeAT1.6
	WeAT3
	WeAT3.3
	WeAT3.4
	WeCT1
	WeCT2
	WeCT3
	WeCT4
	WeCT4.10
	WeCT5
Belowska, Anna	WeBT3.2
Beltrame, Giovanni	WeCT3.9
Ben Ouezdou, Fathi	WeAT4.2
Beran, Vitezslav	TuAT2.5
	TuCT2
	TuCT2.1
Berger, Jaden	TuBT1.3
Bhatnagar, Shalabh	WeAT2.4
	WeAT2.5
Bhatt, Dhaivat	WeCT3.6
Bhatt, Umang	WeBT2.2
Bhattacharjee, Tapomayukh	TuBT4.1
Bhattacharya, Indrajit	WeBT2.4
Bhattacharya, Shounak	WeAT2.4
	WeAT2.5
Bickmore, Timothy	TuCT3.4
Billard, Aude	WeBT1.4
Biswas, Shiladitya	WeCT3.11
Björling, Elin	TuBT1.6
Blankenburg, Janelle	WeCT4.5
Bolano, Gabriele	TuAT2.3
Bonarini, Andrea	TuAT3.4
Bowman, Nick	TuAT3.1
Broadbent, Elizabeth	TuCS1.3
Bruno, Barbara	TuBS1.1
Bryson, Joanna	TuAT4.3
Buchina, Nina	WeAT2.6
Buoncompagni, Luca	TuBT4.3

Busch, Baptiste	WeAT1
	WeBT1.4
Buyukgoz, Sera	WeCT5.10
C	
Caballero, Fernando	TuAT2.1
Cabezudo, Maria-Isabel	WeCT1.3
Cabibihan, John-John	TuAT3
	TuAT3.4
	TuBT3
	WeIII_PL
Cabrera, Maria Eugenia	TuBT1.6
	WeBT4.6
Cai, Zekun	TuAS1.5
Cakmak, Maya	TuBT1.6
	WeBT4.6
Cambria, Erik	WeBT1.1
Campbell, Mark	WeAT1.5
Carpio Mazariegos, Estuardo Rene	TuAT1.6
Carreno, Pamela	WeCT3.3
Castellà, Mireia	WeBT4.5
Castellano, Ginevra	TuBT3.5
Castro, Nina	TuBS1.1
Cavallo, Filippo	WeBT4
	WeBT4.4
Cerna, Javier	WeCT1.6
Cervera, Enric	WeCT1.3
Cesta, Amedeo	TuAT1.4
Chacko, Sonia	WeBT3.4
Chakraborty, Debraj	TuBT2.5
Chandra, Shruti	WeBT2.3
Chang, Che-Ming	TuBT2.1
Changizi, Alireza	WeBT3.6
Chao, Wei-Lun	WeAT1.5
Charles-Nicolas, Julien	WeBT2.3
Chatterji, Nupur	WeCT2.9
Chau, Aaron	TuBT4.2
Chaudhary, Ashok Kumar	WeCT4.10
Chemori, Ahmed	TuCT4
Chen, Yu-ping	TuBT3.1
Chernova, Sonia	WeBT1.5
	WeCT2.9
Chetouani, Mohamed	WeCT5.10
Chitour, Yacine	WeAT4.2
Chua, Yi Han Victoria	TuAT4.6
Cimmino, Teresa	TuAS1.2
Ciocirlan, Stefan-Dan	WeCT3.5
Cirstea, Corina	TuCT2.5
Clabaugh, Caitlyn	WeBT3.5
Clark-Turner, Madison	TuAT1.6
Clodic, Aurélie	TuCT1.1
	TuCT4.6
Comandur, Venkatesan	WeCT5.2
Cominelli, Lorenzo	TuAT3.2
	TuBS1
Correia, Filipa	WeBT2.3
Cotugno, Giuseppe	WeBT1.4
Coviello, Luigi	WeBT4.4
Crétual, Armel	WeCT2.7
Cuellar, Francisco	WeCT1.6
Cuijpers, Raymond	WeCT2.1
	WeCT5.6
D	
D'Arcy, Michael	WeAT2.3
D'Onofrio, Grazia	WeBT4.4
da Silva Filho, José Grimaldo	WeCT2.7
Dahiya, Abhinav	WeCT3.3
Dame, Amaury	WeCT3.2
Das, Shome S	TuBT4.4
Dascalu, Sergiu	WeCT4.4
Dash, Ratnakar	WeCT3.4
Dautenhahn, Kerstin	TuAS1.3
Dauwels, Justin	TuAT4.6
Davari, Mohammad-Javad	WeAT1.3
Davies, Aled	TuCT2.2
Dayal, Udai, Arun	WeCT3.11
De Jong, Chiara	TuBT3.6
De Oliveira, Ana Christine	WeAT5.5
De Rossi, Danilo	TuAT3.2
De Visser, Ewart	TuCT1.4
Deacon, Graham	WeBT1.4
Del Duchetto, Francesco	TuCS1.6
del Pobil, Angel P.	WeCT1.3
Demeter, Marton	TuAT4.2
	WeCT1.10
Deng, Eric	WeBT3.5
Deora, Puneesh	WeBT5.2
Desai, Indrajit	TuBT2.5
Deshmukh, Amol	TuAT3
	TuBT1.5
	WeCT4.8
	WeCT5.9
Deshpande, Ashish	WeAT5.5
Dhall, Abhinav	TuBT4.6
Dholakiya, Dhaivat	WeAT2.4
	WeAT2.5
Di Nuovo, Alessandro	WeAT2
Dillenbourg, Pierre	TuBT1.2
	TuBT1.4
	WeCT1.1
Dillmann, Rüdiger	TuAT2.3
Ding, Ming	TuBS1.4
Diprose, James	TuCT1.5
Doelling, Kris	TuAT3.3
Doryab, Afsaneh	WeBT2.2
Dutta, Samrat	TuCT4.5
	WeAT2.1
	WeCT2.5
Dwivedi, Anany	TuAT4.5
Dychus, Eric	WeAT4.2
Dziok, Maria	WeBT3.2
E	
Ebrahimi, Ali	WeAT4.5
Edwards, Autumn	TuAT2
	TuAT2.2
El Hamamsy, Laila	WeCT1.1
Elahi, M. M. Lutfe	TuCT2.6
Elangovan, Nathan	TuBT2.1
Elara, Mohan Rajesh	WeBT3.3
Ercolano, Giovanni	WeBT4.3
Eto, Haruhiko	TuCT2.3
Ewelina, Bakała	TuCT1.3
F	

