The 29th IEEE International Conference on **Robot and Human** Interactive Communication

31 AUGUST • 04 SEPTEMBER 2020

IEEE RO-MAN

2020 VIRTUAL CONFERENCE

THE CONFERENCE PROGRAM BOOK

Robots with Heart, Mind, and Soul

IEEE RO-MAN 2020 - PROGRAM BOOK

29th IEEE International Conference on Robot and Human Interactive Communication

(RO-MAN2020)

August 31– September 4, 2020 Virtual Conference

Welcome!

The RO-MAN 2020 General Chairs and the Steering Committee have decided to take this year's conference fully virtual. Following a careful assessment of the uncertainty due to the pandemic evolution and its impact on international travel and people's safety, it has been inevitable to make this difficult decision. We worked hard to restructure the program for a virtual event following the IEEE guidelines and also taking from other conference experiences. Through the underline.io platform, we planned activities to actively engage the participants and try to recreate the sense of community that deeply characterizes the RO-MAN conference. We sincerely hope to see you all very soon when this emergency will be behind us.

This conference is a leading forum where 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 conference covers a wide range of topics related to Robot and Human Interactive Communication, involving theories, methodologies, technologies, empirical and experimental studies. Papers related to the study of robotic technology, psychology, cognitive science, artificial intelligence, human factors, ethics and policies, interaction-based robot design and other topics related to human-robot interaction are welcome.

The theme of the conference of this year is **Robots with Heart, Mind, and Soul.** The fruitful interaction of Artificial Intelligence and Robotics is currently leading the Robot and Human Interactive Communication community towards new frontiers where perceptual, reasoning, manipulation, and interaction capabilities are effectively deployed in real word applications.

Still, there are several research challenges to be addressed. Firstly, the robot mind can be enhanced by a heart, so social and emotional capabilities are required to complement every single robotic functionality. It is not just a matter of performing an interaction task correctly, but mainly of performing such tasks in a way that is believable and acceptable to humans. The user's experience with the robot is key to its large-scale adoption. Companies need to build solutions rooted in a deeper analysis of humans' specificities.
At the same time, academia needs to nurture the development of an extended research community with a set of interdisciplinary skills to investigate the required robot's capabilities for interactive communication with human beings, for defining decision, machine learning algorithms, and cognitive architectures to appropriately adapt the robot's behavior to the social context.

Finally, such new bootstrap in robotic technologies for everyday life will require a soul, so to address social, legal, and ethical issues that arise by the uptake robots in personal domains, as such skills are fundamental to achieve technological innovation which aligns with social, ethical and legal values, in the direction of an ELSE (Ethical, Legal, Social, and Economic) Robotics. Works that address open

research problems with a clear view of the practical application, both from the point of view of a direct realization in the market and from the point of view of possible implications of such technologies are welcome.

The **main conference** will host presentations of original contributions including new methods, studies, designs, theories, and applications of Human-Robot Interactive Communication systems and technologies surrounding it. Despite the international crisis, we have received a number of submissions greater than in previous years. This was a great sign of how lively and resilient our community is. This year, we accepted 207 regular papers in the technical program with an acceptance rate of 62%. The **workshops** will provide an opportunity for participants from academia and industry to focus on prospective topics. We have 19 workshops planned for the event. Three expert keynote speakers from academia, industry, end users and policy-making bodies will give plenary talks about emerging technologies, methods, R&D and Technological barriers to market in the domain. Finally, we have 8 **Special sessions** throughout the week targeting specific topics and audiences.

We understand that you may be disappointed to miss the opportunity to enjoy the conference in the unique landscape of Naples. In this regard, we are already looking to organize the RO-MAN conference in the future, to make the committee's work concrete and finally welcome you all to this beautiful city.

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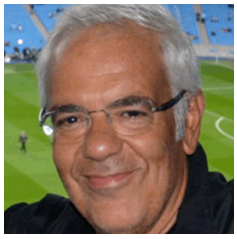

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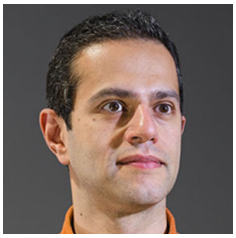

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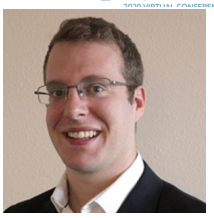

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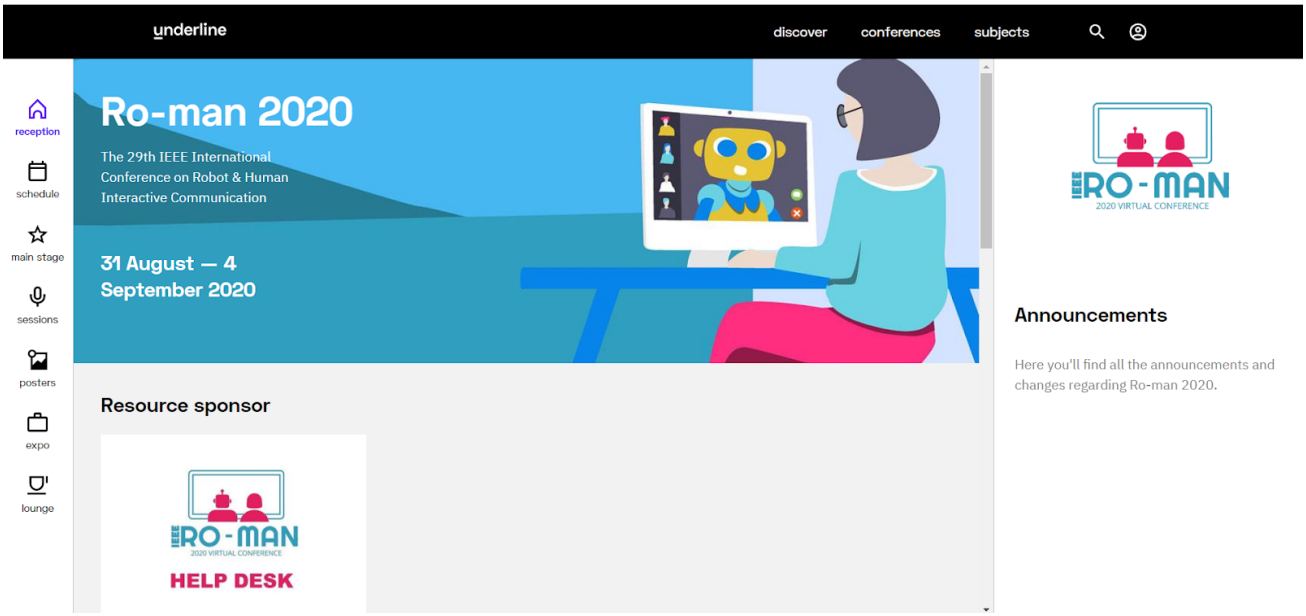
The Virtual Venue

General information:

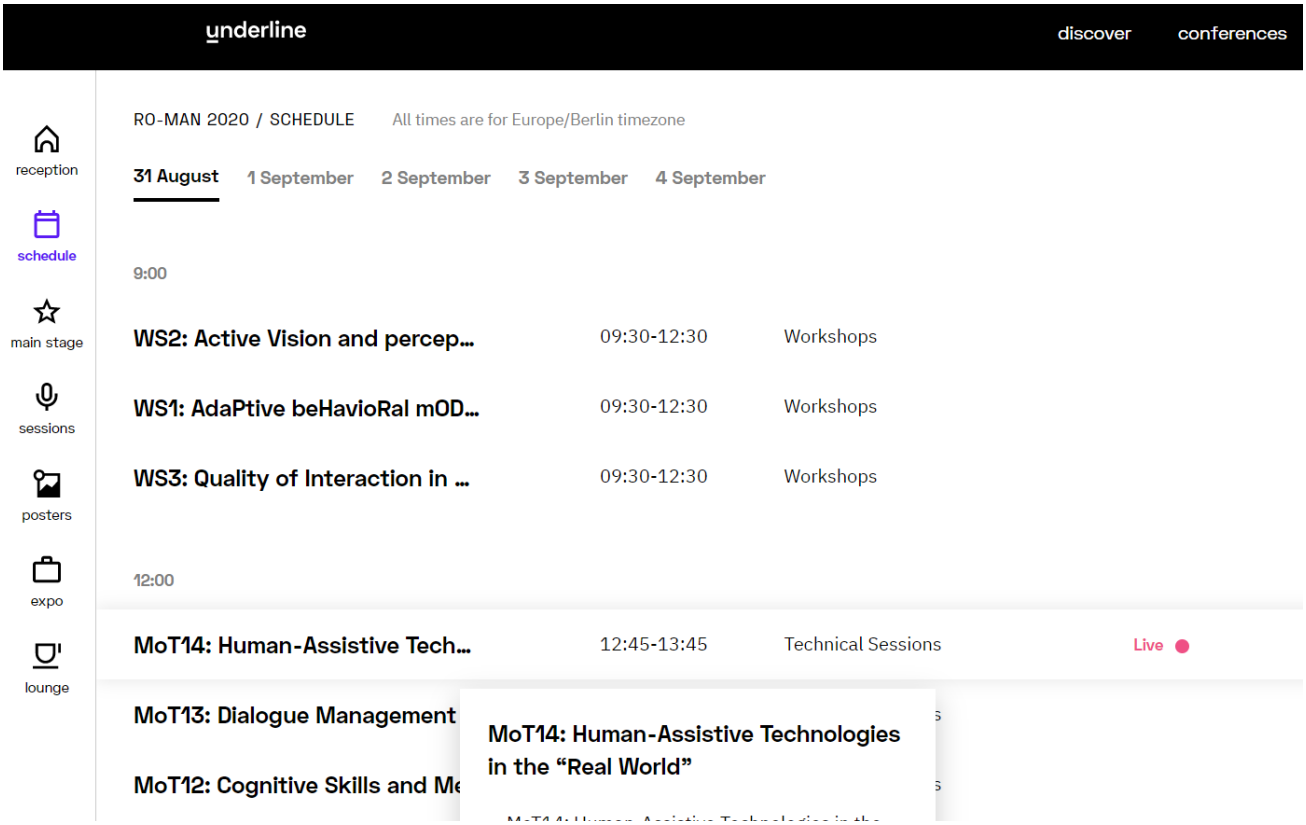
- Once registered, you will receive an email from Underline inviting you to join the conference. An account on Underline will already be created for you. You will have to confirm it with a password.
- You need to be logged into Underline with the email you registered for RO-MAN 2020 in order to have full access to the conference.
- You can access the Ro-man 2020 conference by clicking on CONFERENCES tab on Underline website.
- If you didn't receive your invitation, please contact.

RO-MAN 2020 on Underline:



- The conference on Underline has 6 main parts:
  - **Reception page** - with announcements, help desk and important exhibitor and supporter information
  - **Schedule** - where you can access sessions and other happenings by date, track or search
  - **Main stage** - the place where opening, keynotes, panels and awards happen
  - **Sessions -** list of all live rooms for sessions and later a hub for the pre-recorded videos
  - **Posters -** poster exhibit room
  - **Expo -** a place for our sponsors, exhibitors and other supporters
  - **Lounge** - a place where we hang in breaks or when we want to have a chat with some familiar faces

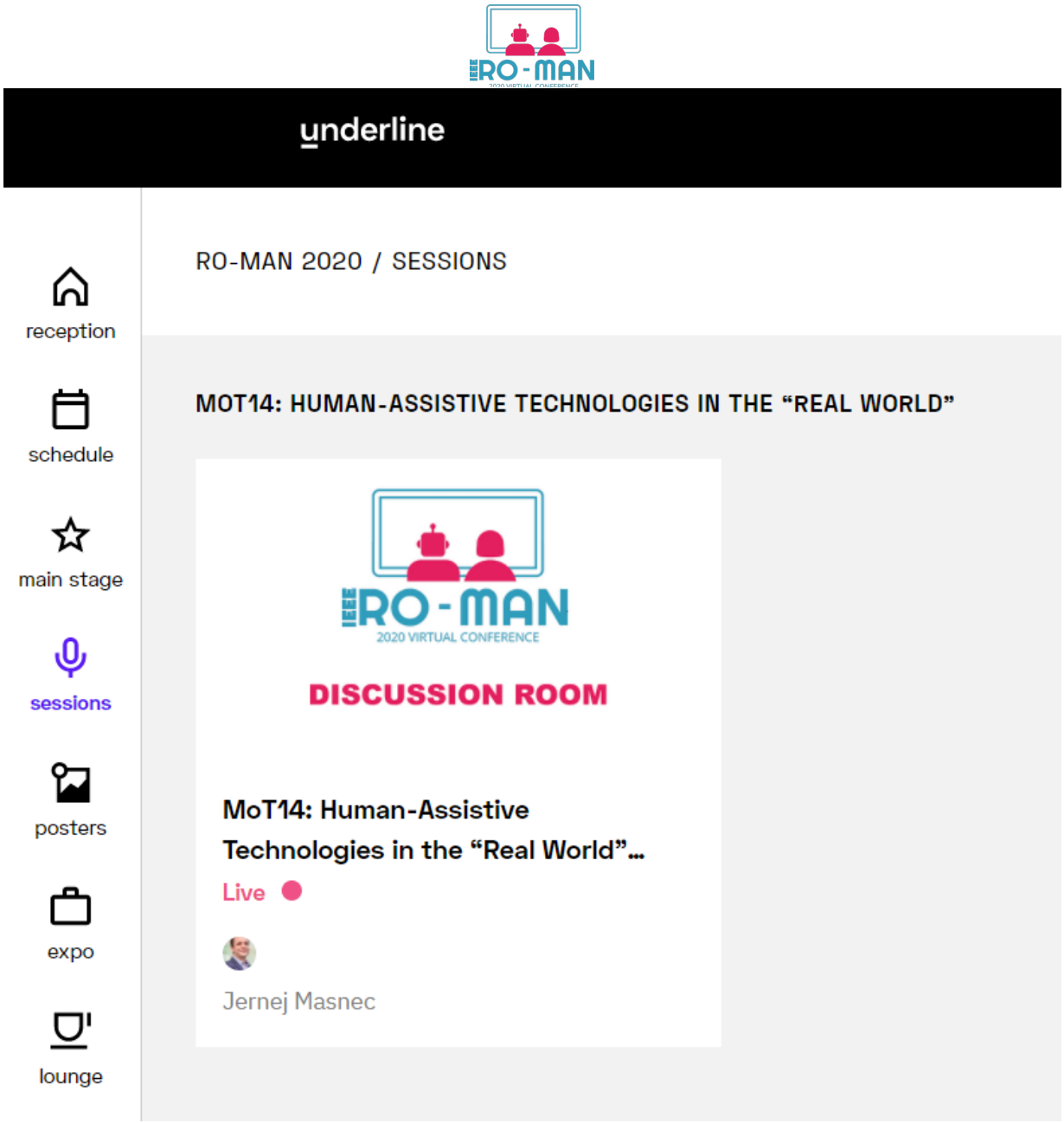
Schedule:



- all conference content is listed in the schedule

Sessions:

- all session discussion rooms are listed on the sessions page
- you can search for sessions in the dropdown or search menu
- within desired session, you will see a DISCUSSION ROOM tile - this is where the live discussion and presentations are happening



- When you enter the discussion room you will see a central panel for video content and chat to the right.
- As an attendee, you can spectate the session (not join with video). In this case you can still ask questions in text form. If you want to join with video, you can do so by pressing on 'ASK A QUESTION' button and moderator will let you in if possible.
- Questions can be asked in a text form during the presentation or in a verbal/video form for a few minutes after each talk.

Posters:

- Each poster has it's own poster room in a session. These poster sessions are accessible by clicking on 'POSTERS' or through 'SCHEDULE'
- You are able to ask questions about a poster in text form or join the Q&A at predesignated poster session times

Other tips:

- Underline is entirely web based and does not require any software downloads or installations
- Although all browsers are supported, we recommend to use updated versions of Chrome or Firefox.
- In case you have any problems or need technical support, please write to roman2020@underline.io

Social Gathering

During breaks it will be possible to meet in small group of people using gather.town. Links to thematic rooms will be made available in the Lounge Area

Gather.Town Instructions

You must use a computer - not a cell phone - to access Gather.Town successfully.

To join:

1. Click on the "Lounge" icon at the lower left of your screen, this will take you to Gather.Town
2. Set your name. Please include your first and last name and pronouns if you feel comfortable sharing them.

Using Gather.Town:

3. Experiment with the controls in the left sidebar.

a. **Settings**: change your name and video quality.

b. **Set busy status**: setting to busy will mute your audio and video if you are not actively on the Gather.Town tab.

c. **Interaction distance**: Click it to change how close someone's avatar needs to be to yours in order to interact.

d. **Screenshare**: currently in Beta, this button lets you share your screen.

e. **Mute Video**: turns your camera on and off.

f. **Mute Audio**: turns your mic on and off.

g. **Minimap**: shows the whole room in a small icon.

h. **Change Character**: lets you to customize your avatar.

4. When your avatar gets close to another/s, an emerging group video-conferencing will emerge, allowing live interaction.

5. Use the chat box if you like.

6. Orient yourself to the other information on your screen.

. **Participants** - shows who is in the room

a. **My Spaces** - lists what rooms you can access

b.

Leaving Gather.Town:

1. It is best to:

a. Sign Out by clicking the 'sign out' button in the top right corner

b. Then close the Gather.Town tab or window

2. It is possible to simply close the Gather.Town tab or window without signing out, but if you do not, the system will remember where you were last and automatically put you there.

The platform may rely heavily on the cache stored by your browser to remember your settings, rooms, etc. If you want to be extra sure you have logged out fully, we suggest clearing your browser's cache or making sure you turn off or restart your computer before returning to Gather.Town.