Fang, Fei	WeBT2.2
Farden, Fahim	WeBT4.6
Fazli, Pooyan	WeAT2.3
	WeBT1
Feil-Seifer, David	WeCT4.4
	WeCT4.5
Ferraro, Francis	WeBT2.5
Ferreira Duarte, Nuno	WeCT3.8
Fields, Noelle	TuAT3.3
Fiorini, Laura	WeAT5
	WeBT4
	WeBT4.4
Fiorino, Humbert	WeAT3.5
Fischer, Daniel K. B.	WeBT4.2
Fitter, Naomi T.	TuAT4
	TuAT4.2
	WeCT1.10
Födisch, Thomas	WeCT1.9
Folch, Annabel	WeBT4.5
Folgheraiter, Michele	WeCT4.7
Foster, Mary Ellen	WeCT5.9
Fraichard, Thierry	WeCT2.7
Frisk, Martin	TuBT3.5
Fry, Katelyn	TuBT3.1
Fu, Li-Chen	TuCT3.2
Fukui, Yuta	TuCT2.4
Fukuta, Kazuaki	WeCT5.11
Funakoshi, Kotaro	TuBT4.2
G	
Gale, Lucas	TuCT1.4
Gally, Justin Philippe Roger Luc	WeBT2.3
Gamborino, Edwinn	TuCT3.2
Ganguly, Pallab	WeBT3.6
Gao, Yuan	TuBT3.5
Garcia Ricardez, Gustavo Alfonso	TuBS1.4
	WeCT2.4
Garg, Akash	WeCT3.6
Garg, Jatin	TuCT3.3
Garofalo, Roberto	TuAT3.2
Garrote, Luís Carlos	WeAT1.2
Gehlbach, Peter	WeAT4.5
Gerez, Lucas	TuBT2.1
Ghonasgi, Keya	WeAT5.5
Ghosal, Ashitava	WeAT2.4
	WeAT2.5
Ghosh, Ayan	TuAT4.1
Ghosh, Bishal	TuBT4.6
Go, Albert	WeCT1.5
Goel, Yash	WeAT3.1
Gombolay, Matthew	WeBT1.5
Gomez, Randy	TuAT2.1
Gómez-Sena, Leonel	TuCT1.3
Gonzalez, Glebys	WeBT5.6
Gopalakrishnan, Bharath	WeCT3.6
Gorjup, Gal	TuAT4.5
Graf, Birgit	WeCT1.9
Graf, Florenz	WeCT1.9
Greer, Julienne	TuAT3.3
Groechel, Thomas	TuBS1.2
Gross, Horst-Michael	WeBT1.2
Gupta, Abhishek	TuBT2.5
Gupta, Kamal	WeAT1
	WeAT1.3
H	
Hald, Kasper	TuBS1.6
Hamandi, Mahmoud	WeAT2.3
Hanchinal, Suraj Veerabhadra	WeCT4.10
Hanheide, Marc	TuCS1.6
Haque, Mohammad Ahsanul	TuCT3.1
Haring, Kerstin Sophie	TuCT1.4
Hasegawa, Masaki	TuCT4.4
Hashemian, Mojgan	TuAT3.5
Hassen, Nigatu	WeCT4.3
Hayashi, Kotaro	TuAT3.6
	TuCT4
	TuCT4.4
	WeCT1.8
He, Changyan	WeAT4.5
Hegedus, Michael James	WeAT1.3
Heinke, Dietmar	TuCS1.1
Hernandez, Daniel	TuBT3.5
Herse, Sarita	TuAS1.4
Herstad, Jo	TuCT1.6
Hietanen, Antti Eerikki	WeBT3.6
Hijaz, Alaaldin	TuBT4.5
Hill, Tetiana	TuBS1.1
Hirche, Sandra	TuAT2.6
Hirschmanner, Matthias	TuAS1.6
Hoffman, Guy	WeCT5.1
Holthaus, Patrick	TuCT1.6
Hope, Ryan	TuAT1.2
Howard, Ayanna	TuBT3.1
	WeBT1.5
Hu, Zijian	TuAT4.2
	WeCT1.10
Huzaifa, Umer	WeAT3.6
Hwang, Eui Jun	TuCS1.3
	WeCT5.5
Hwang, Minho	WeAT4.4
I	
Iacob, David-Octavian	WeAT4.6
Ibrahimov, Roman	TuBT2.6
IJsselsteijn, Wijnand	WeCT5.6
Ikeda, Tetsushi	TuAT4
	TuAT4.4
	TuCT2.4
	WeCT3.1
Ikeuchi, Katsushi	WeCT4.6
Ilyas, Chaudhary Muhammad	TuCT3.1
Indurkhya, Bipin	TuAT2
	WeBT3
	WeBT3.2
Inoue, Tomoaki	TuBS1.4
Iocchi, Luca	TuCS1.4
Iordachita, Ioan Iulian	WeAT4.5
Ishi, Carlos Toshinori	WeCT3.10
	WeCT4.11
Ishiguro, Hiroshi	WeCT3.10
	WeCT4.11
Ishihata, Kenji	TuCT2.4
Ishikawa, Ryoichi	WeCT4.6
Islam, Atiqul	WeBT4.6