Program at Glance

RO-MAN 2020 Technical Program Monday August 31, 2020

Track 1	Track 2	Track 3	Track 4
12:45-13:45 MoT11 Room 1 Social Touch Interaction	12:45-13:45 MoT12 Room 2 Cognitive Skills and Mental Models	12:45-13:45 MoT13 Room 3 Dialogue Management Systems for Human-Robot Interaction	12:45-13:45 MoT14 Room 4 Human-Assistive Technologies in the "Real World"
13:45-14:00 MoBP Main Room Break I			
14:00-14:15 MoOP Main Room Opening			
14:15-15:45 MoPlP Main Room Best Paper Candidates			

RO-MAN 2020 Technical Program Tuesday September 1, 2020

Track 1	Track 2	Track 3	Track 4
11:30-12:30 TuT21 Room 1 Non-Verbal Cues and Expressiveness	11:30-12:30 TuT22 Room 2 Novel Interfaces and Interaction Modalities (I)	11:30-12:30 TuT23 Room 3 Evaluation Methods	11:30-12:30 TuT24 Room 4 Children and Robots
12:30-12:45 TuB1P Main Room Break II			
12:45-13:45 TuT31 Room 1 Applications of Social Robots / Social Intelligence for Robots (I)	12:45-13:45 TuT32 Room 2 Novel Interfaces and Interaction Modalities (II)	12:45-13:45 TuT33 Room 3 Machine Learning and Adaptation / Programming by Demonstration (I)	12:45-13:45 TuT34 Room 4 Value in Use and Customer Engagement with Social Robots: A Service Management Perspective
13:45-14:00 TuB2P Main Room Break III			
14:00-15:00 TuIP Main Room Keynote: Prof. Roger K. Moore - Talking with Robots: Are We Nearly There Yet?			

RO-MAN 2020 Technical Program Wednesday September 2, 2020

Track 1	Track 2	Track 3	Track 4	Track 5
12:45-13:45 WeT41 Room 1 Applications of Social Robots / Social Intelligence for Robots (II)	12:45-13:45 WeT42 Room 2 Motion Planning and Navigation in Human-Centered Environments (I)	12:45-13:45 WeT43 Room 3 Robots in Education, Therapy and Rehabilitation (I)	12:45-13:45 WeT44 Room 4 Machine Learning and Adaptation / Programming by Demonstration (II)	12:45-13:45 WeT45 Room 5 Stakeholders' Views on Social Robots in Education
13:45-14:00 WeB1P Main Room Break IV				
14:00-15:00 WeIP Main Room Keynote: Dr. Jun Baba - the Value of Interaction in Terms of Commercial Service Robots				
15:00-15:15 WeB2P Main Room Break V				
15:15-16:15 WePIP Main Room Poster Session 1				

RO-MAN 2020 Technical Program Thursday September 3, 2020

Track 1	Track 2	Track 3	Track 4	Track 5
11:30-12:30 ThPIP Main Room Poster Session 2				
12:30-12:45 ThB1P Main Room Break VI				
12:45-13:45 ThT51 Room 1 Applications of Social Robots / Social Intelligence for Robots (III)	12:45-13:45 ThT52 Room 2 Motion Planning and Navigation in Human-Centered Environments (II)	12:45-13:45 ThT53 Room 3 Robots in Education, Therapy and Rehabilitation (II)	12:45-13:45 ThT54 Room 4 Machine Learning and Adaptation / Programming by Demonstration (III)	12:45-13:45 ThT55 Room 5 Cooperation and Collaboration in Human-Robot Teams (I)
13:45-14:00 ThB2P Main Room Break VII				
14:00-15:00 ThIP Main Room Keynote: Prof. Ana Paiva - Prosocial Robotics				

RO-MAN 2020 Technical Program Friday September 4, 2020

Track 1	Track 2	Track 3	Track 4
12:45-13:45 FrT61 Room 1 Detecting and Understanding Human Activity (I)	12:45-13:45 FrT62 Room 2 Safe and Acceptable Human-Robot Collaboration	12:45-13:45 FrT63 Room 3 Degrees of Autonomy and Teleoperation	12:45-13:45 FrT64 Room 4 Cooperation and Collaboration in Human-Robot Teams (II)
13:45-14:00 FrB1P Main Room Break VIII			
14:00-14:45 FrPAP Main Room Panel: Robots with Heart, Mind, and Soul: The Challenging Role of Research on Robotics During a Pandemic / Panelists: Tony Belpaeme, Antonio Bicchi, Hatice Gunes, and Tetsunari Inamura			
14:45-15:00 FrCP Main Room Awards / Closing			
15:00-15:15 FrB2P Main Room Break IX			
15:15-16:15 FrT71 Room 1 Detecting and Understanding Human Activity (II)	15:15-16:15 FrT72 Room 2 Creating Human-Robot Relationships	15:15-16:15 FrT73 Room 3 Towards Intelligent and Natural Human-Robot Interaction in Medical Robot Applications	15:15-16:15 FrT74 Room 4 When Robots Become Members of Human Communities They Must Face the Powerful Role of Norms

Keynote Speakers

Prof. Roger K. Moore (Tuesday September 1)

Talking with Robots: Are We Nearly There Yet?

Recent years have seen considerable progress in the deployment of 'intelligent' communicative agents such as Apple's Siri and Amazon's Alexa. However, effective speech-based human-robot dialogue is less well developed; not only do the fields of robotics and spoken language technology present their own special problems, but their combination raises an additional set of issues. In particular, there appears to be a large gap between the formulaic behaviour that typifies contemporary spoken language dialogue systems and the rich and flexible nature of human-human conversation. As a consequence, we still seem to be some distance away from creating Autonomous Social Agents such as robots that are truly capable of conversing effectively with their human counterparts in real world situations. This talk will address these issues and will argue that we need to go far beyond our current capabilities and understanding if we are to move from developing robots that simply talk and listen to evolving intelligent communicative machines that are capable of entering into effective cooperative relationships with human beings.

BIOGRAPHY

Prof. Moore (http://staffwww.dcs.shef.ac.uk/people/R.K.Moore/) has over 40 years' experience in Speech Technology R&D and, although an engineer by training, much of his research has been based on insights from human speech perception and production. As Head of the UK Government's Speech Research Unit from 1985 to 1999, he was responsible for the development of the Aurix range of speech technology products and the subsequent formation of 20/20 Speech Ltd. Since 2004 he has been Professor of Spoken Language Processing at the University of Sheffield, and also holds Visiting Chairs at Bristol Robotics Laboratory and University College London Psychology & Language Sciences. He was President of the European/International Speech Communication Association from 1997 to 2001, General Chair for INTERSPEECH-2009 and ISCA Distinguished Lecturer during 2014-15. In 2017 he organised the first international workshop on 'Vocal Interactivity in-and-between Humans, Animals and Robots (VIHAR)'. Prof. Moore is the current Editor-in-Chief of Computer Speech & Language and in 2016 he was awarded the LREC Antonio Zampoli Prize for "Outstanding Contributions to the Advancement of Language Resources & Language Technology Evaluation within Human Language Technologies".

Dr. Jun Baba (Wednesday September 2)

The value of interaction in terms of commercial service robots

In recent years, many service robots have been introduced in society as professional applications, such as agriculture, surgery, logistics, or public relations. However, it is rare to see service robots properly interacting with people and taking on essential roles in the city. In particular, service encounters are communicative operations in commerce, where many interactive robots have been tried and tested, but there are few examples of their effectiveness. From a business perspective, service robots are just one of the ways to solve business problems, and non-robotic or non-agent solutions, such as tablet ordering apps, self-checkout systems, and digital signages with human tracking cameras, are also considered at the same time. Why do we keen to choose service robots as a commercial solution? What is the value of verbal/non-verbal interaction? Our research group has explored the value of interaction through a number of practical experiments in various fields. This talk will introduce our observations in the experiments and discuss this inevitable question of spreading service robots in society.

BIOGRAPHY

Jun Baba is a chief research scientist at CyberAgent AI Lab. CyberAgent, inc. is one of the leading advertising agency in Japanese digital advertising market, and focus on conversational agents such as robots, virtual agents as next technologies for retail marketing. CyberAgent and Osaka University set up a joint research group and have started research projects with Prof. Hiroshi Ishiguro since 2017. Baba is a coordinator of the joint research group and a visiting researcher in Osaka University. He received his ME degree in informatics from Kyoto University, Kyoto, Japan in 2014 and he was a data scientist at CyberAgent from 2014 to 2017. His research interests include human-computer interaction in service encounter and machine learning. He focuses on influential conversational agents that can change people’s behaviors and actions by verbal/non-verbal interaction. In order to research and develop such influential agents, he has conducted a lot of field studies in various retail fields, i.e business hotels, online shopping sites, and shopping malls, and he has investigated what is essentially an important interaction based on people's real reactions and behaviors in the fields. Not only has he published his research findings in academic conferences in the area of HRI and HAI, but he's also trying to develop businesses based on his research findings.

Prof. Ana Paiva (Thursday September 3)

Prosocial Robotics

Throughout the past few years robots have become increasingly more sophisticated in terms of their hardware and software, paving the way for their more frequent use in a myriad of scenarios: homes; healthcare; schools; entertainment and in many other settings. At the same time, new situations emerge where robots not only have to interact with humans but are also required to collaborate with them, creating hybrid groups of humans and robots. With this vision in mind, it is important to reflect on the impact that robots have in humans' well-being and consider the effects they may have in supporting collaboration and prosocial behaviour in these new hybrid groups of humans and machines. Pro-social behaviour occurs when people and agents perform costly actions that benefit others. Acts such as helping others voluntarily, donating to charity and providing information or sharing resources, are all forms of prosocial behaviour. In this talk I will explore the role of robotics to foster prosociality- Prosocial Robotics. Several questions will be discussed: What are the conditions that encourage humans to be more prosocial when interacting with robots? What features of robots are relevant to promote prosociality? Does embodiment matter? Do humans respond empathically and prosocially to non-verbal and verbal behaviours by robots? If robots act repetitively in a prosocial manner, do humans respond similarly, or will they exploit the robots' apparent weakness? Lastly, how can we engineer “prosocial robots” in general, leading to more altruistic and cooperative behaviours in a hybrid group? To examine these questions I will describe some preliminary work done in different scenarios. I'll start with a home scenario and then explore collaborative games where hybrid groups play social dilemmas including a public goods game and a collective risk dilemma (CRD). The results obtained so far seem to indicate that social robots can play a role in prosociality but their efficacy will depend largely on a variety of features of the robots.

BIOGRAPHY

Ana Paiva is a Full Professor in the Department of Computer Engineering at Instituto Superior Técnico (IST) from the University of Lisbon and is also the Coordinator of GAIPS - "Group on AI for People and Society" at INESC-ID (see http://gaips.inesc-id.pt/). Her group investigates the creation of complex systems using an agent-based approach, with a special focus on social agents. Prof. Paiva’s main research focuses on the problems and techniques for creating social agents that can simulate human-like behaviours, be transparent, natural and eventually, give the illusion of life. Over the years she has addressed this problem by engineering agents that exhibit specific social capabilities, including emotions, personality, culture, non-verbal behaviour, empathy, collaboration, and others. She has published extensively in the area of social agents, received best paper awards in many conferences, in particular she won the first prize of the Blue Sky Awards at the AAAI 2018. She has further advanced the area of artificial intelligence and social agents worldwide, having served for the Global Agenda Council in Artificial Intelligence and Robotics of the World Economic Forum and as a member of the Scientific Advisory Board of Science Europe. She is an EuroAI fellow.

Panel

Robots with Heart, Mind, and Soul: The Challenging Role of Research on Robotics During a Pandemic (Friday September 4)

Tony Belpaeme - *Professor at Ghent University and Professor of Cognitive Systems and Robotics at Plymouth University.*

Antonio Bicchi - *Professor of Robotics at the University of Pisa, and Senior Scientist at the Italian Institute of Technology in Genoa.*

Hatice Gunes - *Professor in Affective Intelligence and Robotics at University of Cambridge's Department of Computer Science and Technology.*

Testunari Inamura - *Professor with the Principles of Informatics Research Division, National Institute of Informatics.*

Workshops

WS1 - AdaPtive beHavioRal mODels of robotic systems based on brain-inspired AI cogniTivE architecture (APHRODITE)

DATE Monday, August 31
WEBSITE https://www.santannapisa.it/en/institute/biorobotics/news/adaptive-behavioral-models-robotic-systems-based-brain-inspired-ai
ORGANIZERS Laura Fiorini, Filippo Cavallo, Gabriella Cortellessa, Artur Serrano, Marek Bundzel, João Quintas

ABSTRACT The cooperation between humans and robots is becoming increasingly important in our society. Consequently, there is a growing interest in the development of models that can enhance the interaction between humans and robots. A key challenge in the Human-Robot Interaction (HRI) field is to provide robots with cognitive and affective capabilities, developing architectures that let them establish empathetic relationships with users. Current literature demonstrates that a substantial part of research work in this area is addressing fundamental scientific problem in cognitive human robot interaction, i.e. development of cognitive models for robots and understanding of human mental models of robots. Indeed, nowadays research efforts aim to develop innovative adaptable behavioral models of robotic systems based on brain-inspired AI cognitive architectures to enhance spatial communication capabilities in robots to interact with humans with different cognitive and motor capabilities. The key challenge is how to develop a computational model that can simulate the modality human beings interact with each other. The idea to develop a robot with a social behavior is to let him aware to properly react, up to now the development of robotic functionality are mainly devoted to transmit the content of information without pay so much attention to “how” say it like human beings usually do. The robot should be able to process all the input data it gathered from the sensors but also the ones provided by the clinicians to profile the user and provide the appropriate behaviors. While these research topics are potentially relevant with a high social and scientific impact, there are still gaps from a scientific perspective. It is needed to have more discussions and

developments, and extensive testing on the field, for improving robot capabilities and clinically validating solutions for healthcare applications. In this context, this workshop aims to: present the main results in the development of behavioral model for robot solutions; investigate the social cues to be included in the system; investigate how to tailor and personalize the HRI; investigate the role of the clinician and the therapist in user profiling; investigate how robot could be used in understanding social cognition. Reports from preliminary on the field tests will also be reported.

WS2 - AVHRC 2020 - Active Vision and perception in Human(-Robot) Collaboration

DATE Monday, August 31 and Wednesday, September 2
WEBSITE https://www.essex.ac.uk/departments/computer-science-and-electronic-engineering/events/avhrc-2020
ORGANIZERS Dimitri Ognibene, Fiora Pirri, Letizia Marchegiani, Tom Foulsham, Giovanni Maria Farinella, Francesco Rea, Manuela Chessa, Yan Wu, Fabio Solari, Ayse Kucukyilmaz, Francesca Bianco, Vito Trianni, Angela Faragasso, Lucas Paletta

ABSTRACT Humans naturally interact and collaborate in unstructured social environments that produce an overwhelming amount of information and may yet hide behaviourally relevant variables. Finding the underlying design principles that allow humans to adaptively find and select relevant information is important for Robotics but also other fields, such as Computational Neuroscience, Interaction Design, and Computer Vison. Current solutions cover specific tasks, e.g. autonomous cars, and usually employ over-redundant, expensive, and computationally demanding sensory systems that attempt to cover the wide set of sensing conditions which the systems may have to deal with. A promising alternative is to take inspiration from the brain. Adaptive control of sensors and the perception process is a key solution found by nature to cope with computational and sensory demands, as shown by the foveal anatomy of the eye and its high mobility. Alongside this application of “active” vision, collaborative robotics has recently progressed to human-robot interaction in real manufacturing. Partners’ gaze behaviours are a crucial source of information that humans exploit for collaboration and coordination. Thus measuring and modelling task-specific gaze behaviours seems to be essential for smooth human-robot interaction. Indeed, anticipatory control for human-in-the-loop architectures, which can enable robots to proactively collaborate with humans, could gain much from parsing the gaze and actions patterns of the human partners. We are interested in manuscripts that present novel, brain inspired computational and robotic models, theories and experimental results as well as reviews relevant to these topics. Submissions should further our understanding of how humans actively control their perception during social interaction, in which conditions they fail, and how these insights may enable natural interaction between humans and embodied artificial systems in non-trivial conditions.

WS3 - QISAR: Quality of Interaction in Socially Assistive Robots

DATE Monday, August 31
WEBSITE : https://sites.google.com/view/qisar-roman20/
ORGANIZERS Antonio Andriella, Silvia Rossi, Raquel Ros Espinoza, Neziha Akalin

ABSTRACT This half-day workshop will focus on the quality of interaction in socially assistive robots. Socially assistive robots (SAR) are entering our everyday lives, which brings about human-robot interactions across in diverse settings including private homes, workplaces, health care centers, schools, and public spaces. To facilitate successful interaction between humans and

robots, it is essential that the interaction between robots and their users be of high quality; not only to ensure that the interaction is natural for the users but also to prevent misunderstandings by the users with potential harm as a result.
The workshop aims to be a forum for discussion on what defines the quality of interaction from a range of different perspectives. It will be an opportunity to discuss methodologies and approaches to achieve a high quality of interaction, as well as how to combine different qualitative and quantitative metrics for a general evaluation of interaction between SAR and their users. This workshop aims to enhance our knowledge of the quality of human-robot interactions to lead better HRI.
We invite researchers from different backgrounds ranging from psychology, sociology, computer vision, human-robot interaction design, natural language processing, machine learning, neuroscience, ethics and robotics, among others. It will be an excellent opportunity for sharing the ideas towards understanding the quality of interaction in SAR and potentially define guidelines for a standardized definition and evaluation.
Authors are invited to submit original, previously unpublished research papers written in English. All submitted papers will be reviewed by two reviewers from the program committee. All accepted papers will appear on the workshop website. The extended versions of the accepted papers will be invited to SPECIAL ISSUE on Human-Robot Interaction Quality on Interaction Studies.

WS4 - Trust, Acceptance and Social Cues in Human Robot Interaction – SCRITA

DATE Tuesday, September 1
WEBSITE http://scrita.herts.ac.uk/2020/
ORGANIZERS Alessandra Rossi, Patrick Holthaus, Giulia Perugia, Scheunemann Marcus, Sílvia Moros

ABSTRACT The SCRITA workshop is a continuation of two successful previous workshops at the RO-MAN conference in 2018 and 2019. This workshop focuses on investigating users' trust in robots. Although the previous editions had the pleasure to welcome the participation of leading researchers in the field, and several exceptional invited speakers, who identified some of the principal points in this research direction, current research still presents several limitations. For this reason, we continue to further explore the role of trust in social robotics to effectively support the design and development of socially acceptable and trustable service robots. In this context, a deeper exploration of trust in HRI approached from a multidisciplinary perspective (from AI to Psychology, passing through Ethics and Law) is required. Therefore, this workshop will analyse the different aspects of human-robot interaction that can affect, enhance, undermine, or recover humans' trust in robots, such as the use of social cues, behaviour transparency (goals and actions), etc.

WS5 – Integrating Sensor Fusion and Perception for Human-Robot Interaction

DATE Tuesday, September 1
WEBSITE https://sites.google.com/view/romanhri/
ORGANIZERS Hang Su, Chenguang Yang, Sara Moccia, Mingchuan Zhou, Aldo Marzullo, Elena De Momi

ABSTRACT Human-robot interaction (HRI) is devoted to the development of smarter systems that study the interaction between humans and robots, which has attracted increasing research interests in the past years. In many practical scenarios, such as factories, rehabilitation robots,

and operating rooms, HRI technology can be exploited to increase safety using intelligence for human operation. However, both available commercial robotic systems and some ongoing researches lack intelligence due to their limited capabilities in the perception of the environment, hampering their spreading in the applications and development. Nowadays, the HRI usually relies on a single sensing system, with separates algorithms and hardware developed for sensing systems, for instance, tactile perception and computer vision. Future intelligent robots should integrate all available sensing systems to interact with the environment in the ways humans do. Sensor fusion and perception with Artificial Intelligence (AI) techniques have been popular in environment perception and activity recognition, by fusing information from a multi-modal sensing system and selecting the most appropriate information to achieve the perception. Hence, how to combine the technique of multi-sensor fusion and perception for HRI is an inspiring and promising topic. This workshop aims at bringing world-class researchers to present the state-of-art research achievements and advances that contribute to the HRI using integrating sensor fusion and perception techniques.

WS6 - Solutions for socially intelligent HRI in real-world scenarios

DATE Tuesday, September 1 and Thursday, September 3
WEBSITE https://sites.google.com/view/realworldhri-workshop
ORGANIZERS Karen Tatarian, Mohamed Chetouani, Marine Chamoux, B...Sera Buyukgoz, Aaquib Tabrez

ABSTRACT This interactive full-day workshop aims at providing a forum to bring together a large community of researchers working on autonomous and innovative challenges inherent to Human-Robot Interaction (HRI) in order to improve and increase the presence of robots in real-world scenarios, including public places such as hospitals, schools, retail stores to even work places and homes. As the state of the art in HRI seems to be expanding and growing, one would expect that the presence of robots in everyday encounters would spread at a similar rate. However that does not seem to be the case. There is a considerable need for a central venue within which researchers can get together and engage in sustained community building at this important intersection of HRI in academia and HRI in industry. This would allow further discussions on autonomous solutions that could be implemented on robots placed outside of labs and into the wild and thus helping bring the world of robotics and specifically HRI forward. We would like to explore and enrich the bridging of the world of robotics in academia and industry together. In addition, we hope to create a space and place where researchers can also talk and present work that did not lead to significant results. This is important for other researchers to learn from the community. Moreover, in his/her turn the fellow researcher would have a place where he/she can receive feedback on his/her attempt.This first edition of the workshop would serve as the foundation for the core ideals and outlook for HRI in real-world scenarios.

WS7 - TIGHT - Tactile InteGration for Humans and arTificial systems

DATE Wednesday, September 2
WEBSITE http://sirslab.diism.unisi.it/TIGHTWorkshop/index.html
ORGANIZERS Maria Pozzi, Tommaso Lisini Baldi, Matteo Bianchi, Domenico Prattichizzo

ABSTRACT The acceptance of new assistive and collaborative robotic devices strongly depends on the levels of confidence and awareness that the user has towards them. Confidence is essential, as it allows humans to tackle known or unfamiliar tasks in cooperation with artificial devices with increased hope, optimism, and resilience. Awareness enables confidence: the more we know about the task we must perform, and about the agent we must interact with, the more we are confident. This workshop will discuss how new tactile communication paradigms can be exploited to increase user's confidence in her/his collaborator in human-human and human-robot collaboration scenarios. Whether the partner is another human (e.g., assistant for visually impaired people) or a robot (e.g., collaborative arm in an industrial set-up), mutual understanding is fundamental to achieve a common goal. Starting from the successful results of the WEARHAP project (concluded EU-Project coordinated by University of Siena), and leveraging on the beginning of a National Italian Grant (TIGHT), speakers will talk about advantages and disadvantages of exploiting the tactile channel to transmit information, focusing, in particular, on the neuroscientific and technological challenges that derive from the use of wearable haptic interfaces. Also, the adoption of multi-modal interfaces will be discussed, together with innovative methods to evaluate human-machine interaction, and skill training techniques.

WS8 - Social Human-Robot Interaction of Human-care Service Robots

DATE Wednesday, September 2
WEBSITE https://cares.blogs.auckland.ac.nz/education/activities-on-international-conferences-and-journals/ro-man-2020-workshop/
ORGANIZERS Ho Seok Ahn, Minsu Jang, Jongsuk Choi, Yoonseob Lim

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 2020 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.

WS9 – Behavior Adaptation, Interaction and Learning for Assistive Robotics BAILAR

DATE Thursday, September 3 and Friday, September 4
WEBSITE http://www.cogrobotics.unina.it/bailar2020/index.php
ORGANIZERS Mariacarla Staffa, Silvia Rossi, Mehdi Khamassi, Daniela Conti, Francesca Cordella

ABSTRACT Endowing robots with learning and online behavioral adaptation abilities is a key objective for enabling natural and efficient human-robot interaction, especially in the areas of assistive and rehabilitation robotics. Nevertheless, as one of the novels of Asimov pointed out in The Complete Robot (1982), enabling a robot such as Lenny to learn inevitably leads to it making mistakes before adapting. One of the critical issues is thus to design robot learning and

adaptation abilities that lead to a behavior that meets three criteria at the same time: efficiency, acceptability and security for the human.
To achieve efficiency, it is necessary to enhance the ability of the robots to adapt on the fly to the users' behavior, needs and motivations. Social assistive robots have to incrementally learn user preferences and categories of user preferences experienced during past interactions (so that they do not start each new interaction from scratch), and to accordingly modify and adapt their behavior. This adaptation requires learning a model of human behavior and integrating this model into the decision-making algorithm of the robot. Efficient on the fly adaptation also requires model-free learning abilities to cope with local uncertainties of the environment, variations of the human's desires and motivations, and volatilities of the interaction itself.
To achieve acceptability, robots have to be designed under a human-centered approach, which accounts for all the aspects that can affect the acceptability from the users' point of view: from the users' expectation, to robot behavior legibility, to robot safe interactive behavior. Additionally, in the domain of assistive and social robotics and when working with vulnerable user populations, additional aspects have to be taken into account, such as ethical considerations and psychological/cognitive aspects. Both efficiency and acceptability can be enhanced if we consider the human-robot communication as a two-way street: both the user and the robot should be able to understand messages from the conversation partner, including the non-verbal ones. Meaning that the robot should be not only able to understand human activities, intentions and internal states, but also to show a similar behavior to humans.
Last but not the least, the security aspect have not to be neglected , since despite the recognized potential and usefulness of social robots for assistive purposes, people are still worried about their utilization also for fear of being victims of cybersecurity attacks, from privacy violation to remote robot tampering that can in the worst cases cause bodily harm.

WS10 - Lifelong Learning for Long-term Human-Robot Interaction (LL4LHRI)

DATE Thursday, September 3 and Friday, September 4
WEBSITE https://sites.google.com/view/ll4lhri2020/
ORGANIZERS Hatice Gunes, German Ignacio Parisi, Sinan Kalkan

ABSTRACT Lifelong learning is an essential requirement for social robots since it facilitates learning new concepts, situations, or abilities so that the robots can "appropriately adapt [their] behavior to the social context" as well as other contexts that may arise. Consider the robot at the right-hand side, who happens to be vacuuming while a person is reading a newspaper. When given a negative feedback (e.g. "don't hoover now") in such a context, the robot should be able to identify this as a new context, and from thereon, adapt its behaviors accordingly in this and similar spatial or social contexts. E.g., when the human is watching TV the next time when the robot is vacuuming, the robot should make the link to the previously experienced similar context and be mindful by not vacuuming in this similar context.

WS11 - 1st International workshop on Designerly HRI knowledge: Bridging HRI and Design Research

DATE Thursday, September 3
WEBSITE http://hridesign.eu/
ORGANIZERS Maria Luce Lupetti, Cristina Zaga, Cila Nazli

ABSTRACT We welcome submissions to the 1st International Workshop on Designerly HRI Knowledge. The ultimate goal of the workshop is to build strong bridges between the fields of HRI and Interaction Design (IxD) with the purpose of extending the state-of-art of HRI knowledge. This first edition is dedicated to the investigation of the concept of intermediate-level knowledge through the specific perspective of HRI studies. By exploring perspectives, approaches, methods, tools, techniques, and contributions that fall within the concept of intermediate-level knowledge, we will start a conversation on what HRI design epistemology is (i.e., the study of knowledge creation) and could be, and how to evaluate and legitimate knowledge produced through HRI design practices.

WS12 – Trusting and Overtrusting Robots - When Boundaries are Crossed

DATE Friday, September 4
WEBSITE https://sites.google.com/view/overtrusting-robots/home
ORGANIZERS Aurelia Tamò-Larrieux, Christoph Lutz, Eduard Fosch-Villaronga

ABSTRACT We are living in a time where we increasingly rely on algorithmic systems for a multitude of activities. Simple activities, such as finding the nearest shared bike on an app, and more complex ones, such as voting or getting a job, are often directly affected by decision-making processes carried out by algorithms. Thus, as a society, we need to trust that the systems run correctly and that we can rely upon them. The case of autonomous vehicles or surgery robots very intuitively illustrates this need for trust in automation. Yet, while many researchers and policymakers highlight the importance of trust in a (robotically) mediated world, comparatively little research exists on what happens when too much trust is placed in robots. Therefore, we call for new research on overtrust and automation biases. In this workshop, we will investigate what happens when trust becomes overtrust and automation bias seeps in. We will analyze scenarios when trust in automation becomes destructive for an individual, groups of individuals, and society at large, in particular when such overtrust leads to physical (e.g., injuries, damages) and psychological (e.g., manipulation) consequences. Upon this basis we will determine the policy implications of our findings and set a research agenda that we will publish as an expert opinion. The workshop will bring together a group of researchers across disciplines and practitioners interested in sharing their knowledge and expertise on how to address the topic of overtrust in robots. We welcome input statements from researchers that have studied trust in robots, experts from the HRI and HCI communities, experts in NLP, design, psychology, and the social sciences including ethics, law, sociology, and philosophy.

WS13 - HOBI Hand-Object Interaction: from Human Demonstrations to Robot Manipulation

DATE Monday, September 7
WEBSITE https://theengineroom.dibris.unige.it/index.php/hobi/
ORGANIZERS Alessandro Carfì, Timothy Patten, Abraham Itzhak Weinberg, Ali Hammou, Fulvio Mastrogiovanni, Markus Vincze, Diego Faria, Véronique Perdereau

ABSTRACT Humans use their hands to interact with the environment, and they do so for a broad spectrum of activities, from the physical manipulation of objects to non-verbal communication. Examples range from simple grasping of everyday objects, tool usage, deictic gestures, or communication via the sign language. It is therefore of the utmost importance to focus on how humans use their hands with the aim of developing novel robot capabilities to deal with tasks usually considered a human prerogative, and in general being able to interact, collaborate or

communicate with humans in a socially acceptable and safe manner. For example, a robot should be able to dexterously make use of tools, to synchronize its movements with the human it is collaborating with, either for joint work or turntaking, or to manipulate objects such as to enhance a sense of trust in humans. These examples require robot hands to coordinate with human motions, as well as advanced capabilities to deduce objects' affordance, their intrinsic characteristics, and to understand how objects can be manipulated according to the social context. The Workshop aims at gathering new approaches and experience from different fields to discuss which conceptual and engineering tools are better suited to sense human hand motions, to recognize objects and their physical characteristics, as well as to model and encode this knowledge to develop new robot behaviors. The Workshop aims also at being a starting point for further activities: 1. We will set up a mailing list including all participants, aiming to build a scientific community interested in the Workshop topics. The mailing list will be used for the Workshop organization, to foster debate after the workshop and to share the community results. 2. We aim to write a paper reviewing ideas emerged during the Workshop, asking the contribution of all the participants. The spirit will be that of synthesizing a contribution putting forth a research agenda for future activities, common challenges to address, and sustaining reproducible research. 3. A journal special issue will be proposed, open to all Workshop participants, related to the Workshop topics. Possible target journals are Robotics and Autonomous Systems and IEEE Transactions on Human-Machine Systems.

WS14 - 2nd International Workshop on Blockchain Technologies for Robotic Systems (BCT4ROS'2020)

DATE Tuesday, September 15

WEBSITE https://ondergurcan.netlify.app/site/bct4ros2020/

ORGANIZERS Onder Gurcan, Fabio Bonsignorio

ABSTRACT It's been 11 years since Satoshi Nakamoto unleashed the first blockchain, the Bitcoin, into our lives. Since then, the theoretical and experimental foundations of blockchain systems are becoming increasingly well understood and today the term "blockchain" is not anymore a buzzword. And the the combination of such a ground-breaking technology with robotics, seems to be very promising since it would allow the robotic applications be more secure, flexible, autonomous, and even profitable.Robotics is an interdisciplinary research area at the interface of computer science and engineering. Robotics involves design, construction, operation, and use of robots. The goal of robotics is to design intelligent machines that can help and assist humans in their day-to-day lives and keep everyone safe. However, it is quite challenging to perform research and development in enabling and fostering the development of autonomous robots and to help such robots become accepted by society. To enable the development of robots that can operate autonomously and safely, important issues like data privacy, security and transparency need to be tackled for the future use of robots in high-sensitive scenarios. Therefore, solutions to these issues might be necessary steps towards mainstream adoption. Blockchain technologies provide an immutable shared data structure, thanks to the distributed consensus protocols and cryptographic techniques, that can store various kinds of data including program codes (known as smart contracts) that can be deterministically executed the same way by all the participants. Thanks to its characteristics that fit very well the multi-agent systems, blockchain technologies show great potential for making robotic applications more open, trustworthy, secure and tolerant to faults.

WS15 - Robots from Pathways to Crowds: Ethical, Legal and Safety Concerns of Robots Navigating Human Environments

DATE Monday, August 31
WEBSITE http://crowdbot.eu/workshop-roman2020/
ORGANIZERS Aude Billard, Diego Felipe Paez-Granados, Julien Pettre, Tom Carlson

ABSTRACT Nowadays, robots share public and private spaces with us in many ways: drones flying commercially, autonomous cars, service robots in buildings, and delivery robots coming to the pathways. Although public attention has been focused on autonomous vehicles and drones, the arrival of multiple robots to the pathway and the questions arising from sharing the public pedestrian space are still under-represented.
The focus of this workshop is on "Crowdbots", that is, robots that share the floor with pedestrians, including any robot with semi/autonomous mobile capabilities designed to perform tasks in public places (i.e., carry loads, move people around or provide assistance) and the safety, ethical and legal challenges that we will face and should be considered for achieving these robots in our society.
This workshop aims at providing an overview of the challenges in navigating through highly dynamic human environments and a better understanding of potential sources
of physical and psychological hazards. From robot-human crowd interaction simulation, robot navigation control, to an overview of the main ethical, legal and societal implications emerging from research and deployment of robots in such unconstrained environments with humans.
To this end, the workshop brings together a set of well-known experts on standards and safety for robots moving close to people, as well as a group of experts on ethics, law and social sciences. Herewith, focusing on an audience of both researchers and industrial roboticists with an interest in human-robot interaction, autonomous driving robots, robot control and navigation, design and safety of robot operation. While fostering involvement between the audience and speakers in an open and interactive discussion for sharing awareness of both technical and social challenges.

WS16 - CognitIve RobotiCs for intEraction (CIRCE)

DATE Monday, August 31 and Thursday, September 3
WEBSITE https://circe-roman2020.loria.fr
ORGANIZERS Alessia Vignolo, Alessandra Sciutti, Serena Ivaldi, Katrin Solveig Lohan, Giovanna Varni

ABSTRACT Humans can easily collaborate with others, thanks to their capacity of understanding other agents and anticipate their actions. This possibility is given by the fact that humans are cognitive agents who combine sensory perception with internal models of the environment and people, and that they perceive other humans with the same features: this enables mutual understanding and coordination.
Robots, in order to be able to interact with humans in an efficient and natural way, need to have a cognitive architecture as well. Without cognition machines lack the abilities to predict, understand and adapt to their partners, preventing the establishment of long-lasting rapport. On the other hand, robots are an ideal stimulus to understand which basic skills are necessary for a cognitive social agent to make natural human-robot interaction possible.
The implementation of cognitive architectures on robots could validate cognitive theories or give cognitive scientists inputs for new questions to investigate, while the results about human

behavior during human-robot interaction studies could give robotics engineers new hints for developing more socially intelligent robots.
The goal of the workshop will be to provide a venue for researchers interested in the study of HRI, with a focus on cognition. It will be an ideal venue to discuss about the open challenges in developing cognitive architectures for HRI, such as anticipation, adaptation (both emotional and motoric), dyadic and group interaction, the human inspiration and the technological implementation of cognitive architectures by means of, among others, computer vision and machine learning techniques.
The workshop is targeted to HRI researchers who are interested in interdisciplinary approaches. In particular, in order to encourage discussion, we would like to welcome researchers from a broad range of disciplines such as robotics, neurosciences, social sciences, psychology and computer science.