Itti, Laurent	TuBT3.4
Iwaki, Satoshi	TuAT4.4
	TuCT2.4
	WeCT3.1
Iyer, S. Srikesh	WeAT5.6
Izui, Takamune	WeBT3.2
J	
Jędras, Wojciech	WeBT3.2
Jacobs, Theo	WeCT1.9
Jada, Chakravarthi	WeCT4.9
Jamshad, Rabeya	TuBT3.1
Jang, Jaeyoon	TuCS1.2
Jang, Minsu	TuCS1
Jarosz, Mateusz	WeBT3.2
Jayasekara, A.G.B.P.	WeBT3.3
Jindai, Mitsuru	WeCT5.4
Joglekar, Ashish	WeAT2.5
Johal, Wafa	TuBT1
	TuBT1.2
	TuBT1.4
	WeCT1.1
	WeCT3.2
Johanson, Deborah	TuCS1.3
Johnston, Benjamin	TuAS1.4
Jonathan, Gratch	TuCT1.4
Jordan, Kristin	WeCT3.7
Joshi, Deepak	TuBT2.3
Joshi, Ravi Prakash	WeCT1.7
Joung, Youngseok	TuAT4.2
	WeCT1.10
Juelg, Christian	TuAT2.3
K	
K Babu, Sooraj	TuBT1.5
	WeCT4.8
Kamarainen, Joni-Kristian	WeBT3.6
Kamath, Archit Krishna	WeAT1.6
	WeAT3.3
	WeAT3.4
Kang, Le	TuAS1.4
Kang, Long	WeCT4.2
Kansal, Prarthana	TuCT3.3
Kapila, Vikram	WeBT3.4
	WeCT1.5
Kapinus, Michal	TuAT2.5
	TuCT2.1
Kardofaki, Mohamad	WeAT4.2
Karim, S M Mujibul	TuCT2.6
Karlapalem, Kamalakar	TuBT2.4
	WeCT5.7
Kato, Ryu	WeAT4.3
Kato, Shohei	TuBT2
	WeCT4.1
	WeCT5.11
Kato, Yumiko	TuAT4.4
Kawai, Yuji	TuCT1.2
Kawamoto, Hiroki	WeCT5.3
Kery, Caroline	WeBT2.5
Kher, Manan	WeBT5.5
Khoramshahi, Mahdi	WeBT1.4
Kim, Anton	TuBT1.4
Kim, Doik	WeCT4.3
Kim, Hansoul	WeAT4.4
Kim, Joonhwan	TuBT2
	WeAT4.4
Kim, Jung-Hee	WeCT4.3
Kim, Moonki	WeCT4.3
Kim, Sang-Hwa	WeCT4.2
Kim, Taewoo	TuCS1.5
Kirstein, Franziska	WeBT2
	WeCT1.4
Kiselev, Andrey	TuAT1.3
Klein, Lauren	TuBT3.4
Knight, Heather	TuBT1.3
	TuCT3.5
Koay, Kheng Lee	TuAS1.3
	TuCT1.6
Kobayashi, Toru	TuAT4.4
Koeszegi, Sabine Theresia	TuAS1.6
Kolota, Anna	WeBT3.2
Korneder, Jessica	WeCT5.8
Kramer, Ivanna	WeAT5.2
Kress-Gazit, Hadas	WeCT5.1
Krishna, Madhava	WeAT3
	WeAT3.1
	WeCT3.6
Krishnamoorthy, Sai-Prasanth	WeCT1.5
Kristiansen, Jakob	WeBT4.2
Kristofferson, Annica	TuAT1.3
Kshirsagar, Alap	WeCT5.1
Kühne, Rinaldo	TuBT3.6
Kulic, Dana	WeCT3.3
Kumar, Abhinay	WeCT5.2
Kundu, Olyvia	TuCT4.3
	WeCT2.5
Kurono, Yuya	WeCT1.11
Kwon, Dong-Soo	WeAT1.4
	WeAT4.4
Kwon, Yongje	TuAT4.5
Kyrki, Ville	TuBT1.1
	WeBT2.1
L	
La Viola, Carlo	TuAT1.4
Lambert, Jacey	WeAT3.6
Lambiase, Paolo D.	WeBT4.3
Lambrecht, Jens	WeBT1
	WeBT1.3
Lanz, Minna	WeBT3.6
Latella, Claudia	WeAT3.2
Latokartano, Jyrki Matias	WeBT3.6
LaViers, Amy	WeAT3.6
Lee, Dong-Ho	WeAT4.4
Lee, Ji Yang	WeCT4.3
Lee, Joo-Haeng	TuCS1.5
Lee, Min Ho	TuCS1.3
Lee, Rhianna	WeBT3.5
Leone, Enrico	WeBT4.3
Levillain, Florent	WeCT3.9
Lewandowski, Benjamin	WeBT1.2
Lewis, Michael	TuCT1
Lewis, Mike	TuAS1.1
	TuAS1.5
Liang, Ying Siu	WeAT3.5

Liarokapis, Minas TuAT4.5
..... TuBT2.1
Lim, Jong Yoon TuCS1.3
Limosani, Raffaele WeBT4.4
Lin, Weijane TuCT3.2
Liu, Chao WeAT5.3
Liu, Rui TuAS1.5
Lopes, Diana WeBT2.3
Louie, Wing-Yue Geoffrey TuBT4
..... TuBT4.5
..... WeCT5.8
Lourens, Tino WeAT2.6
Loutfi, Amy TuAT1.3
Lyons, Joseph TuAS1.5

M

MacDonald, Bruce TuCS1.3
..... WeCT5.5
Macovetchi, Ana Maria WeCT1.4
Madhisetty, Srinivas TuAS1.4
Magnenat, Stéphane WeCT3.2
Mahapatro, Neelam WeCT3.4
Majumder, Anima WeAT1.1
..... WeAT2.1
Mansour, Iyad TuBT4.5
Maria Joseph, Felix Orlando WeBT5
Maria Joseph, Felix Orlando WeBT5.1
..... WeBT5.3
..... WeBT5.4
Mariager, Casper Sloth WeBT4.2
Marrella, Andrea TuCS1.4
Martínez-Leal, Rafael WeBT4.5
Mascarenhas, Samuel TuAT3.5
..... WeBT2.3
Mastrogiovanni, Fulvio TuBT4.3
Matarese, Marco TuAS1.2
Mataric, Maja TuAT4.2
..... TuBT3.4
..... TuBS1.2
..... WeBT3.5
..... WeCT1.10
..... WeCT3.7
Materna, Zdenek TuAT2.5
..... TuCT2.1
Matsui, Tetsuya WeCT2.10
Matsumaru, Takafumi WeCT2.2
Matsumoto, Yoshio WeCT1.7
Matuszek, Cynthia WeBT2.5
Maurya, Heera Lal WeAT3.4
Mayet, Ralf TuCT1.5
Mazel, Alexandre WeCT5.9
McCarthy, Jillian WeAT5.1
McEllin, Luke WeBT3.1
Mehrandezh, Mehran WeAT1.3
Melo, Francisco S. WeBT2.3
Memmesheimer, Raphael WeAT5.2
Merino, Luis TuAT2.1
Michael, John WeBT3
..... WeBT3.1
Mier, Gonzalo TuAT2.1
Migovich, Miroslava WeAT5.1
Mikata, Ryusuke WeCT3.10
..... WeCT4.11
Minato, Takashi WeCT3.10
..... WeCT4.11
Mishra, Nidhi WeBT1.1
Miura, Jun TuCT4.4
Miyake, Tomohito TuCT1.2
Mizuuchi, Ikuo WeCT1.8
Moeslund, Thomas B. TuBS1.6
..... TuCT3.1
Mohan, Rajesh Elara WeCT2.11
Mondada, Francesco WeCT3.2
Moros, Sílvia TuAS1.3
Motahar, Tamanna WeBT4.6
Moura, Joao TuCT2.2
Mower, Christopher Edwin TuCT2.2
Mueller, Steffen WeBT1.2
Mukai, Masaya WeAT4.3
Mukherjee, Snehasis WeCT2.3
Murali, Prasanth TuCT3.4
Musić, Selma TuAT2.6
Muthugala Arachchige, Viraj Jagathpriya Muthugala WeBT3.3

N

Nadubettu Yadukumar, Shishir WeAT2.4
..... WeAT2.5
Nagasawa, Isamu TuAT4.4
Naito, Kosuke WeCT4.1
Nakamura, Keisuke TuAT2.1
Nakazawa, Atsushi WeCT2.4
Nakka, S S Sanjeevi WeAT5.6
Nardi, Daniele TuCS1.4
Nasir, Jauwairia TuBT1.2
..... WeCT1.1
Nasrollahi, Kamal TuCT3.1
Nath, Prasanmit WeCT3.4
Nava, Gabriele WeAT3.2
Nayyar, Mollik TuBT3.3
Neggers, Margot WeCT5.6
Nemoto, Takuma WeCT2.11
Neville, Glen WeBT1.5
Nikolaidis, Stefanos TuBT3.4
Nimpsch, Sebastian WeBT1.3
Norman, Utku TuBT1.2
Nugraha, Aditya Arie TuBT4.2
Nunes, Urbano J. WeAT1.2