WS18 – HRIpreneur Workshop: Human-Robot Interaction (HRI) from Basic Science to New Venture Creation for Social Good

DATE Monday, August 31
WEBSITE https://www.hripreneur.io
ORGANIZERS Ker-Jiun Wang, Mohammad Shidujaman, Caroline Yan ZHENG, Prakash Thakur

ABSTRACT The "HRIpreneur Workshop: Human-Robot Interaction (HRI) from Basic Science to New Venture Creation for Social Good" 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. As a continuation of the two successful RO-MAN workshops in 2018 & 2019, 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 to create social values. On top of the lectures/tutorials, we also have startup/venture Make-a-Thon competition this year, where the students, research labs, startup companies, will go through the "Online Innovation" and "Onsite Innovation" rapid innovation processes under the supervision of world-renowned experts in competing for the final-stage awards in our workshop. In the meanwhile, all the participants can have a perfect networking venue to seek collaboration opportunities to solve the social challenges particularly for Italian society. 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 end-users, focusing 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.
Based on our mission: "HRIpreneur = HRI + Entrepreneur" spirit, we hope through hosting 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.

WS19 - Socialware in human-robot collaboration and physical interaction

DATE Tuesday, September 1
WEBSITE https://dil.atr.jp/crest2018_STI/socialware-in-roman2020/page.html
ORGANIZERS Masahiro Shiomi, Chie Hieida, Hidenobu Sumioka, Takayuki Nagai

ABSTRACT Recent advances in the robotic technologies enable us to more conveniently build social robots that can physically collaborate with us in real world. Especially, the standardized hardware and software platforms such as ROS allows for the development of social robots effectively. On the other hand, we still have difficulty in designing social behaviors of the robots since we must hardcode even such common knowledge as social norm into them. To facilitate the human-robot collaboration including physical interaction in our society, it is important to develop middleware and that helps us implement social behavior for social robots to work in our society in an appropriate manner.
This workshop will propose fundamental design paradigms for social behaviors as "socialware" and discuss how we should design them for social robot with explainable artificial intelligence, bringing together leading researchers from Robotics, Computer Science, Engineering, Cognitive science, and Psychology. Our aim is to open formal discussion on the fundamental components of socialware, thereby sharing ideas on how we can design socialware for social robots that interact with people in our society.

WS20 - HRI and Folklore Studies/Cultural Anthropology(HRFC)

DATE Friday, September 4
WEBSITE https://sites.google.com/senshu-u.jp/hrfc2020/home
ORGANIZERS Tetsuya Matsui, Naoki Ohshima, Kazuki Kobayashi, Hideyasu Takahashi

ABSTRACT Once, the human lived with other strange agents; ghost, monstrous being, fairly and God. At that time, all events were not specifically connected by causality. For example, the fairly and Yokai (Japanese monstrous being) often abducted people into our world. These phenomena were called “spirited away”. The people who were spirited away were freed from the causal chain in their community. Then, they could return to their village without accountability when they want to return. Currently, our world has been connected by one causal chain as the national science has spread all over the world. Other strange agents are disappearing, however, new strange agents are appearing in the world; Robot and AI. We aim to focus on the aspect of the robots that remain us the other strange agents and make the robots take part in the other strange agents’ roles. We focused on the affinities between the robots and other strange agents; ghost, monstrous being, fairly and alien. Also, we aim to apply these affinities with engineering approaches. We expect that this trial can support our smooth communication and encourage our life.

Book of Abstracts

Technical Program for Monday August 31, 2020

MoT11 Room 1

Social Touch Interaction (Regular Session)

Chair: Khodr, Hala — EPFL

Co-Chair: Sato, Daiki — Nippon Telegraph and Telephone Corporation

12:45-12:55 MoT11.1

Affective Touch Robots with Changing Textures and Movements, pp. 1-6

Sato, Daiki — Nippon Telegraph and Telephone Corporation

Sasagawa, Mana — NTT Corporation

Niijima, Arinobu — NTT Corporation

We explore how to design emotional expression using tabletop social robots with multiple texture modules. Previous studies in human-robot interaction have presented various designs for emotionally expressive robots without using anthropomorphic forms or cues. They revealed that haptic stimulation based on the textures and movements of the robots could evoke some emotions in users, although these were limited. In this work, we propose using a combination of textures and movements for richer emotional expression. We implemented tabletop robots equipped with detachable texture modules made of five different materials (plastic resin, aluminum, clay, Velcro, and cotton) and performed a user study with 13 participants to investigate how they would map the combinations of textures and movements to nine emotions chosen from Russell's circumplex model. The results indicated that the robots could express various emotions such as excited, happy, calm, and sad. Deeper analysis of these results revealed some interesting relationships between emotional valence/arousal and texture/movement: for example, cold texture played an important role in expressing negative valence, and controlling the frequency of the movements could change the expression of arousal.

12:55-13:05 MoT11.2

Effects of Touch Behaviors and Whispering Voices in Robot-Robot Interaction for Information Providing Tasks, pp. 1-7

Okada, Yuka — ATR

Taniguchi, Riko — Doshisha University

Tatsumi, Akihiro — Doshisha University

Okubo, Masashi — Doshisha University

Kimoto, Mitsuhiko — Keio University

Iio, Takamasa — University of Tsukuba / JST PRESTO

Shimohara, Katsunori — Doshisha University

Shiomi, Masahiro — ATR

Using multiple robots for information providing tasks is one effective approach to attract people by showing conversational interaction between robots. In this study, we investigate the effectiveness of showing such intimate interaction between robots as touching because it has positive effects on human-robot interactions, even though it has received less attention than robot-robot interaction. We prepared touch behaviors and whispering voices between robots and conducted experiments where robots provided information to participants. Our experiment results showed the effectiveness of both touch behaviors and whispering voices between robots in information providing tasks. On the other hands, we also found that whispering voices decreased their likeability, although touch behavior did not have such negative effects.

13:05-13:15 MoT11.3

Touching a Human or a Robot? Investigating Human-Likeness of a Soft Warm Artificial Hand, pp. 1-7

Ueno, Azumi — Tokyo University of Agriculture and Technology

Hlavac, Vaclav — Czech Technical University in Prague

Mizuuchi, Ikuo — Tokyo University of Agriculture and Technology

Hoffmann, Matej — Faculty of Electrical Engineering, Czech Technical University In

With the advent of different electronic skins sensitive to touch and robots composed of soft materials, tactile or haptic human-robot interaction is gaining importance. We designed a highly realistic artificial hand aiming to reproduce human-to-human physical contact through a special morphology imitating flesh and bones and a heating system imitating human body temperature. The mechanical response properties of different finger designs were analyzed and the most mimetic one came very close to a human finger. We designed three experiments with participants using haptic exploration to evaluate the human-likeness of: (1) finger morphologies; (2) complete hands: real human vs. soft and warm artificial hand vs. rubber hand (3) the hand mounted on a manipulator with fixed vs. passive compliant wrist in a handshake scenario. First, participants find the mimetic finger morphology most human-like. Second, people can reliably distinguish the real human hand, the artificial one, and a rubber hand. In terms of human- likeness (Anthropomorphism, Animacy, and Likeability), the human hand scores better than the artificial hand which in turn clearly outperforms the rubber hand. The temperature, or “warmth”, was rated as the most human-like feature of the artificial hand.

13:15-13:25 MoT11.4

Design of Haptic Gestures for Affective Social Signaling through a Cushion Interface, pp. 1-6

Nunez, Eleuda — University of Tsukuba

Hirokawa, Masakazu — University of Tsukuba

Suzuki, Kenji — University of Tsukuba

In computer-mediated communication, the amount of non-verbal cues or social signals that machines can support is still limited. By integrating haptic information into computational systems, it might be possible to give a new dimension to the way people convey social signals in mediated communication. This research aims to distinguish different haptic gestures using a physical interface with a cushion-like form designed as a mediator for remote communication scenarios. The proposed interface can sense the user through the cushion's deformation data combined with motion data. The contribution of this paper is the following: 1) Regardless of each participant's particular interpretation of the gesture, the proposed solution can detect eight haptic gestures with more than 80% of accuracy across participants, and 2) The classification of gestures was done without the need of calibration, and independent of the orientation of the cushion. These results represent one step toward the development of affect communication systems that can support haptic gesture classification.

13:25-13:35 MoT11.5

AlloHaptic: Robot-Mediated Haptic Collaboration for Learning Linear Functions, pp. 1-8

Khodr, Hala — EPFL

Kianzad, Soheil — UBC

JOHAL, Wafa — University of New South Wales

Kothiyal, Aditi — EPFL

Bruno, Barbara — Swiss Federal Institute of Technology in Lausanne (EPFL)

Dillenbourg, Pierre — EPFL

Collaborative learning appears in a joint intellectual efforts of individuals to understand an object of knowledge collectively. In their search for understanding the problems, meanings, and solutions, learners employ different multi-modal strategies. In this work, we explore the role of force feedback in learners interaction with tangible

hand-held robots. We designed a collaborative learning environment to provide embodied intuitions on linear mathematical functions combined with graphical representations and ran a first study involving 24 participants. Our analysis shows a positive learning gain for our learning activity. %but also that this learning gain was significantly higher for those students who were more engaged with the robots in the learning activity. Moreover, to explore the link between different types of force feedback and learners' collaboration, we designed a focus group study with 12 participants. Our results suggest that the haptic communication channel affects the collaboration dynamic differently according to the nature of the learning task. We finish by proposing design insights for future exploration of haptic in collaborative learning.

MoT12 Room 2

Cognitive Skills and Mental Models (Regular Session)

Chair: Fischer, Kerstin — University of Southern Denmark

Co-Chair: Perez-Osorio, Jairo — Istituto Italiano Di Tecnologia

12:45-12:55 MoT12.1

Enactively Conscious Robots: Why Enactivism Does Not Commit the Intermediate Level Fallacy, pp. 1-6

Scarinzi, Alfonsina — Georg-August University Göttingen

Conscious experience is needed to adapt to novel and significant events, to perform actions, to have perceptions. This contribution shows how a robot can be enactively conscious. It questions the view by Manzotti and Chella (2018) according to which the enactive approach to consciousness falls into the so called “intermediate level fallacy” and shows that the authors' remark is implausible because it is based on a partial and reductive view both of enactivism and of one of its main tenets called embodiment. The original enactive approach to experience as it was developed by Varela/Thompson/Rosch (1991) is discussed. Manzotti's and Chella's criticism that in enactivism it is unclear why the knowledge of the effects of movement on sensory stimulation should lead to conscious experience is rejected. In this contribution, it is explained why sensorimotricity and the actionist approach to perception do lead to (robot) conscious experience in the perception of objects located in outer space.

12:55-13:05 MoT12.2

Understanding the Perception of Incremental Robot Response in Human-Robot Interaction, pp. 1-7

Jensen, Lars Christian — University of Southern Denmark

Langedijk, Rosalyn Melissa — University of Southern Denmark

Fischer, Kerstin — University of Southern Denmark

Incremental feedback, i.e. the timely response to human behavior while it is happening, has previously been found to potentially speed up human-robot interactions, but it is unclear how people evaluate incremental robots. In this study, we show that the evaluation of incremental robot response depends on the actual success of the incremental feedback; that is, if the feedback leads to increased efficiency, people evaluate the robot as more competent and more credible. If the robot does not use incremental feedback, no interaction between evaluation and efficiency can be found. Thus, incremental feedback draws people's attention to interaction success.

13:05-13:15 MoT12.3

PredGaze: A Incongruity Prediction Model for User's Gaze Movement, pp. 1-6

Otsuka, Yohei — Keio Univercity

Akita, Shohei — Keio University

Okuoka, Kohei — Keio University

Kimoto, Mitsuhiko — Keio University

Imai, Michita — Keio University

With digital signage and communication robots, digital agents have gradually become popular and will become more popular. It is important to make humans notice the intentions of agents throughout the interaction between them. This paper is focused on the gaze behavior of an agent and the phenomenon that if the gaze behavior of an agent is different from human expectations, human will have a sense of incongruity and feel the existence of the agent's intention behind the behavioral changes instinctively. We propose PredGaze, a model of estimating this sense of incongruity which humans have according to the shift in gaze behavior from the human's expectations. In particular, PredGaze uses the variance in the agent behavior model to express how well humans sense the behavioral tendency of the agent. We expect that this variance will improve the estimation of the incongruity. PredGaze uses three variables to estimate the internal state of how much a human senses the agent's intention: error, confidence, and incongruity. To evaluate the effectiveness of PredGaze with these three variables, we conducted an experiment to investigate the effects of the timing of gaze behavior change and sense of incongruity. The experimental results indicated that there were significant differences in the subjective scores of the naturalness of agents and sense of incongruity with agents according to the difference in the timing of the agent's change in its gaze behavior.

13:15-13:25 MoT12.4

Don't Overthink: Fast Decision Making Combined with Behavior Variability Perceived As More Human-Like, pp. 1-6

Marchesi, Serena — Social Cognition in Human-Robot Interaction, Istituto Italiano D

Perez-Osorio, Jairo — Istituto Italiano Di Tecnologia

De Tommaso, Davide — Istituto Italiano Di Tecnologia

Wykowska, Agnieszka — Istituto Italiano Di Tecnologia

Understanding the human cognitive processes involved in the interaction with artificial agents is crucial for designing socially capable robots. During social interactions, humans tend to explain and predict others' behavior adopting the intentional stance, that is, assuming that mental states drive behavior. However, the question of whether humans would adopt the same strategy with artificial agents remains unanswered. The present study aimed at identifying whether the type of behavior exhibited by the robot has an impact on the attribution of mentalistic explanations of behavior. We employed the Instance Questionnaire (ISQ) pre and post-observation of two types of behavior (decisive or hesitant). The ISQ probes participants' stance towards a humanoid robot by requiring them to choose the likelihood of an explanation (mentalistic vs. mechanistic) of iCub depicted in sequences of photographs. We found that decisive behavior, with rare and unexpected “hesitant” behaviors, lead to more mentalistic attributions relative to primarily hesitant behavior. Findings suggest that higher expectations regarding the robots' capabilities and unexpected actions might lead to more mentalistic descriptions.

13:25-13:35 MoT12.5

Tell Me More! a Robot's Struggle to Achieve Artificial Awareness, pp. 1-7

Hewa Pelendage, Chapa Sirithunge — University of Moratuwa

Priyanayana, Kodikarage Sahan — University of Moratuwa

Bandara, H.M. Ravindu T. — University of Moratuwa

Jayasekara, A.G.B.P. — University of Moratuwa

Dedduwa Pathirana, Chandima — University of Moratuwa

Dahn, Nikolas — Ilmenau University of Technology

There are many cognitive and psychophysical theories to explain human behavior as well as the behavior of robots. Even so, we still lack a model to perceive and predict appropriate behaviors for both the human and the robot during a human-robot encounter. Humans make an instant evaluation of their surroundings and its people before approaching a person or a situation. As robots become more common in social environments, a similar perception of the situation around a human user prior to an interaction is required. Social constraints during an interaction could be demolished by a faulty assessment. Through this paper, we discuss the requirements of a robot to proactively perceive a situation's nature and take an effort to report functional units which come into play during such an encounter. We further identify the cues that are utilized by such intelligent agents to simulate and evaluate the outcomes of their environment. From this, we discuss the requirements of a unified theory of cognition during human-robot encounters. We also highlight implications for design constraints in such a scenario.

13:35-13:45 MoT12.6

A Unified Decision-Theoretic Model for Information Gathering and Communication Planning, pp. 1-8

Renoux, Jennifer	Örebro University
Veiga, Tiago	Norwegian University of Science and Technology
Lima, Pedro U.	Instituto Superior Técnico - Institute for Systems and Robotics
Spaan, Matthijs T. J.	Delft University of Technology

We consider the problem of communication planning for human-machine cooperation in stochastic and partially observable environments. Partially Observable Markov Decision Processes with Information Rewards (POMDPs-IR)form a powerful framework for information-gathering tasks in such environments. We propose an extension of the POMDP-IR model, called a Communicating POMDP-IR (com-POMDP-IR), that allows an agent to proactively plan its communication actions by using an approximation of the human's beliefs. We experimentally demonstrate the capability of our com-POMDP-IR agent to limit its communication to relevant information and its robustness to lost messages.

MoT13 Room 3

Dialogue Management Systems for Human-Robot Interaction (Special Session)

Chair: Magnini, Bernardo	FBK
Co-Chair: Gili Fivela, Barbara	University of Salento
Organizer: Cutugno, Franco	University of Naples
Organizer: Magnini, Bernardo	FBK
Organizer: Gili Fivela, Barbara	University of Salento

12:45-12:55 MoT13.1

A Model for the Representation of the Extraversion-Introversion Personality Traits in the Communication Style of a Social Robot (I), pp. 1-7

Speranza, Sabrina	University of Genova
Recchiuto, Carmine Tommaso	University of Genova
Bruno, Barbara	Swiss Federal Institute of Technology in Lausanne (EPFL)
Sgorbissa, Antonio	University of Genova

Personality is one of the most important factors in human interactions, which retains its importance in human-robot interactions with social robots. This work focusses on the varied linguistic strategies which characterize the personality traits of extraversion and introversion, analysing the main features that differentiate both personalities and eventually proposing a verbal communication model for the extraverted and introverted personality of a conversational social robot. The model classifies and converts phrases, with the result of building different communication styles. A pilot study, involving human subjects and the humanoid robot Pepper, programmed to mimic both extraverted and introverted personality types, has been conducted, with the twofold aim of assessing if differences between the two personalities of the robot can be perceived, and analyzing the effects of different personality traits on verbal interaction with human subjects. Preliminary results seem to confirm the law of attraction in human-human interaction for the extraverted personality.