O

O'Leary, Teresa TuCT3.4
Odabasi, Cagatay WeCT1.9
Ogasawara, Tsukasa TuBS1.4
..... WeCT2.4
Ogata, Kunihiro WeCT1.7
Oishi, Takeshi WeCT4.6
Oliván, Rebeca WeBT4.5
Oliver, Joan WeBT4.5
Olivier, Anne-Hélène WeCT2.7
Olsen, Jennifer TuBT1.2
Omarova, Meruyert TuBT1.4
Omran, Hassan WeBT4.1
Orlandini, Andrea TuAT1
..... TuAT1.4
Ota, Shunsuke WeCT5.4

Otarbay, Zhenis WeCT4.7

P

P, Mithun TuCT4.2
Padmakumar Bindu, Jyothsna WeAT2.2
Paiva, Ana TuAT3.5
..... WeBT2.3
Pakkar, Roxanna TuBS1.2
..... WeBT3.5
..... WeCT3.7
Palmer, Andrew WeCT4.5
Pandey, Amit Kumar ..... TuI_PL
..... TuBT4
..... TuCT1.5
..... WeCT5.10
Papadopoulos, Chris TuBS1.1
Papadopoulos, Irena TuBS1.1
Parekh, Sagar WeCT2.6
Pariasca, Franco WeCT1.6
Park, Jihoon TuCT1.2
Patel, Niravkumar WeAT4.5
Pathak, Pushparaj M. WeBT5.1
Pathi, Sai Krishna TuAT1.3
Paulus, Dietrich WeAT5.2
Pellier, Damien WeAT3.5
Penders, Jacques TuAT4.1
..... TuCT2
Penisetty, Sree Aslesh WeCT3.11
Perdiz, João WeAT1.2
Pesenti, Mattia WeBT4.1
Pesty, Sylvie WeAT3.5
Peter, Jochen TuBT3.6
Peters, Christopher TuBT3.2
..... TuBT3.5
Petrak, Björn WeBT2.6
Pettre, Julien WeCT2.7
Phillips, Elizabeth TuCT1.4
Pieters, Roel S. WeBT3.6
Pillai, Nisha WeBT2.5
Pires, Gabriel WeAT1.2
Poonganam, SriSai Naga Jyotish WeAT3.1
Powell, Henry WeBT3.1
Prada, Rui TuAT3.5
Pradhan, PyariMohan WeBT5
..... WeBT5.2
Prajapati, Pratik WeCT2.6
Prakash, Ravi TuAT1.1
..... TuCT4.1
Pramanick, Pradip WeBT2.4
Prattichizzo, Domenico TuAT2.6
Pucci, Daniele WeAT3.2
Puig, Domenec WeBT4.5

R

Racca, Mattia TuBT1.1
..... WeBT2.1
Radhakrishnan, Unnikrishnan TuBT1.5
..... WeCT4.8
Raggioli, Luca TuBS1.5
..... WeBT4.3
Rahman, Md Masudur WeBT5.6
Raiano, Mario TuAS1.2
Raina, Deepak TuCT4.2
Raj, Ankita WeAT1.1
Rajamohan, Vineeth WeCT4.4
Rakovic, Mirko WeCT3.8
Ramachandruni, Kartik WeAT2.1
Ramanathan, Manoj WeBT1.1
Ramchurn, Sarvapali TuCT2.5
Ramesh, Shanker TuBT1.5
..... WeCT4.8
Ramirez, Renzo WeCT1.6
Rao R, Bhavani TuBT1.5
..... WeCT4.8
Rapetti, Lorenzo WeAT3.2
Rath, Prabin Kumar WeCT3.4
Rawat, Abhay WeCT5.7
Raza, Syed Ali TuAS1.4
Rea, Francesco WeBT3.1
Recchiuto, Carmine Tommaso TuBS1.1
Rehm, Matthias TuBS1.6
..... TuCT3.1
..... WeBT4.2
Reig, Samantha WeBT2.2
Reutskiy, Vadim WeCT1.6
Rizvi, Wali WeAT3.6
Robins, Ben TuBT1
Robu, Olguta WeCT3.2
Rodriguez, Laureano WeCT1.6
Roennau, Arne TuAT2.3
Rohit, Mehboob Hasan TuCT2.6
Rond, Jesse TuBT1.3
Rosales, Marcelo R. TuBT3.4
Rose, Chad WeAT5.5
Rose, Ryan WeCT2.8
Rossi, Alessandra TuAS1
..... TuAS1.3
Rossi, Silvia TuAS1
..... TuAS1.2
..... TuBS1.5
..... WeBT4.3
Roth, Aaron M. WeBT2.2
Rotsidis, Alexandros TuAT4.3
Rout, Bijay Kumar WeCT1.2
Rovini, Erika WeBT4.4
Rowe, Ryan TuBT4.1
Ruijten, Peter WeCT2.1
..... WeCT5.6
Russell, Duncan WeBT1.4

S

Sagara, Yuto WeAT4.3
Sagi, Aditya Varma WeAT2.5
Saini, Sarvesh WeBT5.1
Samarakoon, Bhagya WeBT3.3
Sancarlo, Daniele WeBT4.4
Sanchez, Alan TuBT1.3
Sanchez-Tamayo, Natalia WeBT5.6
Sandygulova, Anara TuBT1.4
..... TuBT3
..... TuCT3.6
Santos, Fernando P. WeBT2.3
Santos, Francisco C. WeBT2.3
Santos, Pedro A. TuAT3.5
Santos-Victor, José WeCT3.8

Sarkar, Chayan WeBT2.4
Sarkar, Dibya Prokash WeBT4.6
Sarthou, Guillaume TuCT1.1
Satapathy, Ranjan WeBT1.1
Sato, Kenjiro TuCT2.4
Sato, Yoichiro WeCT5.3
Savery, Richard WeCT2.8
Saxena, Somya TuBT2.3
Schmidbauer, Christina TuAS1.6
Schmidt, Niko WeAT5.2
Schmuck, Viktor TuCT3.1
Schrum, Mariah WeBT1.5
Schulz, Trenton TuCT1
..... TuCT1.6
Schwaninger, Isabel TuAS1.6
Sciutti, Alessandra WeBT3.1
Scully-Allison, Connor WeCT4.4
Sejima, Yoshihiro WeCT5.3
Sekiguchi, Kouhei TuBT4.2
Senbonmatsu, Hikaru TuAT1.5
Seo, Jong-Tae WeCT4.2
Seré, Andrés TuCT1.3
Sgorbissa, Antonio TuBS1
..... TuBS1.1
..... WeAT4
Shafer, Anna WeAT5.5
Shah, Suril Vijaykumar TuCT4.2
..... WeBT1.6
Shahabeddini Parizi, Mohammad WeCT1.4
Shahmoradi, Sina TuBT1.2
Shaik, Gouse Basha WeCT4.9
Shamekhi, Ameneh TuCT3.4
Shen, Hao WeAT4.1
Shetty, Suhan WeAT2.5
Shi, Zhonghao TuBS1.2
Shibata, Tomohiro WeCT1.7
Shimaya, Jiro TuCT1.2
Shinozawa, Kazuhiko WeCT3.1
Shirokun, Vladimir TuBT2.6
Shree, Vikram WeAT1.5
Shukla, Jainendra TuCT3.3
..... WeBT4.5
Shulgach, Jonathan WeBT2.2
Singh, Aalind TuAT4.6
Singh, Abhimanyu WeAT2.4
..... WeAT2.5
Singh, Kumar Surjdeo TuBT2.2
Singh, Neha WeBT5.2
Singh, Prerna TuCT4.5
Singh, Virender TuCT4.5
Singh, Yogesh WeAT5.6
..... WeBT5.5
Singhal, Shivam TuBT4.1
Singla, Abhik WeAT2.4
..... WeAT2.5
Singla, Ekta TuBT4.6
Skaltsas, Grigorios WeBT1.4
Smith, Beth TuBT3.4
Smith, Stephen L. WeCT3.3
Smrz, Pavel TuCT2.1
Sniezynski, Bartlomiej WeBT3.2
Somov, Andrey TuBT2.6
Sondej, Filip WeBT3.2
Song, KyuSeob WeAT1.4
Soranzo, Alessandro TuAT4.1
Sorrentino, Alessandra WeBT4.4
Srinivasa, Siddhartha TuBT4.1
Sripada, Venkatesh TuBT2.4
..... WeBT1.6
Sripian, Peeraya WeCT1.11
St-Onge, David WeCT3.9
Sterkenburg, Paula WeAT2.6
Struckmeier, Oliver WeBT2.1
Sturgeon, Stephanie WeCT4.5
Sugaya, Midori WeCT1.11
Surendran, Vidullan TuAT2.4
Suri, Venkata Ratnadeep TuCT3
..... TuCT3.3
Swagat, Kumar TuCT4.2
..... TuCT4.3
..... TuCT4.5
..... WeAT1.1
..... WeAT2.1
..... WeCT2.5
Sycara, Katia TuAT1.2
..... TuAS1.1
..... TuAS1.5

T

Tabti, Nahla WeAT4.2
Takahashi, Hideyuki TuCT1.2
Takamatsu, Jun TuBS1.4
..... WeCT2.4
Tallamraju, Rahul TuBT2.4
..... WeBT1.6
Tanaka, Fumihide TuAT1.5
Tapus, Adriana WeAT4.6
..... WeCT3.5
Taylor, Russell H. WeAT4.5
Tejera López, Gonzalo Daniel TuCT1.3
Telisheva, Zhansaule TuCT3.6
Tenhundfeld, Nathan TuCT1.4
Tetsuya, Sano WeCT2.4
Thakur, Ravi Kumar WeCT2.3
Thalmann, Nadia Magnenat TuAT4.6
..... WeBT1.1
Theodorou, Andreas TuAT4.3
Thondiyath, Asokan TuBT2.2
Tirupachuri, Yeshasvi WeAT3.2
Tiwari, Ashlee WeCT1.5
Tiwari, Ashutosh TuBT2.3
Tobias, Jessica TuCT1.4
Tonkin, Meg TuAS1.4
Torras, Carme WeAT5.4
Torresen, Jim TuCT1.6
Toshimitsu, Yasunori TuAT3.6
Tossell, Chad TuCT1.4
Trepiccione, Davide WeBT4.3
Tripathi, Vibhu Kumar WeAT1.6
..... WeAT3.3
Trovato, Gabriele WeBT2
..... WeCT1.6
Tsetserukou, Dzmitry TuBT2.6

Tsykunov, Evgeny	TuBT2.6
Turarova, Aizada	TuCT3.6
Turchi, Dario	WeBT1.4
U	
Ueno, Azumi	WeCT1.8
Umbrico, Alessandro	TuAT1.4
Urbano, Leonardo	WeBT1.4
Urias, Muller	WeAT4.5
Urlana, Ashok	WeCT4.9
Utsumi, Akira	TuAT4.4
V	
V Joseph, Joel	WeAT5.6
van Straten, Caroline Lianne	TuBT3.6
Vaneet, Aggarwal	WeBT5.6
Vankadari, Madhu Babu	WeAT2.1
Vashista, Vineet	WeAT5
	WeAT5.6
	WeBT5.5
	WeCT2.6
Velentza, Anna Maria	TuCS1.1
Veloso, Manuela	WeBT2.2
Venkatesh, L.N Vishnunandan	WeAT2.2
Venture, Gentiane	WeBT3.2
Verma, Krit	TuCT3.3
Verma, Nishchal K.	WeAT3.4
Verma, Pulkit	TuBT2.4
Vignolo, Alessia	WeBT3.1
Vijayakumar, Sethu	TuCT2.2
Visca, Jorge	TuCT1.3
Vishwanath, Ajay	TuAT4.6
Vitale, Jonathan	TuAS1.4
Vohra, Mohit	TuAT1.1
	TuCT4.1
Voyles, Richard	WeAT2.2
	WeBT5.6
Vu, The Duc	TuAS1.4
W	
Wachs, Juan	WeAT2
	WeAT2.2
	WeBT5.6
Wade, Eric	WeAT5.1
Waechter, Mirko	WeBT1.4
Wagner, Alan Richard	TuAT2.4
	TuBT3.3
Waldhart, Jules	TuCT4.6
Waligora, Justin	TuCT1.4
Walters, Michael Leonard	TuAS1.3
Wang, Hesheng	WeAT4.1
Wang, Ker-Jiun	TuBS1.3
Wang, Lun	TuCS1.4
Wang, Xinzhi	TuAS1.1
Watanabe, Tomio	WeCT5.3
Weinberg, Gil	WeCT2.8
Weir, Daryl	TuBT1.1
Weiss, Astrid	TuAS1.6
Weitz, Katharina	WeBT2.6
Wengefeld, Tim	WeBT1.2
Williams, Mary-Anne	TuAS1.4
Wortham, Robert Hale	TuAT4.3
Wyatt, Jeremy	TuCS1.1
X	
Xiang, Yujia	WeAT4.1
Xie, Le	WeAT4
	WeAT4.1
Xu, Ling	TuAT3.3
Xu, Wendy M.	TuBT1.6
Xue, Yexiang	WeBT5.6
Y	
Yadav, Ritesh	WeCT1.2
Yamada, Seiji	WeCT2.10
Yamashita, Shohei	WeCT3.1
Yang, Chenguang	WeAT5.3
Yang, Fangkai	TuBT3.2
	TuBT3.5
Yasuda, Toshiyuki	WeCT5.4
Ye, Sean	WeBT1.5
Ye, Yuhang	WeAT5.3
Yeh, Su-Ling	TuCT3.2
Yi, Byung-Ju	WeCT4.2
Yi, Daqing	TuBT4.1
Yogi, Subhash Chand	WeAT1.6
	WeAT3.3
Yoshida, Reiji	WeCT1.11
Yoshii, Kazuyoshi	TuBT4.2
You, Jae Min	WeAT4.4
Yskak, Asset	WeCT4.7
Yuan, Shengcheng	TuAS1.1
Yueh, Hsiu-Ping	TuCT3.2
Yuguchi, Akishige	TuBS1.4
	WeCT2.4
Z	
Zafari, Setareh	TuAS1.6
Zemiti, Nabil	WeAT5.3
Zguda, Paulina	WeBT3.2
Zhaksylyk, Adil	TuBT1.4
Zhanatkyzy, Aida	TuCT3.6
Zhang, Hui	TuAS1.1
Zheng, Caroline Yan	TuBS1.3
Zhou, You	WeBT1.4
Zhu, Chen	WeCT2.2
Zibetti, Elisabetta	TuCT3
	WeCT3.9
Zisimatos, Agisilaos	TuBT2.1