12:55-13:05 MoT13.2

A Two-Layered Approach to Adaptive Dialogues for Robotic Assistance, pp. 1-8

De Benedictis, Riccardo	CNR-ISTC
Umbrico, Alessandro	National Research Council of Italy
Fracasso, Francesca	ISTC-CNR
Cortellessa, Gabriella	CNR -- National Research Council of Italy, ISTC
Orlandini, Andrea	National Research Council of Italy
Cesta, Amedeo	CNR -- National Research Council of Italy, ISTC

Socially assistive robots should provide users with personalized assistance within a wide range of scenarios such as hospitals, home or social settings and private houses. Different people may have different needs both at the cognitive/physical support level and in relation to the preferences of interaction. Consequently the typology of tasks and the way the assistance is delivered can change according to the person with whom the robot is interacting. The authors' long-term research goal is the realization of an advanced cognitive system able to support multiple assistive scenarios with adaptations over time. We here show how the integration of model-based and model-free AI technologies can contextualize robot assistive behaviors and dynamically decide what to do (assistive plan) and how to do it (assistive plan execution), according to the different features and needs of assisted persons. Although the approach is general, the paper specifically focuses on the synthesis of personalized therapies for (cognitive) stimulation of users.

13:05-13:15 MoT13.3

Social Practices Based Characters in a Robotic Storytelling System, pp. 1-6

Adriana, Bono	University of Palermo
Augello, Agnese	CNR
Gentile, Manuel	National Research Council of Italy - Institute for Educational T
Gaglio, Salvatore	Università Degli Studi Di Palermo

In this work, we present a robotic storytelling system, where the characters have been modelled as cognitive agents embodied in Pepper and NAO robots. The characters have been designed by exploiting the ACT-R architecture, taking into account knowledge, behaviours, norms, and expectations typical of social practices and desires resulting from their personality. The characters explain their reasoning processes during the narration, through a sort of internal dialogue that generate a high level of credibility experienced over the audience.

13:15-13:25 MoT13.4

How Can a Robot Trigger Human Backchanneling?, pp. 1-8

Bliek, Adna	Umeå University
Bensch, Suna	Umeå University
Hellström, Thomas	Umeå University

In human communication, backchanneling is an important part of the natural interaction protocol. The purpose is to signify the listener's attention, understanding, agreement, or to indicate that a speaker should go on talking. While the effects of backchanneling robots on humans have been investigated, studies of how and when humans backchannel to talking robots is poorly studied. In this paper we investigate how the robot's behavior as a speaker affects a human listener's backchanneling behavior. This is interesting in Human-Robot Interaction since backchanneling between humans has been shown to support more fluid interactions, and human-robot interaction would therefore benefit from mimicking this human communication feature. The results show that backchanneling increases when the robot exhibits backchannel-inviting cues such as pauses and gestures. Furthermore, clear differences between how a human backchannels to another human and to a robot are shown.

MoT14 Room 4

Human-Assistive Technologies in the "Real World" (Special Session)

Chair: Yokota, Sho	Toyo University
Co-Chair: Makino, Koji	University of Yamanashi
Organizer: Chugo, Daisuke	Kwansei Gakuin University
Organizer: Yokota, Sho	Toyo University
Organizer: Makino, Koji	University of Yamanashi
Organizer: Hashimoto, Hiroshi	Advanced Institute of Industrial Technology

12:45-12:55 MoT14.1

Overhead Work Assist with Passive Gravity Compensation Mechanism and Horizontal Link Mechanism for Agriculture (I), pp. 1-8

Yamada, Yasuyuki	HOSEI University
Arakawa, Hirokazu	Chuo Univercity

Watanabe, Taro	Chuo University
Fukuyama, Shunya	Chuo University
Nishihama, Rie	Chuo University
Kikutani, Isao	Nabtesco Corporation
Nakamura, Taro	Chuo University

Busy agricultural seasons involve long-term continuous work and heavy labor. Particularly during overhead work, such as harvesting, gibberellin treatment, and bagging, workers need to consistently raise upper limb weights of approximately 2 to 4 kg with their own muscular strength, resulting in a high work burden. For long-duration work in the field, a passive and robust assist system is advantageous. Therefore, we propose an assistance device named TasKi that uses self-weight compensation mechanisms and horizontal link mechanisms to reduce the burden on a worker's upper limbs during overhead work. TasKi can compensate for upper limb weight by using the force of a spring in various postures of the upper limbs without battery support. In this report, we describe the design of the TasKi mechanisms that achieve the upward work assist in actual agriculture with a simple structure. The mechanism of self-weight compensation and the degree of freedom and parameters of the link mechanism are studied.

12:55-13:05 MoT14.2

Study on the Manipulatable Endoscope with the Fin Knit by a Biodegradable String (I), pp. 1-6

Makino, Koji	University of Yamanashi
Iwamoto, Fumihiko	Ymanashi University
Watanabe, Hiromi	University of Yamanashi
Terada, Hidetsugu	University of Yamanashi
Sato, Tadashi	University of Yamanashi
Sekiya, Naoto	University of Yamanashi

The accuracy of the inspection of the capsule endoscope is increased, if it can be manipulated by the operator with wireless communication. To develop it, the feasibility is important, however there are various studies. We consider the behavior of the endoscope in the broken-down. Therefore, this paper describes the manipulatable capsule endoscope that can behaves as the normal encoscope even if it is broken in the body of the patient, and that is not modified from the normal endoscope drastically. The fin for the maneuverability is knit using the biodegradable string for the surgical operation which is dissolved in the body, since the various shape can be realized. The safety is guaranteed, since the fin is dissolved in case that it comes off in the body. And, the small motor is employed as the actuator for the movement of the fin in the fundamental experiment to prevent from changing the shape of the capsule endoscope. The proposed endoscpoe can behave as the normal capsule endoscope, since the shape is similar to the normal capsule endoscope. Using it, the feasibility of the proposed endoscope is confirmed by the fundamental experiments.

13:05-13:15 MoT14.3

Development of a Learning-Based Intention Detection Framework for Power-Assisted Manual Wheelchair Users, pp. 1-6

Khalili, Mahsa	University of British Columbia
Zhang, Yang	University of British Columbia
Gil, Alexandra	University of British Columbia
Zhao, Leo	University of British Columbia
Kuo, Calvin	Jet Propulsion Laboratory
Van der Loos, H.F. Machiel	University of British Columbia (UBC)
Borisoff, Jaimie	British Columbia Institute of Technology

Pushrim-activated power-assisted wheels (PAPAWs) are assistive technologies that provide on-demand assistance to wheelchair users. PAPAWs operate based on a collaborative control scheme. Therefore, they rely on accurate interpretation of the user's intent to provide effective propulsion assistance. This paper presents a learning-based approach to predict wheelchair users' intention when performing a variety of wheelchair activities. First, we obtained kinematic and kinetic data from manual wheelchair users when performing standard wheelchair activities such as turns and ascents. Our measurements revealed variability in physical capabilities and propulsion habits of different users, therefore, highlighting the need for the development of personalized intention inference models. We used Gaussian Mixture models to label different phases of user-puhsrim interactions based on individual user's wheeling behaviour. Supervised classifiers were trained with each user's data and these models were used to predict the user's intentions during different propulsion activities. We found random forest classifiers had high accuracy (>92%) in predicting different states of individual-specific wheelchair propulsion and user intent for 2 participants. This proposed framework is computationally efficient and can be used for real-time prediction of wheelchair users' intention. The outcome of this clustering-classification pipeline provides relevant information for designing user-specific and adaptive PAPAW controllers.

13:15-13:25 MoT14.4

Using a Personalised Socially Assistive Robot for Cardiac Rehabilitation: A Long-Term Case Study (I), pp. 1-7

Irfan, Bahar	University of Plymouth
Céspedes, Nathalia	Escuela Colombiana De Ingenieria Julio Garavito
Casas, Jonathan	Mechanical and Aerospace Engineering Department
Senft, Emmanuel	University of Wisconsin Madison
Gutierrez, Luisa	Fundación Cardio-Infantil Instituto De Cardiología
Rincon-Roncancio, Monica	Instituto De Cardiologia Fundacion Cardioinfantil
Munera, Marcela	Escuela Colombiana De Ingeniería Julio Garavito
Belpaeme, Tony	Ghent University
Cifuentes Garcia, Carlos Andres	Colombian School of Engineering Julio Garavito

This paper presents a longitudinal case study of Robot Assisted Therapy for cardiac rehabilitation. The patient, who is a 60-year old male that suffered a myocardial infarction and received angioplasty surgery, successfully recovered after 35 sessions of rehabilitation with a social robot, lasting 18 weeks. The sessions took place directly at the clinic and relied on an exercise regime which was designed by the clinicians and delivered with the support of a social robot and a sensor suite. The robot monitored the patient's progress, and provided personalised encouragement and feedback. We discuss the recovery of the patient and illustrate how the use of a social robot, its sensory systems and its personalised interaction was instrumental to maintain engagement with the programme and to the patient's recovery. Of note is a critical event that was promptly detected by the robot, which allowed fast intervention measures to be taken by the medical staff for the referral of the patient for further surgery.

MoPIP Main Room

Best Paper Candidates (Regular Session)

Chair: Mastrogiovanni, Fulvio	University of Genoa
Co-Chair: Chong, Nak Young	Japan Advanced Inst. of Sci. and Tech

14:15-14:25 MoPIP.1

Investigating Taste-Liking with a Humanoid Robot Facilitator, pp. 1-6

Jie, Zhuoni	University of Maryland, College Park
Gunes, Hatice	University of Cambridge

Tasting is an essential activity in our daily lives. Implementing social robots in the food and drink service industry requires the social robots to be able to understand customers' nonverbal behaviours, including taste-liking. Little is known about whether people alter their behavioural responses related to taste-liking when interacting with a humanoid social robot. We conducted the first beverage tasting study where the facilitator is a human versus a humanoid social robot with priming versus non-priming instruction styles. We found that the facilitator type and facilitation style had no significant influence on cognitive taste-liking. However, in robot facilitator scenarios, people were more willing

to follow the instruction and felt more comfortable when facilitated with priming. Our study provides new empirical findings and design implications for using humanoid social robots in the hospitality industry.

14:25-14:35 MoPIP.2

Benchmarks for Evaluating Human-Robot Interaction: Lessons Learned from Human-Animal Interactions, pp. 1-7

Lagerstedt, Erik	University of Skövde
Thill, Serge	Radboud University

Human-robot interaction (HRI) is fundamentally concerned with studying the interaction between humans and robots. While it is still a relatively young field, it can draw inspiration from other disciplines studying human interaction with other types of agents. Often, such inspiration is sought from the study of human-computer interaction (HCI) and the social sciences studying human-human interaction (HHI). More rarely, the field also turns to human-animal interaction (HAI).

In this paper, we identify two distinct underlying motivations for making such comparisons: to form a target to recreate or to obtain a benchmark (or baseline) for evaluation. We further highlight relevant (existing) overlap between HRI and HAI, and identify specific themes that are of particular interest for further trans-disciplinary exploration. At the same time, since robots and animals are clearly not the same, we also discuss important differences between HRI and HAI, their complementarity notwithstanding. The overall purpose of this discussion is thus to create an awareness of the potential mutual benefit between the two disciplines and to describe opportunities that exist for future work, both in terms of new domains to explore, and existing results to learn from.

14:35-14:45 MoPIP.3

An Adaptive Control Approach to Robotic Assembly with Uncertainties in Vision and Dynamics, pp. 1-7

Mobedi, Emir	Istituto Italiano Di Tecnologia
Villa, Nicola	Istituto Italiano Di Tecnologia
Kim, Wansoo	Istituto Italiano Di Tecnologia
Ajoudani, Arash	Istituto Italiano Di Tecnologia

The objective of this paper is to propose an adaptive impedance control framework to cope with uncertainties in vision and dynamics in robotic assembly tasks. The framework is composed of an adaptive controller, a vision system, and an interaction planner. A finite state machine is implemented to supervise the sequential states of a task. In this framework, the target assembly object's pose is detected through the vision module, which is then used for the planning of the robot trajectories. The adaptive impedance control module copes with the uncertainties of the vision and the interaction planner modules in alignment of the assembly parts (a peg and a hole in this work). Unlike the classical impedance controllers, the online adaptation rule regulates the level of robot compliance in constrained directions, acting on and responding to the external forces. This enables the implementation of a flexible and adaptive Remote Center of Compliance (RCC) system, using active control. We first evaluate the performance of the proposed adaptive controller in comparison to classical impedance control. Next, the overall performance of the integrated system is evaluated in a peg-in-hole setup, with different clearances and orientation mismatches.

14:45-14:55 MoPIP.4

The Effects of Internet of Robotic Things on In-Home Social Family Relationships, pp. 1-8

Moon, Byeong June	Seoul National University
Kwak, Sonya Sona	Korea Institute of Science and Technology (KIST)
Kang, Dahyun	Korea Institute of Science and Technology
Lee, Hanbyeol	Korea Institute of Science and Technology
Choi, Jongsuk	Korea Inst. of Sci. and Tech

Robotic things and social robots have been introduced into home, and they are expected to change the relationships between humans. Our study examines whether the introduction of robotic things or social robots, and the way that they are organized, can change the social relationship between family members. To observe this phenomenon, we designed a living lab experiment that simulated a home environment and recruited two families to participate. Families were asked to conduct home activities within two different types of Internet of Robotic Things(IoRT):1)internet of only robotic things(IoRT without mediator condition), and 2)internet of robotic things mediated by a social robot(IoRT with mediator condition). We recorded the interactions between the family members and the robotic things during the experiments and coded them into a dataset for social network analysis. The results revealed relationship differences between the two conditions. The introduction of IoRT without mediator motivated younger generation family members to share the burden of caring for other members, which was previously the duty of the mothers. However, this made the interaction network inefficient to do indirect interaction. On the contrary, introducing IoRT with mediator did not significantly change family relationships at the actor-level, and the mothers remained in charge of caring for other family members. However, IoRT with mediator made indirect interactions within the network more efficient. Furthermore, the role of the social robot mediator overlapped with that of the mothers. This shows that a social robot mediator can help the mothers care for other members of the family by operating and managing robotic things. Additionally, we discussed the implications for developing the IoRT for home.

14:55-15:05 MoPIP.5

Explainable Temperament Estimation of Toddlers by a Childcare Robot, pp. 1-6

Sano, Taiga	Osaka University
Horii, Takato	Osaka University
Abe, Kasumi	The University of Electro-Communications
Nagai, Takayuki	Osaka University

Personality estimation of others is a critical ability to communicate with each other. It enables robots to interact with humans and provides the former the ability to predict the intentions of the latter. Many researchers have developed personality estimation mechanisms. However, the estimation method for toddlers' personality, such as the dominance of their innate temperament, has not been proposed yet. In this paper, we proposed an estimation model of toddlers' temperament based on interaction data with a teleoperated childcare robot, ChiCaRo. The proposed method utilized the feature selection algorithm to increase estimation accuracy. Additionally, we employed an explainable AI model called Shapley additive explanations (SHAP) to understand which features from the interaction were important in terms of temperament estimation. The proposed estimation model demonstrated over 85% estimation accuracy for the average of all temperament factors. The experimental results of SHAP provided an understandable relation between the features and temperament factors and indicated that similar feature values from interaction videos used in child personality estimation could also be used for the temperament estimation of toddlers.

15:05-15:15 MoPIP.6

The Effects of Robot's Facial Expressions on Children's First Impressions of Trustworthiness, pp. 1-7

Calvo-Barajas, Natalia	Uppsala University
Perugia, Giulia	Uppsala University
Castellano, Ginevra	Uppsala University

Facial expressions of emotions influence the perception of robots in first encounters. People can judge trustworthiness, likability, and aggressiveness in a few milliseconds by simply observing other individuals' faces. While first impressions have been extensively studied in adult-robot interaction, they have been addressed in child-robot interaction only rarely. This knowledge is crucial, as the first impression children build of robots might influence their willingness to interact with them over extended periods of time, for example in applications where robots play the role of companions or tutors. The present study focuses on investigating the effects of facial expressions of emotions on children's perceptions of trust towards robots during first encounters. We constructed a set of facial expressions of happiness and anger varying in terms of intensity. We implemented these facial expressions onto a Furhat robot that was either male-like or female-like. 129 children were exposed to the robot's expressions for a few

seconds. We asked them to evaluate the robot in terms of trustworthiness, likability, and competence and investigated how emotion type, emotion intensity, and gender-likeness affected the perception of the robot. Results showed that a few seconds are enough for children to make a trait inference based on the robot's emotion. We observed that emotion type, emotion intensity, and gender-likeness did not directly affect trust, but the perception of likability and competence of the robot served as facilitator to judge trustworthiness.

15:15-15:25 MoPIP.7

Design of Dynamic Tangible Workspaces for Games: Application on Robot-Assisted Upper Limb Rehabilitation, pp. 1-7

Guneysu Ozgur, Arzu	EPFL
Bruno, Barbara	Swiss Federal Institute of Technology in Lausanne (EPFL)
Taburet, Victor	EPFL
Özgür, Ayberk	École Polytechnique Fédérale De Lausanne
Dillenbourg, Pierre	EPFL

A key element for the success of any game is its ability to produce a different experience at each round, thus keeping the player engagement high. This is particularly important for those games that also have a serious objective, such as gamified rehabilitation systems, aiming at encouraging patients in performing home rehabilitation exercises. In all cases, a game element which is typically static is the workspace, i.e. the ``floor'' upon which the game takes place. This is especially true for robot-assisted rehabilitation games, where the workspace must satisfy the requirements given by the robot's locomotion and localization systems, as well as the patient's exercise motion requirements.

In this article we present a simple yet effective solution for designing dynamic and customizable tangible workspaces, which relies on hexagonal tiles and our previously proposed Cellulo localization system. These ``hextiles'' can be easily tangibly rearranged at each game round to yield a desired workspace shape and configuration, allowing tabletop mobile robots to move continuously within each new workspace. We ground our solution in the context of robot-assisted rehabilitation, where high adaptability is crucial for the efficacy of the solution, and propose a dynamic extension of our ``tangible Pacman'' rehabilitation game.

Experiments show that the proposed solution allows for adaptation in range of motions, exercise types, physical and cognitive difficulty, besides reducing repetitiveness.

15:25-15:35 MoPIP.8

HATEB-2: Reactive Planning and Decision Making in Human-Robot Co-Navigation, pp. 1-8

Singamaneni, Phani Teja	IIIT Hyderabad
Alami, Rachid	CNRS

We propose a new framework combining decision making and planning in human-robot co-navigation scenario. This new framework called, HATEB-2, introduces different modalities of planning and shift between them based on the situation at hand. These transitions are controlled by decision making loop present on top of the planning. The improvements made to human prediction and estimations are also presented, apart from the modifications to few social constraints from our previous work, that are included in HATEB-2. Finally, several experiments are performed in human-robot co-navigation scenarios and results are presented. One of the modalities of HATEB-2 is used in EU-funded MuMMER project (url{http://mummer-project.eu/}).

15:35-15:45 MoPIP.9

A Robotic Positive Psychology Coach to Improve College Students' Wellbeing, pp. 1-8

Jeong, Sooyeon	MIT
Alghowinem, Sharifa	MIT Media Lab, Prince Sultan University
Aymerich-Franch, Laura	Pompeu Fabra University
Arias, Kika	MIT
Lapedriza, Agata	Universitat Oberta De Catalunya
Picard, Rosalind W.	MIT Media Lab
Park, Hae Won	MIT
Breazeal, Cynthia	MIT

A significant number of college students suffer from mental health issues that impact their physical, social, and occupational outcomes. Various scalable technologies have been proposed in order to mitigate the negative impact of mental health disorders. However, the evaluation for these technologies, if done at all, often reports mixed results on improving users' mental health. We need to better understand the factors that align a user's attributes and needs with technology-based interventions for positive outcomes. In psychotherapy theory, therapeutic alliance and rapport between a therapist and a client is regarded as the basis for therapeutic success. In prior works, social robots have shown the potential to build rapport and a working alliance with users in various settings. In this work, we explore the use of a social robot coach to deliver positive psychology interventions to college students living in on-campus dormitories. We recruited 35 college students to participate in our study and deployed a social robot coach in their room. The robot delivered daily positive psychology sessions among other useful skills like delivering the weather forecast, scheduling reminders, etc. We found a statistically significant improvement in participants' psychological wellbeing, mood, and readiness to change behavior for improved wellbeing after they completed the study. Furthermore, students' personality traits were found to have a significant association with intervention efficacy. Analysis of the post-study interview revealed students' appreciation of the robot's companionship and their concerns for privacy.

Technical Program for Tuesday September 1, 2020

TuT21 Room 1

Non-Verbal Cues and Expressiveness (Regular Session)

Chair: Cavallo, Filippo — University of Florence

Co-Chair: Umemuro, Hiroyuki — Tokyo Institute of Technology

11:30-11:40 TuT21.1

Exploring Human Attitude During Human-Robot Interaction, pp. 1-6

Sorrentino, Alessandra — Scuola Superiore Sant'Anna

Fiorini, Laura — The BioRobotics Institute, Scuola Superiore Sant'Anna

Fabbricotti, Isabelle — Erasmus School of Health Policy and Management, Erasmus Universi

Sancarlo, Daniele — Complex Unit of Geriatrics, Department of Medical Sciences, IRC

Filomena, Ciccone — Unit of Geriatrics, Department of Medical Sciences, Fondazione “

Cavallo, Filippo — University of Florence

The aim of this work is to provide an automatic analysis to assess the user attitude when interacts with a companion robot. In detail, our work focuses on defining which combination of social cues the robot should recognize so that to stimulate the ongoing conversation and how. The analysis is performed on video recordings of 9 elderly users. From each video, low-level descriptors of the behavior of the user are extracted by using open-source automatic tools to extract information on the voice, the body posture, and the face landmarks. The assessment of 3 types of attitude (neutral, positive and negative) is performed through 3 machine learning classification algorithms: k-nearest neighbors, random decision forest and support vector regression. Since intra- and inter- subject variability could affect the results of the assessment, this work shows the robustness of the classification models in both scenarios. Further analysis is performed on the type of representation used to describe the attitude. A raw and an auto-encoded representation is applied to the descriptors. The results of the attitude assessment show high values of accuracy (>0.85) both for unimodal and multimodal data. The outcome of this work can be integrated into a robotic platform to automatically assess the quality of interaction and to modify its behavior accordingly.

11:40-11:50 TuT21.2

Conditional Generative Adversarial Network for Generating Communicative Robot Gestures, pp. 1-7

Tuyen, Nguyen Tan Viet — Japan Advanced Institute of Science and Technology

Elibol, Armagan — Japan Advanced Institute of Science and Technology

Chong, Nak Young — Japan Advanced Inst. of Sci. and Tech

Non-verbal behaviors have an indispensable role for social robots, which help them to interact with humans in a facile and transparent way. Especially, communicative gestures allow robots to have the capability of using bodily expressions for emphasizing the meaning of their speech, describing something, or showing clear intention. This paper presents an approach to learn the synthesis of human actions and natural language. The generative framework is inspired by Conditional Generative Adversarial Network (CGAN), and it makes use of the Convolutional Neural Network (CNN) with the Action Encoder/Decoder for action representation. The experimental and comparative results verified the efficiency of the proposed approach to produce human actions synthesized with text descriptions. Finally, through the Transformation model, the generated data were converted to a set of joint angles of the target robot, being the robot's communicative gestures. By employing the generated human-like actions for robots, it suggests that robots' social cues could be more understandable by humans.

11:50-12:00 TuT21.3

Should Robots Have Accents?, pp. 1-7

Torre, Ilaria — KTH Royal Institute of Technology

Le Maguer, Sébastien — ADAPT Centre / Trinity College Dublin

Accents are vocal features that immediately tell a listener whether a speaker comes from their same place, i.e. whether they share a social group. This in-groupness is important, as people tend to prefer interacting with others who belong to their same groups. Accents also evoke attitudinal responses based on their supposed prestigious status. These accent-based perceptions might affect interactions between humans and robots. Yet, very few studies so far have investigated the effect of accented robot speakers on users' perceptions and behaviour, and none have collected users' explicit preferences on robot accents. In this paper we present results from a survey of over 500 British speakers, who indicated what accent they would like a robot to have. The biggest proportion of participants wanted a robot to have a Standard Southern British English (SSBE) accent, followed by an Irish accent. Crucially, very few people wanted a robot with their same accent, or with a machine-like voice. These explicit preferences might not turn out to predict more successful interactions, also because of the unrealistic expectations that such human-like vocal features might generate in a user. Nonetheless, it seems that people have an idea of how their artificial companions should sound like, and this preference should be considered when designing them.

12:00-12:10 TuT21.4

*How Context Shapes the Appropriateness of a Robot's Voice**

Torre, Ilaria — KTH Royal Institute of Technology

Latupeirissa, Adrian — KTH Royal Institute of Technology

McGinn, Conor — Trinity College Dublin

Social robots have a recognizable physical appearance, a distinct voice, and interact with users in specific contexts. Previous research has suggested a `matching hypothesis', which seeks to rationalise how people judge a robot's appropriateness for a task by its appearance. Other research has extended this to cover combinations of robot voices and appearances. In this paper, we examine the missing connection between robot voice, robot appearance, and deployment context. In so doing, we asked participants to match a robot image to a voice within a defined interaction context. We selected widely available social robots, identified task contexts they are used in, and manipulated the voices in terms of gender, naturalness, and accent. We found that the task context mediates the `matching hypothesis'. People consistently selected a robot based on a vocal feature for a certain context, and a different robot based on the same vocal feature for another context. We suggest that robot voice design should take advantage of current technology that enables the creation and tuning of custom voices. They are a flexible tool to increase perception of appropriateness, which has a positive influence on Human-Robot Interaction.

12:10-12:20 TuT21.5

Automatic Generation of Eye Expressions with End-To-End Learning, pp. 1-6

PARK, UNG — Korea University of Science and Technology

Hwang, Eui Jun — KAIST

Choi, Jongsuk — Korea Inst. of Sci. and Tech

The generation of eye expressions in robots is very important to enhance their ability to find appropriate expressions required for a situation among the major social facilities. In particular, it is the main research subject to be addressed to achieve a positive human–robot interaction. We used a learning-based facial expression generation method utilizing human facial expression data, rather than a conventional heuristic method where all the pre-rules should be defined by experts. We designed a neural network model based on an end-to-end learning model, which showed effective results for learning gestures from given image data. Our proposed model consists of an encoder for processing speech and a decoder for generating facial expressions. The model successfully generates eye expressions corresponding to input sentences. Through this, we propose a new approach for enhancing human–robot interaction and studying the robot's eye expressions.

12:20-12:30 TuT21.6

The Effect of Robot Gaze Direction While Idle on User Comfort and Subjective Impressions, pp. 1-8

Nakamura, Yoshiki	Tokyo Institute of Techonology
Umemuro, Hiroyuki	Tokyo Institute of Technology

The current study investigated the effect of a robot's gaze direction while not engaged in any tasks (i.e., while "idle") on users' comfort and subjective impressions of the robot. We predicted that users would feel differently when the robot looked at the same objects as the user (i.e., during joint attention between robot and user) or not, even when the robot's gaze direction was the same. We conducted an experiment in which participants watched a video clip five times in five different robot gaze direction conditions. To examine the effects of joint attention, participants were divided into two groups by the distance from the monitor on which the video was presented. Joint attention between the robot and participant occurred in different robot gaze directions between the two groups. We measured participants' comfort, subjective impressions of the robot, and related variables. The results revealed that the robot's gaze direction affected participants' comfort and subjective impressions among participants 75 years old and above. However, we found no effect of joint attention. Additionally, participants felt most comfortable and had the most positive impressions of the robot when it looked at a monitor on which participants did not watch the video clip.

TuT22 Room 2

Novel Interfaces and Interaction Modalities (I) (Regular Session)

Chair: JOHAL, Wafa	University of New South Wales
Co-Chair: Chung, Michael Jae-Yoon	University of Washington

11:30-11:40 TuT22.1

Designing Proactive Objects with Artificial Eyes Based on Perceptual Crossing Paradigm, pp. 1-8

binti Anas, Siti Aisyah	Eindhoven University of Technology
Rong-Hao, Liang	Eindhoven University of Technology
Hu, Jun	Eindhoven University of Technology
Rauterberg, Matthias	Eindhoven University of Technology

This paper presents a crowd-sourcing video-based investigation on the users' perception of proactiveness towards an object with artificial eyes through winking. Based on both the session initiation protocol (SIP) and the perceptual crossing paradigm, we synthesized a set of minimally-designed video clips and tested them in Amazon Mechanical Turk with 240 participants. The results show that, in both single- or multi-user scenarios, winking can be a useful expression that makes the user view the object as being proactive and encourages reciprocal input. We also discuss how the object-initiated interaction extends the perceptual crossing paradigm in human-object communication.

11:40-11:50 TuT22.2

ConCodeIt! a Comparison of Concurrency Interfaces in Block-Based Visual Robot Programming, pp. 1-8

Chung, Michael Jae-Yoon	University of Washington
Nakura, Mino	University of Washington
Neti, Sai Harshita	University of Washington
Lu, Anthony	University of Washington
Hummel, Elana	University of Washington
Cakmak, Maya	University of Washington

Concurrency makes robot programming challenging even for professional programmers, yet it is essential for rich, interactive social robot behaviors. Visual programming aims to lower the barrier for robot programming but does not support rich concurrent behavior for meaningful robotics applications. In this paper, we explore extensions to block-based visual languages to enable programming of concurrent behavior with (1) asynchronous procedure calls, which encourage imperative programming, (2) callbacks, which encourage event-driven programming, and (3) promise, which also encourages imperative programming by providing event synchronization utilities. We compare these approaches through a systematic analysis of social robot programs with representative concurrency patterns, as well as a user study (N=23) in which participants authored such programs. Our work identifies characteristic differences between these approaches and demonstrates that the promise-based concurrency interface enables more concise programs with fewer errors.

11:50-12:00 TuT22.3

Designing Robotic Cabinets That Assist Users' Tidying Behaviors, pp. 1-6

Lee, Hanbyeol	Korea Institute of Science and Technology
Kang, Dahyun	Korea Institute of Science and Technology
Kwak, Sonya Sona	Korea Institute of Science and Technology (KIST)
Choi, Jongsuk	Korea Inst. of Sci. and Tech

With the development of robotic technology, various types of robotic products have been developed, ranging from robotic objects that support small daily necessities (such as robotic umbrellas and frames) to robotic furniture (such as robotic chairs and drawers). Owing to consumerism, the consumer marketplace now overflows with surplus products, and storage and organizational products have been increasingly necessary. With this social stream, we focused on designing robotic storage furniture in this study. To create such a type of furniture that is acceptable by consumers, a qualitative user study was conducted with 16 subjects by analyzing the users' behaviors when using ordinary storage furniture. From this user study, we found strong user needs in terms of organizing and finding objects. Thus, we developed two types of robotic cabinets: the first one to assist users' organizing behavior and the second one to assist their finding behavior. To examine the effectiveness of the developed prototypes, we executed a 3 (behavior the robotic cabinet assists: baseline vs. organizing vs. finding) within-participants experiment. The result shows that significant effects vary depending on the type of robotic cabinet.

12:00-12:10 TuT22.4

A Laser Projection System for Robot Intention Communication and Human Robot Interaction, pp. 1-7

Wengefeld, Tim	Ilmenau University of Technology
Hoechemer, Dominik	Ilmenau University of Technology
Lewandowski, Benjamin	Ilmenau University of Technology
Köhler, Mona	Ilmenau University of Technology
Beer, Manuel	Ilmenau University of Technology
Gross, Horst-Michael	Ilmenau University of Technology

In order to deploy service robots in environments where they encounter and/or cooperate with persons, one important key factor is human acceptance. Hence, information on which upcoming actions of the robot are based has to be made transparent and understandable to the human. However, considering the restricted power resources of mobile robot platforms, systems for visualization not only have to be expressive but also energy efficient. In this paper, we applied the well-known technique of laser scanning on a mobile robot to create a novel system for intention visualization and human-robot-interaction. We conducted user tests to compare our system to a low-power consuming LED video projector solution in order to evaluate the suitability for mobile platforms and to get human impressions of both systems. We can show that the presented system is preferred by most users in a dynamic test setup on a mobile platform.

12:10-12:20 TuT22.5

Evaluation of Usability of a 3-DOF Linkage-Driven Robotic Gripper through Grasping Experiments, pp. 1-6

Kim, Sanghwa	Hanyang University
Khan, Muhammad Umair Ahmad	Hanyang University Erica Campus South Korea
Kang, Long	Hanyang University
Seo, Jong-Tae	Hanyang University
Yi, Byung-Ju	Hanyang University

Choi, Youngjin — Hanyang University
Lee, Sungon — Hanyang University
Lee, Ji Yeong — Hanyang University, Ansan

Conventional dexterous grippers are not only heavy and complex but also task dependent. As a result, they cannot provide power, intermediate and precision grasping together. We propose usability evaluation of a novel gripper mechanism which can provide 1-Degree of Freedom (DOF) parallel grasping and 2-DOF independent pinching by using a closed chain architecture. The usability of our design and one commercial product has been evaluated based on various grasping tasks: adaptive grasping, parallel pinching grasping, independent pinching grasping and contact grasping. The success rate has been evaluated to validate the excellent usability of the proposed 3-DOF gripper.

TuT23 — Room 3

Evaluation Methods (Regular Session)

Chair: Nomura, Tatsuya — Ryukoku University
Co-Chair: Rossi, Alessandra — University of Hertfordshire

11:30-11:40 — TuT23.1

The Robot Self-Efficacy Scale: Robot Self-Efficacy, Likability and Willingness to Interact Increases after a Robot-Delivered Tutorial, pp. 1-6

Robinson, Nicole Lee — Monash University
Hicks, Teah-Neal — Queensland University of Technology
Suddrey, Gavin — Queensland University of Technology
Kavanagh, David — Queensland University of Technology

An individual's self-efficacy to interact with a robot has important implications around the content, utility and success of the interaction. Individuals need to achieve a high level of self-efficacy in human robot-interaction in a reasonable time-frame for positive effects to occur in short-term human-robot scenarios. This trial explored the impact of a 2-minute automated robot-delivered tutorial designed to teach people from the general public how to use the robot as a method to increase robot self-efficacy scores. This trial assessed scores before (T1) and after (T2) an interaction with the robot to investigate changes in self-efficacy, likability and willingness to use it. The 40 participants recruited had on average very low level of robotic experience. After the tutorial, people reported significantly higher robot self-efficacy with very large effect sizes to operate a robot and apply the robot to a task (eta2 = 0.727 and 0.660). Significant increases in likability and willingness to interact with the robot were also found (eta2 = 0.465 and 0.480). Changes in likability and self-efficacy contributed to 64% of the variance in changes to willingness to use the robot. Initial differences were found in robot self-efficacy for older people and those with less robotics and programming experience compared with other participants, but scores across these subgroups were similar after completion of the tutorial. This demonstrated that high levels of self-efficacy, likeability and willingness to use a social robot can be reached in a very short time, and on comparable levels, regardless of age or prior robotics experience. This outcome has significant implications for future trials using social robots, since these variables can strongly influence experimental outcomes.