KEYWORD INDEX

RO-MAN 2019 Keyword Index

A	
Androids	TuCT1.5, WeCT2.4, WeCT3.10, WeCT4.7, WeCT4.11
Anthropomorphic Robots and Virtual Humans	TuCT1.2, TuCT1.4, TuCT1.5, WeCT1.2, WeCT1.8, WeCT2.10, WeCT3.11, WeCT4.2
Applications of Social Robots	TuAS1.2, TuAS1.3, TuAS1.4, TuAT3.4, TuAT3.5, TuAT4.6, TuBS1.4, TuBT1.4, TuBT1.5, TuBT3.3, TuCS1.2, TuCS1.3, TuCS1.5, TuCS1.6, TuCT3.1, TuCT3.2, TuCT3.3, TuCT3.5, TuCT3.6, TuCT4.4, TuCT4.6, WeAT1.4, WeAT2.6, WeBT1.1, WeBT3.2, WeBT3.5, WeBT4.2, WeCT1.9, WeCT3.7, WeCT4.8, WeCT5.8, WeCT5.9
Art pieces supported by robotics	TuBT1.3
Assistive Robotics	TuAT4.2, TuBS1.1, TuBS1.5, TuBT1.1, TuBT2.2, TuBT2.3, TuBT3.3, TuCS1.3, TuCT2.4, TuCT3.2, TuCT3.3, TuCT4.1, TuCT4.4, WeAT1.2, WeAT1.3, WeAT1.6, WeAT3.3, WeAT3.4, WeAT4.1, WeAT4.2, WeAT4.3, WeAT4.5, WeAT5.2, WeAT5.3, WeAT5.5, WeBT1.2, WeBT1.6, WeBT4.3, WeBT4.4, WeBT4.5, WeBT4.6, WeBT5.4, WeCT1.10, WeCT3.11, WeCT4.2, WeCT5.5, WeCT5.8
C	
Cognitive and Sensorimotor Development	TuAS1.5, TuAT4.1, TuBT2.3, TuBT3.4
Cognitive Skills and Mental Models	TuAS1.5, TuAS1.6, TuAT3.2, TuBS1.3, TuBT2.3, TuBT3.4, TuBT4.3, TuCT1.1, WeCT2.3, WeCT4.5
Computational Architectures	TuAT3.2, TuBT2.4, TuBT4.2, TuCT4.5, WeCT5.10
Cooperation and Collaboration in Human-Robot Teams	TuAT1.3, TuAT2.6, TuCT1.2, TuCT2.2, TuCT2.4, TuCT2.5, TuCT4.6, WeAT1.3, WeAT3.2, WeBT1.3, WeBT1.4, WeBT1.5, WeBT1.6, WeBT2.1, WeBT2.3, WeBT2.5, WeBT3.6, WeCT1.5, WeCT2.6, WeCT2.8, WeCT3.3, WeCT3.5, WeCT3.8, WeCT3.9, WeCT4.10
Creating Human-Robot Relationships	TuAS1.3, TuAS1.5, TuAS1.6, TuAT1.3, TuAT1.5, TuAT3.3, TuAT4.3, TuBS1.6, TuBT2.6, TuCS1.1, TuCS1.3, TuCS1.4, TuCT3.2, WeAT3.6, WeBT1.1, WeBT1.5, WeBT2.3, WeBT2.6, WeBT3.2, WeBT4.1, WeCT1.11, WeCT2.1, WeCT2.6, WeCT2.8, WeCT2.10, WeCT3.4, WeCT3.5, WeCT3.7, WeCT4.4, WeCT5.3
Curiosity, Intentionality and Initiative in Interaction	TuBS1.4, TuCT3.5, WeBT1.5, WeCT1.2, WeCT1.8, WeCT4.9, WeCT5.10
D	
Degrees of Autonomy and Teleoperation	TuAT2.6, TuAT4.5, TuBT4.4, TuCT2.2, TuCT2.3, TuCT4.1, TuCT4.3, WeAT4.1, WeBT4.2, WeBT5.6, WeCT4.10
Detecting and Understanding Human Activity	TuAT2.4, TuBS1.4, TuBS1.5, TuBS1.6, TuBT3.1, TuBT3.4, TuBT4.5, TuCS1.4, TuCT4.4, WeAT5.6, WeBT4.4, WeBT5.5, WeCT3.1, WeCT3.3
E	
Embodiment, Empathy and Intersubjectivity	TuAT2.2, TuAT3.3, TuCT1.6, WeCT5.4
Ethical Issues in Human-robot Interaction Research	TuCT1.2, TuCT2.5
Evaluation Methods and New Methodologies	TuAT1.2, TuAT2.2, TuBS1.1, TuBS1.6, TuBT2.1, TuBT2.5, TuBT3.6, TuCS1.4, TuCT2.6, WeAT2.6, WeAT5.5, WeBT1.4, WeBT5.2, WeCT1.4, WeCT1.7, WeCT4.9
H	
HRI and Collaboration in Manufacturing Environments	TuAT2.3, TuAT2.5, TuCT2.1, TuCT2.2, TuCT2.3, TuCT4.3, WeAT3.2, WeBT1.3, WeBT1.4, WeBT2.4, WeBT3.4, WeBT3.6, WeCT1.4, WeCT4.7, WeCT5.1
Human Factors and Ergonomics	TuAT2.5, TuCT1.4, TuCT2.1, WeBT3.3, WeBT4.1, WeBT4.5, WeBT5.4, WeCT3.3
I	
Innovative Robot Designs	TuAT1.4, TuAT3.4, TuAT3.6, TuBS1.2, TuBT1.5, TuBT2.1, TuBT2.2, TuBT2.4, WeAT2.4, WeBT3.5, WeCT1.6, WeCT1.9, WeCT3.4, WeCT4.2, WeCT4.7, WeCT4.8, WeCT4.10
Interaction Kinesics	TuAT2.1, WeBT5.1
Interaction with Believable Characters	TuAS1.1, TuCT1.4, WeCT5.11
L	
Linguistic Communication and Dialogue	TuAS1.1, TuAS1.6, WeAT5.1, WeBT2.2, WeBT2.4, WeBT2.5, WeCT1.6, WeCT5.9
Long-term Experience and Longitudinal HRI Studies	TuCS1.6
M	
Machine Learning and Adaptation	TuAS1.1, TuAT1.1, TuAT1.2, TuAT1.6, TuAT4.5, TuBS1.5, TuBT3.2, TuBT3.5, TuBT4.5, TuCT4.5, WeAT1.1, WeAT1.2, WeAT1.3, WeAT1.5, WeAT2.1, WeAT2.2, WeAT2.3, WeAT2.4, WeAT2.5, WeBT1.3, WeBT2.1, WeBT2.5, WeBT5.2, WeBT5.6, WeCT2.2, WeCT2.3, WeCT2.5, WeCT3.11, WeCT5.5, WeCT5.7
Medical and Surgical Applications	WeAT4.3, WeAT4.4, WeAT4.5, WeAT5.2, WeAT5.3, WeBT4.1, WeBT5.2, WeBT5.3, WeBT5.6
Monitoring of Behaviour and Internal States of Humans	TuAT4.3, TuBT4.5, WeAT5.6, WeBT5.5, WeCT2.7, WeCT4.1

Motion Planning and Navigation in Human-Centered Environments	TuAT2.3, TuBT2.4, TuBT3.2, TuCT1.6, TuCT4.1, TuCT4.2, TuCT4.3, TuCT4.5, WeAT1.2, WeAT1.6, WeAT2.3, WeAT3.1, WeAT3.2, WeBT1.6, WeBT3.3, WeCT1.2, WeCT1.9, WeCT2.3, WeCT2.6, WeCT2.7, WeCT2.11, WeCT3.6, WeCT4.3, WeCT4.6, WeCT4.9, WeCT5.1, WeCT5.6, WeCT5.7
Motivations and Emotions in Robotics	TuAS1.2, TuAT1.1, TuBS1.3, WeAT1.4, WeAT3.6, WeCT1.11, WeCT2.1, WeCT5.11
Multi-modal Situation Awareness and Spatial Cognition	TuAT4.4, TuBT4.1, TuBT4.2, TuBT4.3, TuBT4.4, WeBT1.2, WeCT1.5, WeCT3.9
Multimodal Interaction and Conversational Skills	WeAT1.5, WeCT2.9, WeCT4.11, WeCT5.3, WeCT5.5
N	
Narrative and Story-telling in Interaction	TuBT4.6
Non-verbal Cues and Expressiveness	TuAS1.2, TuAT1.5, TuAT2.1, TuAT2.4, TuAT3.1, TuAT4.1, TuAT4.2, TuBS1.2, TuBT1.3, TuBT4.6, TuCT1.6, TuCT3.1, TuCT3.5, WeAT4.6, WeBT2.6, WeBT3.1, WeCT1.8, WeCT1.10, WeCT2.1, WeCT3.1, WeCT3.8, WeCT3.10, WeCT4.4, WeCT4.11, WeCT5.3, WeCT5.9
Novel Interfaces and Interaction Modalities	TuAS1.4, TuAT1.5, TuAT2.3, TuAT2.5, TuAT2.6, TuAT4.1, TuAT4.3, TuAT4.4, TuBT4.2, TuCT1.3, TuCT2.1, TuCT2.4, TuCT3.4, WeAT2.6, WeAT3.5, WeAT4.4, WeAT5.3, WeBT3.4, WeBT3.6, WeCT1.5, WeCT1.6, WeCT3.2, WeCT3.9
P	
Personalities for Robotic or Virtual Characters	TuCS1.1, WeBT2.2, WeCT3.10
Philosophical Issues in Human-Robot Coexistence	TuAT4.6
Programming by Demonstration	TuAT2.1, TuBT4.3, TuCT2.3, WeAT2.1, WeAT2.2, WeAT3.5, WeCT1.7
R	
Robot Companions and Social Robots	TuAS1.3, TuAT2.2, TuAT3.1, TuAT3.4, TuAT3.5, TuAT3.6, TuAT4.6, TuBS1.1, TuBT1.4, TuBT1.6, TuBT3.3, TuBT3.5, TuBT3.6, TuCT3.6, TuCT4.6, WeAT4.6, WeAT5.1, WeBT1.2, WeBT2.2, WeBT2.3, WeBT2.6, WeBT3.2, WeBT3.3, WeBT4.3, WeCT1.11, WeCT2.10, WeCT3.4
Robots in art and entertainment	TuAT3.1, TuCS1.6
Robots in Education, Therapy and Rehabilitation	TuAT1.6, TuAT3.3, TuBT1.2, TuBT1.4, TuBT1.6, TuBT2.2, TuBT2.5, TuBT3.1, TuBT3.6, TuBT4.6, TuCT1.3, TuCT3.1, TuCT3.3, TuCT3.4, TuCT3.6, WeAT4.1, WeAT4.4, WeAT5.1, WeAT5.2, WeAT5.4, WeAT5.5, WeBT3.5, WeBT4.2, WeBT4.3, WeBT4.5, WeBT5.4, WeCT1.1, WeCT1.3, WeCT1.7, WeCT3.2, WeCT3.7, WeCT4.1, WeCT5.2, WeCT5.4, WeCT5.8
S	
Social Intelligence for Robots	TuAT1.3, TuAT2.4, TuAT3.2, TuAT3.5, TuBS1.3, TuBT3.2, TuBT3.5, TuCS1.2, WeAT1.4, WeBT1.1, WeBT3.1, WeCT3.1, WeCT3.5, WeCT3.8, WeCT4.1, WeCT4.5, WeCT5.10
Social Learning and Skill Acquisition Via Teaching and Imitation	TuAT1.1, TuAT1.6, TuCS1.5, WeAT2.1, WeAT2.2
Social Presence for Robots and Virtual Humans	TuAT4.2, TuBS1.2, TuCT3.4, WeBT2.4, WeCT1.10, WeCT4.5, WeCT4.8
Sound design for robots	WeCT2.8, WeCT2.9
Storytelling in HRI	TuBT1.3, TuCS1.1
U	
User-centered Design of Robots	TuAS1.4, TuAT3.6, TuBT1.1, TuBT1.5, TuBT1.6, TuBT2.6, TuCT1.3, WeAT3.5, WeAT3.6, WeAT4.2, WeAT5.6, WeBT2.1, WeBT4.6, WeBT5.5, WeCT1.4, WeCT2.9
V	
Virtual and Augmented Tele-presence Environments	TuAT4.4, TuBT2.6, TuBT4.4, WeBT3.4, WeBT5.1, WeCT3.2