11:40-11:50 — TuT23.2

Evaluation of Immersive Teleoperation Systems Using Standardized Tasks and Measurements, pp. 1-8

Illing, Boris — Fraunhofer FKIE
Westhoven, Martin — Federal Institute for Occupational Health and Safety
Gaspers, Bastian — Fraunhofer FKIE
Smets, Nanja — TNO
Brüggemann, Bernd — Fraunhofer FKIE
Mathew, Tintu — Fraunhofer FKIE

Despite advances regarding autonomous functionality for robots, teleoperation remains a means for performing delicate tasks in safety critical contexts like explosive ordnance disposal (EOD) and ambiguous environments. Immersive stereoscopic displays have been proposed and developed in this regard, but bring about their own specific problems, e.g., simulator sickness. This work builds upon standardized test environments to yield reproducible comparisons between different robotic platforms. The focus was placed on testing three optronic systems of differing degrees of immersion: (1) A laptop display showing multiple monoscopic camera views, (2) an off-the-shelf virtual reality headset coupled with a pan-tilt-based stereoscopic camera, and (3) a so-called Telepresence Unit, providing fast pan, tilt, yaw rotation, stereoscopic view, and spatial audio. Stereoscopic systems yielded significant faster task completion only for the maneuvering task. As expected, they also induced Simulator Sickness among other results. However, the amount of Simulator Sickness varied between both stereoscopic systems. Collected data suggests that a higher degree of immersion combined with careful system design can reduce the to-be-expected increase of Simulator Sickness compared to the monoscopic camera baseline while making the interface subjectively more effective for certain tasks.

11:50-12:00 — TuT23.3

Influences of Media Literacy and Experiences of Robots into Negative Attitudes Toward Robots in Japan, pp. 1-5

Nomura, Tatsuya — Ryukoku University

To investigate influences of media literacy into experiences of and negative attitudes toward robots, an online survey was conducted in Japan (N = 500). The results suggested that the connections of robot experiences with media literacy and negative attitudes toward robots were weak, and both media literacy and robot experiences had negative effects on negative attitudes toward interaction with robots.

12:00-12:10 — TuT23.4

Toward a Robot Computing an Online Estimation of the Quality of Its Interaction with Its Human Partner, pp. 1-8

Mayima, Amandine — LAAS-CNRS
Clodic, Aurélie — Laas - Cnrs
Alami, Rachid — CNRS

When we perform a collaborative task with another human, we are able to tell, to a certain extent, how things are going and more precisely if things are going well or not. This knowledge allows us to adapt our behavior. Therefore, we think it is desirable to provide robots means to measure in real-time the Quality of the Interaction with their human partners. To make this possible, we propose a model and a set of metrics targeting the evaluation of the QoI in collaborative tasks through the measure of the human engagement and the online task effectiveness. These model and metrics have been implemented and tested within the high-level controller of an entertainment robot deployed in a mall. The first results show a significant differences in the computed QoI when in interaction with a fully compliant human, a confused human and a non-cooperative one.

12:10-12:20 — TuT23.5

Assistive VR Gym: Interactions with Real People to Improve Virtual Assistive Robots, pp. 1-8

Erickson, Zackory — Georgia Institute of Technology
Gu, Yijun — Georgia Institute of Technology
Kemp, Charlie — Georgia Institute of Technology

Versatile robotic caregivers could benefit millions of people worldwide, including older adults and people with disabilities. Recent work has explored how robotic caregivers can learn to interact with people through physics simulations, yet transferring what has been learned to real robots remains challenging. Virtual reality (VR) has the potential to help bridge the gap between simulations and the real world. We present Assistive VR Gym (AVR Gym), which enables real people to interact with virtual assistive robots. We also provide evidence that AVR Gym can help researchers improve the performance of simulation-trained assistive robots with real people. Prior to AVR Gym, we trained robot control policies (Original Policies) solely in simulation for four robotic caregiving tasks (robot-assisted feeding, drinking, itch scratching, and bed bathing) with two simulated robots (PR2 from Willow Garage and Jaco from Kinova). With AVR Gym, we developed Revised Policies based on insights gained from testing the Original policies with real people. Through a formal study with eight participants

in AVR Gym, we found that the Original policies performed poorly, the Revised policies performed significantly better, and that improvements to the biomechanical models used to train the Revised policies resulted in simulated people that better match real participants. Notably, participants significantly disagreed that the Original policies were successful at assistance, but significantly agreed that the Revised policies were successful at assistance. Overall, our results suggest that VR can be used to improve the performance of simulation-trained control policies with real people without putting people at risk, thereby serving as a valuable stepping stone to real robotic assistance.

TuT24 Room 4

Children and Robots (Special Session)

Chair: Wang, Meng	Tsinghua University
Co-Chair: PENG, YU	Tsinghua University
Organizer: Wang, Meng	Tsinghua University
Organizer: Shidujaman, Mohammad	Tsinghua University
Organizer: PENG, YU	Tsinghua University
Organizer: Jamal, Lafifa	University of Dhaka

11:30-11:40 TuT24.1

WalkingBot: Modular Interactive Legged Robot with Automated Structure Sensing and Motion Planning (I), pp. 1-6

Wang, Meng	Tsinghua University
Su, Yao	UCLA MAE Department
Liu, Hangxin	University of California, Los Angeles
Xu, Yingqing	Tsinghua University

This paper proposes WalkingBot, a modular robot system that allows non-expert users building a multi-legged robot in various morphologies. The system provides a set of building blocks with sensors and actuators embedded. Through the integrated hardware and software, the morphology of the built robot is interpreted automatically, and its kinematic model is reconstructed and displayed in a customized GUI in the computer screen, allowing users to easily observe, control, and program the robot. A Model Predictive Control (MPC) scheme is introduced to generate a control policy for various motions(e.g. moving front, back, left etc.) corresponding to the sensed robot structure, such that the robot can walk around right after assembled. Targeting different levels of programming skill, two programming methods—visual block programming and events programming are also presented to enable users to create their own interactive legged robot.

11:40-11:50 TuT24.2

When Positive Perception of the Robot Has No Effect on Learning (I), pp. 1-8

Nasir, Jauwairia	EPFL
Norman, Utku	Swiss Federal Institute of Technology in Lausanne (EPFL)
Bruno, Barbara	Swiss Federal Institute of Technology in Lausanne (EPFL)
Dillenbourg, Pierre	EPFL

Humanoid robots, with a focus on personalised social behaviours, are increasingly being deployed in educational settings to support learning. However, crafting pedagogical HRI designs and robot interventions that have a real, positive impact on participants' learning, as well as effectively measuring such impact, is still an open challenge. As a first effort in tackling the issue, in this paper we propose a novel robot-mediated, collaborative problem solving activity for school-children, called JUSThink, aiming at improving their computational thinking skills. JUSThink will serve as a baseline and reference for investigating how the robot's behaviour can influence the engagement of the children with the activity, as well as their collaboration and mutual understanding while working on it. To this end, this first iteration aims at investigating (i) participants' engagement with the activity (Intrinsic Motivation Inventory-IMI), their mutual understanding (IMI-like) and perception of the robot (Godspeed Questionnaire); (ii) participants' performance during the activity, using several performance and learning metrics. We carried out an extensive user-study in two international schools in Switzerland, in which around 100 children participated in pairs in one-hour long interactions with the activity. Surprisingly, we observe that while a teams' performance significantly affects how team members evaluate their competence, mutual understanding and task engagement, it does not affect their perception of the robot and its helpfulness, a fact which highlights the need for baseline studies and multi-dimensional evaluation metrics when assessing the impact of robots in educational activities.

11:50-12:00 TuT24.3

LinkBricks: A Construction Kit for Intuitively Creating and Programming Interactive Robots (I), pp. 1-6

GAO, JIASI	Tsinghua University
Wang, Meng	Tsinghua University
Zhu, Yaxin	The Future Laboratory, Tsinghua University
Mi, Haipeng	Tsinghua University

This paper presents LinkBricks, a creative construction kit for intuitively creating and programming interactive robots towards young children. Integrating building blocks, a hierarchical programming framework and a tablet application, this kit is proposed to maintain the low floor and wide walls for children who lack knowledge in conventional programming. The blocks have LEGO-compatible interlock structures and are embedded with various wireless sensors and actuators to create different interactive robots. The programming application is easy-to-use and provides heuristics to involve children in the creative activities. A preliminary evaluation is conducted and indicates that LinkBricks increases young children's engagement with, comfort with, and interest in working with interactive robots. Meanwhile, it has the potential of helping them to learn the concepts of programming and robots.

12:00-12:10 TuT24.4

How Children Interpret Robots' Contextual Behaviors in Live Theatre: Gaining Insights for Multi-Robot Theatre Design (I), pp. 1-8

YU, PENG	TSINGHUA UNIVERSITY
Feng, Yuan-Ling	Tsinghua University
Wang, Nan	Tsinghua University
Mi, Haipeng	Tsinghua University

Robot theatre has been gradually used in children's storytelling activities.The robotic character collaboratively exchange stories with children, react to their actions, and keep them engaged. However, the only robotic protagonist limits the richness of content and cannot fully support children's creativity. To explore a tool with multiple robotic agents to better enhance story creation activities, we designed a simulated multi-robot theatre with three similarly shaped robots. We invited 28 kids (6-12 years old) to watch the video and retell the story. We encode children's story recall and outline that robots' contextual behaviors with emotion expression are reasonably enough for children over six-years-old to understand their performance. We also found no noticeable difference in story understanding among participants. We discuss the insights for designing robots' contextual behaviors for story presentation and the considerations for implementing an accessible and feasible robot theatre creation platform.

TuT31 Room 1

Applications of Social Robots / Social Intelligence for Robots (I) (Regular Session)

Chair: Watanabe, Kentaro	National Institute of Advanced Industrial Science and Technology
Co-Chair: Alami, Rachid	CNRS

12:45-12:55 TuT31.1

Interactive Robotic Systems As Boundary Crossing Robots – the User's View, pp. 1-6

Watanabe, Kentaro	National Institute of Advanced Industrial Science and Technology
Jokinen, Kristiina	AIRC, AIST, Japan and University of Helsinki, Finland

Social robots are receiving more attention through increased research and development, and they are gradually becoming a part of our daily lives. In this study, we investigated how social robots are accepted by

robot users. We applied the theoretical lens of the boundary-crossing robot concept, which describes the role shift of robots from tools to agents. This concept highlights the impact of social robots on the everyday lives of humans, and can be used to structure the development of perceived interactions between robots and human users. In this paper, we report on the results of a web questionnaire study conducted among users of interactive devices (humanoid robots, animal robots, and smart speakers). Their acceptance and roles in daily life are compared from both functional and affective perspectives, with respect to their perceived roles as boundary-crossing robots.

12:55-13:05 TuT31.2

Structuring Human-Robot Interactions Via Interaction Conventions, pp. 1-8

Han, Ji	Johns Hopkins University
Ajaykumar, Gopika	Johns Hopkins University
Li, Ze	Tsinghua University
Huang, Chien-Ming	Johns Hopkins University

Interaction conventions (e.g., using pinch gestures to zoom in and out) are designed to structure how users effectively work with an interactive technology. We contend in this paper that successful human-robot interactions may be achieved through an appropriate use of interaction conventions. We present a simple, natural interaction convention—"Put That Here"—for instructing a robot partner to perform pick-and-place tasks. This convention allows people to use common gestures and verbal commands to select objects of interest and to specify their intended location of placement. We implement an autonomous robot system capable of parsing and operating through this convention. Through a user study, we show that participants were easily able to adopt and use the convention to provide task specifications. Our results show that participants using this convention were able to complete tasks faster and experienced significantly lower cognitive load than when using only verbal commands to give instructions. Furthermore, when asked to give natural pick-and-place instructions to a human collaborator, the participants intuitively used task specification methods that paralleled our convention, incorporating both gestures and verbal commands to provide precise task-relevant information. We discuss the potential of interaction conventions in enabling productive human-robot interactions.

13:05-13:15 TuT31.3

Efficient, Situated and Ontology Based Referring Expression Generation for Human-Robot Collaboration, pp. 1-8

Buisan, Guilhem	LAAS-CNRS
sarthou, guillaume	LAAS-CNRS
Bit-Monnot, Arthur	Université De Toulouse
Clodic, Aurélie	Laas - Cnrs
Alami, Rachid	CNRS

In Human-Robot Interaction (HRI), ensuring non-ambiguous communication between the robot and the human is a key point for carrying out fluently a collaborative task. With this work, we propose a method which allows the robot to generate the optimal set of assertions that are necessary in order to produce an unambiguous reference. In this paper, we present a novel approach to the Referring Expression Generation (REG) problem and its integration into a robotic system. Our method is a domain-independent approach based on an ontology as a knowledge base. We show how this generation can be performed on an ontology which is not dedicated to this task. We then validate our method through simulated situations, compare it with state of the art approach and on a real robotic system.

13:15-13:25 TuT31.4

Development and Evaluation of Mixed Reality Co-Eating System: Sharing the Behavior of Eating Food with a Robot Could Improve Our Dining Experience, pp. 1-6

Fujii, Ayaka	University of Tokyo
Kochigami, Kanae	The University of Tokyo
Kitagawa, Shingo	University of Tokyo
Okada, Kei	The University of Tokyo
Inaba, Masayuki	The University of Tokyo

Eating with others enhances our dining experience, improves socialization, and has some health benefits. Although many people do not want to eat alone, there is an increase in the number of people who eat alone in Japan due to difficulty in matching mealtimes and places with others. In this paper, we develop a mixed reality (MR) system for co-eating with a robot. In this system, a robot and a MR headset are connected enabling users to observe a robot putting food image into its mouth, as if eating. We conducted an experiment to evaluate the developed system with users that are at least 13 years old. Experimental results show that the users enjoyed their meal and felt more delicious when the robot ate with them than when the robot only talked without eating. Furthermore, they eat more when a robot eats, suggesting that a robot could influence people's eating behavior.

13:25-13:35 TuT31.5

Socially Compliant Human-Robot Interaction for Autonomous Scanning Tasks in Supermarket Environments, pp. 1-8

Lewandowski, Benjamin	Ilmenau University of Technology
Wengefeld, Tim	Ilmenau University of Technology
Müller, Sabine	YOUSE GmbH
Jenny, Mathias	YOUSE GmbH, Florastr. 47 13187 Berlin
Glende, Sebastian	YOUSE GmbH
Schroeter, Christof	MetraLabs GmbH
Bley, Andreas	MetraLabs GmbH
Gross, Horst-Michael	Ilmenau University of Technology

In this paper, we present a system for socially aware robot navigation for a wide range of service tasks in supermarkets. It comprises modules for real-time person detection and tracking to gain situation awareness, modules to react to situations, and means for human-robot communication. The technical performance of the situation awareness was evaluated in a shelf out-of-stock (SOOS) detection scenario under real-world conditions in a supermarket in Germany. Furthermore, in order to investigate whether and to what extent our social navigation strategy can improve the acceptance and application of a mobile service robot in a supermarket, we have conducted surveys with N = 60 participants and usability tests with N = 8 participants during a three-day field test. We can show that a robot for SOOS detection operating in a supermarket during the opening hours is generally accepted by customers and that the integration of a real-time person perception is crucial, especially for keeping appropriate distances to persons and for improving user-centered communication. Furthermore, our results indicate that various communication channels (e.g. speech, a video projector, and LED lights) are beneficial in order to address a wider user group in the targeted supermarket setting.

13:35-13:45 TuT31.6

Let Me Join You! Real-Time F-Formation Recognition by a Socially Aware Robot, pp. 1-7

Barua, Hrishav Bakul	TCS Research & Innovation
Pramanick, Pradip	TCS Research & Innovation
Sarkar, Chayan	TCS Research & Innovation
Mg, Theint Haythi	Myanmar Institute of Information Technology

This paper presents a novel architecture to detect social groups/interactions in social setups in real-time continuous image streams from an egocentric view camera. F-formations are social orientations in space where two or more person tends to communicate in a social place. We detect F-formations in social gatherings such as meetings, discussions etc. and predict the robot's approach angle to join a group in real-time. Additionally, we also detect outliers, i.e., the persons who are not part of the group under consideration. We use a two-layer architecture -- a) estimation the key skeletal points (a total of 17) in a detected human, b) based on these points, create a learning model using CRF probabilistic model to detect groups of people and outlier person in a scene. Then we create a learning model using multi-class Support Vector Machine (SVM) to predict the exact F-formation of the group of people in the current scene and the approach angle of the viewing robot. Our system is evaluated using two data-sets and compared with a state-of-the-art F-formation detection system. The results show that our system outperforms the state-of-the-art method significantly in detecting F-formations correctly hence predicting social groups and interactions in noisy scenes.

TuT32	Room 2
Novel Interfaces and Interaction Modalities (II) (Regular Session)	
Chair: Tanaka, Fumihide	University of Tsukuba
Co-Chair: YANG, PIN-CHU	Waseda University, Cutieroid Project

12:45-12:55 TuT32.1

Augmented Reality Interface to Verify Robot Learning, pp. 1-6

Diehl, Maximilian	Chalmers University of Technology
Plopski, Alexander	Nara Institute of Science and Technology
Kato, Hirokazu	Nara Institute of Science and Technology
Ramirez-Amaro, Karinne	Chalmers University of Technology

Teaching robots new skills is considered as an important aspect of Human-Robot Collaboration (HRC). One challenge is that robots cannot communicate feedback in the same ways as humans do. This decreases the trust towards robots since it is difficult to judge, before the actual execution, if the robot has learned the task correctly. In this paper, we introduce an Augmented Reality (AR) based visualization tool that allows humans to verify the taught behavior before its execution. Our verification interface displays a virtual simulation embedded into the real environment, timely coupled with a semantic description of the current action. We developed three designs based on different interface/visualization-technology combinations to explore the potential benefits of enhanced simulations using AR over traditional simulation environments like RViz. We conducted a user study with 18 participants to assess the effectiveness of the proposed visualization tools regarding error detection capabilities. One of the advantages of the AR interfaces is that they provide more realistic feedback than traditional simulations with a lower cost of not having to model the entire environment.