REVIEWERS LIST

A. Saif, Abdul-Wahid
Aaltonen, Iina Elisa
Abah, Colette
Abayasiri, Achintha
Abdi, Elahe
Abe, Kasumi
Adam, Carole
Afshar, Homeira
Aganian, Dustin
Agarwal, Akshat
Agnihotri, Abhijeet
Agrawal, Shrey
Agrigoroaie, Roxana
Aguilar, Hipolito
Ahmad, Muneeb
Ahmadi, Ehsan
Ahn, Ho Seok
Akalin, Neziha
Akiyama, Yasuhiro
Albani, Dario
Alenyà, Guillem
Alhaddad, Ahmad Yaser
Alissandrakis, Aris
Alnajjar, Fady
Althoefer, Kaspar
Alves-Oliveira, Patrícia
Amirabdollahian, Farshid
An, Ho Seok
Anzalone, Salvatore Maria
Aoyagi, Saizo
Arafa, Mostafa
Aroyo, Alexander Mois
Arvola, Anne
Assal, Samy F. M.
asselborn, thibault
Assunção, Gustavo
Auddy, Sayantan
Avizzano, Carlo Alberto
Aydin, Yusuf
Ayub, Ali
Ban, Midori
Baniasad, Mina
Banisetty, Santosh Balajee
Bansal, Ankish
Barakova, Emilia I.
Baroni, Ilaria
Barsotti, Michele
Basiri, Meysam
Basteris, Angelo
Baud-Bovy, Gabriel
Baxter, Paul Edward
Behera, Ardhendu
Behera, Laxmidhar
Belpaeme, Tony
Beltrame, Giovanni
Beran, Vitezslav
Berger, Erik
Bethel, Cindy L.
Bevill Burns, Rachael
Bhounsule, Pranav
Bhowmick, Brojeshwar
Bied, Manuel
Bilac, Miriam
Blankenburg, Janelle
Bodenhagen, Leon
Bolano, Gabriele
Bonarini, Andrea
Boteanu, Adrian
Botzheim, Janos
Bouri, Mohamed
Bowman, Nick
Bozcuoglu, Asil Kaan
Bradford, DanaKai
Brandao, Martim
Bremner, Paul
Brewster, Stephen
Brodeur, David
Brookshaw, Iain
Bruno, Barbara
Bu, Nan
Buisan, Guilhem
Buoncompagni, Luca
Butt, Abdul Haleem
Buyukgoz, Sera
Cabibihan, John-John
Cabrera, Maria Eugenia
Cacace, Jonathan
CANEVET, Olivier
Cao, Hoang-Long
Capi, Genci
Capitanelli, Alessio
Capobianco, Roberto
Carbone, Giuseppe
Carfì, Alessandro
Carreno Medrano, Pamela
Castro González, Álvaro
Celaya, Enric
Celiktutan, Oya
Cervera, Enric
Cha, Elizabeth
Chacko, Sonia
Chakravarthy, Animesh
Chan, Wesley
Chang, Mai Lee
Chanseau, Adeline
Chauhan, Manish
Chemori, Ahmed
Chen, Fei
Chen, Yi
Chernova, Sonia
Chessa, Manuela
Chittawadigi, Rajeevlochana G.
Cho, Young-Jo
Choi, Changmok
Chou, Ting-Shuo
Chouhan, Rajlaxmi
Chugo, Daisuke
Churamani, Nikhil
Clodic, Aurélie
Cominelli, Lorenzo
Controzzi, Marco
Correia, Filipa
Correia, Luís
Cortellessa, Gabriella
Craenen, Bart
Cruz-Maya, Arturo
Cuayahuitl, Heriberto
Cuijpers, Raymond
Dasgupta, Ranjan
Dayal, Udai, Arun
Delisle-Rodríguez, Denis
DePalma, Nick
Dermy, Oriane
Deshmukh, Amol
Dethlefs, Nina
Di Campli San Vito, Patrizia
Di Nuovo, Alessandro
Dias, Jorge
Dondrup, Christian
Drews-Jr, Paulo
Dutta Roy, Sumantra
Dutta, Samrat
Díaz-Boladeras, Marta
Edan, Yael
Eizicovits, Danny
Enzaki, Yuki
Ercolano, Giovanni
Erich, Floris Marc Arden
Erkent, Ozgur
Fan, Jing
Farinelli, Alessandro
Fazli, Pooyan
Ferland, François
Ferrarelli, Paola
Ferreira, João Filipe
Finzi, Alberto
Fiorini, Laura
Fiorino, Humbert
Fischer, Kerstin
Fitter, Naomi T.
Foster, Mary Ellen
Freeman, Euan
Fu, Li-Chen
Fukumori, Satoshi
Funakoshi, Kotaro
Gandhi, Vineet
Gao, Yuxiang
Gasteratos, Antonios
Geiskkovitch, Denise
Gena, Cristina
Ghommam, Jawhar
Giuliani, Manuel
Glas, Dylan F.
Gombolay, Matthew
Gomez Esteban, Pablo
Gomez, Randy
Gora, Sunil
Gorer, Binnur
Gratton, Michael James
Greczek, Jillian
Greer, Julienne
Gross, Horst-Michael
Guerin, Frank
Guha, Prithwijit
Guo, Dejun
Guo, Rui
Gupta, Abhishek
gupta, mukul kumar
Gupta, Sandeep
Hachisu, Taku
Ham, Jaap
Hanheide, Marc
Haring, Kerstin Sophie
Hart, Justin
Hashimoto, Hiroshi
Hassan, Modar
Hayashi, Kotaro
Hayashibe, Mitsuhiro
Hayat, Abdullah Aamir
Hazra, Tanmoy
Hedayati, Hooman
Heikkilä, Päivi
Henrich, Dominik
Hernandez-Gutierrez, Andres
Hiatt, Laura M.
Hirayama, Takatsugu
Ho, YiHsin
Hocaoglu Cetinsoy, Elif
Hoffman, Guy
Holobar, Ales
Holt, Ray
Honig, Shanee
Howard, Thomas
IGARASHI, Hiroki
Ikeda, Tetsushi
Imai, Michita
Inamura, Tetsunari
Indurkhya, Bipin
Indurkhya, Xela
Ishi, Carlos Toshinori
Ishii, Kentaro
Ishii, Yutaka
Ishikawa, Ryoichi
Islas Ramírez, Omar Adair
Jacob Mathew, Michael
Jacobs, Theo
Jang, Minsu
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Suite No. 309-311, DLF City Court, MG Road Gurgaon 122 004, Haryana, India

Contact:

Rashda Khanam, Project Manager | T: +91 124 461 7700 | M: +91 84476 23385 | E: rashda@cimglobal.net

Rajesh Charanda, Project Head | T: +91 124 461 7700 | M: +91 99101 99551 | E: rajesh@cimglobal.net