12:55-13:05 TuT32.2

HATSUKI : An Anime Character Like Robot Figure Platform with Anime-Style Expressions and Imitation Learning Based Action Generation, pp. 1-8

YANG, PIN-CHU	Waseda University, Cutieroid Project
Al-Sada, Mohammed	Waseda University, Qatar University
Chiu, Chang-Chieh	Cutieroid Project
Kuo, Kevin	Cutieroid Project
Tomo, Tito Pradhono	Waseda University
Suzuki, Kanata	Fujitsu Laboratories LTD
Yalta Soplin, Nelson Enrique	Waseda Unviersity
Shu, Kuo-Hao	Cutieroid Project
Ogata, Tetsuya	Waseda University

Japanese character figurines are popular and have a pivot position in *Otaku* culture. Although numerous robots have been developed, few have focused on otaku-culture or on embodying anime character figurines. Therefore, we take the first steps to bridge this gap by developing Hatsuki, which is a humanoid robot platform with anime based design. Hatsuki's novelty lies in its aesthetic design, 2D facial expressions, and anime-style behaviors that allows Hatsuki to deliver rich interaction experiences resembling anime-characters. We explain our design implementation process of Hatsuki, followed by our evaluations. In order to explore user impressions and opinions towards Hatsuki, we conducted a questionnaire in the world's largest anime-figurine event. The results indicate that participants were generally very satisfied with Hatsuki's design, and proposed various use case scenarios and deployment contexts for Hatsuki. The second evaluation focused on *imitation learning*, as such a method can provide better interaction ability in the real world and generate rich, context-adaptive behaviors in different situations. We made Hatsuki learn 11 actions, combining voice, facial expressions and motions, through the neural network based policy model with our proposed interface. Results show our approach was successfully able to generate the actions through self-organized contexts, which shows the potential for generalizing our approach in further actions under different contexts. Lastly, we present our future research direction for Hatsuki and provide our conclusion.

13:05-13:15 TuT32.3

Influence of Vertical Acceleration for Inducing Sensation of Dropping by Lower Limb Force Feedback Device, pp. 1-6

Tanaka, Toshinari	Chuo University
Onozuka, Yuki	Chuo University
Okui, Manabu	Chuo University
Nishihama, Rie	Chuo University
Nakamura, Taro	Chuo University

Many haptic devices are currently being developed for human upper limbs. There are various types of force feedback devices for upper limbs, such as desktop and wearable type. However, the lower limbs absorb most of the force when standing or walking. Therefore, to render the sensation of force to the lower limbs, a device worn like a shoe to enable users to walk and have a wide range of movement and a device that provides a dropping sensation have been developed. However, both wide-area movement and a dropping sensation could not be combined in one device. Therefore, we propose the concept of a lower limb force feedback device that allows the user to wear it like a shoe and provides the sensation of dropping while enabling wide-area movement. In addition, as the first stage of device development, we evaluated the human sensation of dropping. Consequently, it was found that a relatively high sensation of dropping can be provided to a human even with an acceleration smaller than the gravitational acceleration in real space. Thus, the lower limb force feedback device to be developed in the future will allow the user to experience the sensation of dropping by using an acceleration smaller than the gravitational acceleration in real space.

13:15-13:25 TuT32.4

A Tale of Two Suggestions: Action and Diagnosis Recommendations for Responding to Robot Failure, pp. 1-8

Banerjee, Siddhartha	Georgia Institute of Technology
Gombolay, Matthew	Georgia Institute of Technology
Chernova, Sonia	Georgia Institute of Technology

Robots operating without close human supervision might need to rely on a remote call center of operators for assistance in the event of a failure. In this work, we investigate the effects of providing decision support through diagnosis suggestions, as feedback, and action recommendations, as feedforward, to the human operators. We conduct a 10-condition user study involving 200 participants on Amazon Mechanical Turk to evaluate the effects of providing noisy and noise-free diagnosis suggestions and/or action recommendations to operators. We find that although action recommendations (feedforward) have a greater effect on successful error resolution than diagnosis information (feedback), the feedback likely helps ameliorate the deleterious effects of noise. Therefore, we find that error recovery interfaces should display both diagnosis and action recommendations for maximum effectiveness.

13:25-13:35 TuT32.5

Telepresence Robot Blended with a Real Landscape and Its Impact on User Experiences, pp. 1-6

Furuya, Yuki	Keio University
Takashio, Kazunori	Keio University

Telepresence robots using traditional video chats do not yet fully represent the presence of a remote user. To enhance that presence, we propose a novel approach that replaces the background of the remote user with a real-time captured image of the area behind the robot. We assumed that the background of the remote user, which was visible on the telepresence robot's display, was one reason for the reduction in presence because it might remind local viewers that the remote user is in another place. We found that our approach effectively enhanced the presence of remote user and reduced the negative impression of a delay. In this paper, we describe the new approach, its implementation, and an evaluation of the system. We evaluated the subjective impressions of communication through the proposed system. This approach also protects the privacy of the remote user and makes it more acceptable to people using telepresence robots from

private places, e.g., a sickroom in a hospital.

TuT33 Room 3

Machine Learning and Adaptation / Programming by Demonstration (I) (Regular Session)

Chair: Gunes, Hatice	University of Cambridge
Co-Chair: Chan, Wesley Patrick	Monash University

12:45-12:55 TuT33.1

Artistic Style in Robotic Painting; a Machine Learning Approach to Learning Brushstroke from Human Artists, pp. 1-7

bidgoli, ardavan	Carnegie Mellon University
Ladron de Guevara, Manuel	Carnegie Mellon University
Hsiung, Cinnie	Carnegie Mellon University
Oh, Jean	Carnegie Mellon University
Kang, Eunsu	Carnegie Mellon University

Robotic painting has been a subject of interest among both artists and roboticists since the 1970s. Researchers and interdisciplinary artists have employed various painting techniques and human-robot collaboration models to create visual mediums on canvas. One of the challenges of robotic painting is to apply a desired artistic style to the painting. Style transfer techniques with machine learning models have helped us address this challenge with the visual style of a specific painting. However, other manual elements of style, i.e., painting techniques and brushstrokes of an artist, have not been fully addressed. We propose a method to integrate an artistic style to the brushstrokes and the painting process through collaboration with a human artist. In this paper, we describe our approach to 1) collect brushstrokes and hand-brush motion samples from an artist, and 2) train a generative model to generate brushstrokes that pertains to the artist's style, and 3) integrate the learned model on a robot arm to paint on a canvas. In a preliminary study, 71% of human evaluators find our robot's paintings pertaining to the characteristics of the artist's style.

12:55-13:05 TuT33.2

Towards a Multimodal System Combining Augmented Reality and Electromyography for Robot Trajectory Programming and Execution, pp. 1-6

Chan, Wesley Patrick	Monash University
Sakr, Maram	University of British Columbia
Perez Quintero, Camilo Alfonso	University of British Columbia
Croft, Elizabeth	Monash University
Van der Loos, H.F. Machiel	University of British Columbia (UBC)

Programming and executing robot trajectories is a routine manufacturing procedure. However, current interfaces (i.e., teach pendants) are bulky, unintuitive, and interrupts task flow. Recently, augmented reality (AR) has been used to create alternative solutions. However, input modalities of such systems tend to be limited. By introducing the use of electromyography (EMG), we have created a novel multimodal wearable interface for online trajectory programming and execution. Through the use of EMG, our system aims to bridge the user's force activation to the robot arm force profile. Our proposed system provides two interaction methods for trajectory execution and force control using 1) arm EMG and 2) arm orientation. We compared these methods with a standard joystick in a user study to test their usability. Results show that proposed methods have increased physical demands but yield equivalent task performance, demonstrating the potential of our proposed interface to provide a wearable alternative solution.

13:05-13:15 TuT33.3

Continual Learning for Affective Robotics: Why, What and How?, pp. 1-7

Churamani, Nikhil	University of Cambridge
Kalkan, Sinan	Middle East Technical University
Gunes, Hatice	University of Cambridge

Creating and sustaining closed-loop dynamic and social interactions with humans require robots to continually adapt towards their users' behaviours, their affective states and moods while keeping them engaged in the task they are performing. Analysing, understanding and appropriately responding to human nonverbal behaviour and affective states are the central objectives of affective robotics research. Conventional machine learning approaches do not scale well to the dynamic nature of such real-world interactions as they require samples from stationary data distributions. The real-world is not stationary, it changes continuously. In such contexts, the training data and learning objectives may also change rapidly. Continual Learning (CL), by design, is able to address this very problem by learning incrementally. In this paper, we argue that CL is an essential paradigm for creating fully adaptive affective robots (why). To support this argument, we first provide an introduction to CL approaches and what they can offer for various dynamic (interactive) situations (what). We then formulate guidelines for the affective robotics community on how to utilise CL for perception and behaviour learning with adaptation (how). For each case, we reformulate the problem as a CL problem and outline a corresponding CL-based solution. We conclude the paper by highlighting the potential challenges to be faced and by providing specific recommendations on how to utilise CL for affective robotics.

13:15-13:25 TuT33.4

Goal Density-Based Hindsight Experience Prioritization for Multi-Goal Robot Manipulation Reinforcement Learning, pp. 1-6

Kuang, Yingyi	Aston University
Weinberg, Abraham Itzhak	Aston University
Vogiatzis, George	Aston University
Faria, Diego	Aston University

Reinforcement learning for multi-goal robot manipulation tasks is usually challenging, especially when sparse rewards are provided. It often requires millions of data collected before a stable strategy is learned. Recent algorithms like Hindsight Experience Replay (HER) have accelerated the learning process greatly by replacing the original desired goal with one of the achieved points (substitute goals) alongside the same trajectory. However, the selection of previous experience to learn is naively sampled in HER, in which the trajectory selection and the substitute goal sampling is completely random. In this paper, we discuss an experience prioritization strategy for HER that improves the learning efficiency. We propose the Goal Density-based hindsight experience Prioritization (GDP)method that focuses on utilizing the density distribution of the achieved points and prioritizes achieved points which are rarely seen in the replay buffer. These points are used as substitute goals for HER. In addition, we propose an Prioritization Switching with Ensembling Strategy (PSES) method to switch different experience prioritization algorithms during learning, which allows to select the best performance during each learning stage. We evaluate our method with several OpenAIGym robotic manipulation tasks. The results show that GDP accelerates the learning process in most tasks and can be improved when combining with other prioritization methods using PSES.

13:25-13:35 TuT33.5

Monocular 3D Object Detection for an Indoor Robot Environment, pp. 1-8

Kim, Jiwon	KIST, Korea
Lee, GiJae	Korea Institute of Science and Technology
Kim, Jun-Sik	Korea Institute of Science & Technology
Kim, Hyunwoo	Korea University
Kim, KangGeon	Korea Institute of Science and Technology

For a service robot to assist humans, it should interact with objects of varying sizes and shapes existing in an indoor environment. 3D object detection must be preceded to achieve this goal since it provides the robot with the ability to perceive visual information. Most of the existing methods are anchor-based and predict the bounding box close to the ground truth among multiple candidates. However, it is complex to compute Intersection over Union (IoU) and Non-Maximum Suppression (NMS) per each anchor box. Therefore, we propose keypoint-based monocular 3D object detection, where each object's center location is only needed for reproducing predicted 3D bounding

box without extra computation of the anchor boxes. Our 3D object detection also works well even if images are rotated corresponding to the robot's head movement. To properly train our network, the object center is based on a projected 3D location instead of 2D to take advantage of the exact center position of the object. Furthermore, we apply data augmentation using a perspective transformation. The method facilitates adding a small perturbation to the camera rotation angle randomly. We use the SUN RGB-D dataset, which has images taken indoor scenes with camera rotations for training and test set. Our approach particularly shows that the errors of object center location based on a single image reduce 15.4% and 24.2%, respectively, compared to the method without data augmentation.

13:35-13:45 TuT33.6

DroneLight: Drone Draws in the Air Using Long Exposure Light Painting and ML, pp. 1-5

Ibrahimov, Roman	Skolkovo Institute of Technology and Science
Zherdev, Nikolay	Skolkovo Institute of Science and Technology
Tsetserukou, Dzmitry	Skolkovo Institute of Science and Technology

We propose a novel human-drone interaction paradigm where a user directly interacts with a drone to light-paint predefined patterns or letters through hand gestures. The user wears a glove which is equipped with an IMU sensor to draw letters or patterns in the midair. The developed ML algorithm detects the drawn pattern and the drone light-paints each pattern in midair in the real time. The proposed classification model correctly predicts all of the input gestures. The DroneLight system can be applied in drone shows, advertisements, distant communication through text or pattern, rescue, etc. To our knowledge, it would be the world's first human-centric robotic system that people can use to send messages based on light-painting over distant locations (drone-based instant messaging). Another unique application of the system would be the development of vision-driven rescue system that reads light-painting by person who is in distress and triggers rescue alarm.

TuT34 Room 4

Value in Use and Customer Engagement with Social Robots: A Service Management Perspective (Special Session)

Chair: Mele, Cristina	University of Naples Federico II
Co-Chair: Tregua, Marco	University of Naples "Federico II"
Organizer: Mele, Cristina	University of Naples Federico II
Organizer: Russo Spena, Tiziana	University of Naples "Federico II"
Organizer: Tregua, Marco	University of Naples "Federico II"

12:45-12:55 TuT34.1

Maturational Aspects of Visual P300 in Children: A Research Window for Pediatric Brain Computer Interface (BCI) (I), pp. 1-5

Forest, Cristina	Pediatric Section, University of Ferrara
Beraldo, Gloria	University of Padua
Mancin, Roberto	University of Padua
Menegatti, Emanuele	The University of Padua
Suppiej, Agnese	University of Ferrara

The P300 is an endogenous event-related potential (ERP) involved in several cognitive processes, apparently preserved between adults and children. In the pediatric age it shows different age-related characteristics. Its application in Brain Computer Interface (BCI) pediatric research remains to date still unclear. The aim of this paper is to give an overview of the maturational aspects of the visual P300, that could be used for developing BCI paradigms in the pediatric age.

12:55-13:05 TuT34.2

Physical Embodiment of Conversational Social Robots (I), pp. 1-8

Gava, Luna	University of Genova
Grassi, Lucrezia	University of Genova
Lagomarsino, Marta	University of Genova
Recchiuto, Carmine Tommaso	University of Genova
Sgorbissa, Antonio	University of Genova

Achieving natural and engaging verbal interactions is one of the main challenges faced by Social Robotics. In this context, physical embodiment may be one of the most critical factors: indeed, previous work indicates that physical robots elicit more favorable social responses than virtual agents. However, the effects of physical embodiment have been analysed only in some specific and limited scenarios, where verbal interaction was reduced to basic commands. The current work aims at investigating the effect of robots' physical embodiment in a pure conversation task, by considering some relevant aspects of social interaction, such as usability, speech interface quality, user satisfaction and engagement. To this aim, a pilot experiment where participants were required to chitchat with a robot and a smartphone app, both connected to the same conversation framework, has been carried out. Preliminary results are presented and discussed, and they offer interesting insights about the positive effects of physical embodiment on some of the analysed aspects.

13:05-13:15 TuT34.3

Increasing Engagement with Chameleon Robots in Bartending Services (I), pp. 1-6

Rossi, Silvia	Universita' Di Napoli Federico II
Dell'Aquila, Elena	University of Naples Federico II
Russo, Davide	University of Naples Federico II
Maggi, Gianpaolo	Università Della Campania L. Vanvitelli

As the field of service robotics has been rapidly growing, it is expected for such robots to be endowed with the appropriate capabilities to interact with humans in a socially acceptable way. This is particularly relevant in the case of customer relationships where a positive and affective interaction has an impact on the users' experience. In this paper, we address the question of whether a specific behavioral style of a barman-robot, acted through para-verbal and non-verbal behaviors, can affect users' engagement and the creation of positive emotions. To that end, we endowed a barman-robot taking drink orders from human customers, with an emphatic behavioral style. This aims at triggering to alignment process by mimicking the conversation partner's behavior. This behavioral style is compared to an entertaining style, aiming at creating a positive relationship with the users, and a neutral style for control. Results suggest that when participants experienced more positive emotions, the robot was perceived as safer, so suggesting that interactions that stimulate positive and open relations with the robot may have a positive impact on the affective dimension of engagement. Indeed, when the empathic robot modulates its behavior according to the user's one, this interaction seems to be more effective than when interacting with a neutral robot in improving engagement and positive emotions in public-service contexts.

13:15-13:25 TuT34.4

Understanding Robot Acceptance/rejection: The SAR Model (I), pp. 1-6

Mele, Cristina	University of Naples Federico II
Russo-Spena, Tiziana	University of Naples Federico II
Tregua, Marco	University of Naples "Federico II"
Laddaga, Cesare	University of Naples "Federico II"
Ranieri, Angelo	University of Naples Federico II
Ruggiero, Andrea	Univeristy of Naples Federico II
Gargiulo, Robera	University of Naples Federico II

By shifting the focus from the future and robots' potentiality to real opportunities, the aim of this paper is to investigate key factors of acceptance and rejection of robots' service provision. A qualitative method was adopted due to the novelty of the topic, with several steps of investigation, aimed at dealing with the socially constructed meanings related to the agents' acceptance and use of robots. By building on the service robot acceptance model, the paper addresses the role of value-in-context and context congruence to explain the contribution of conversational agents and service robots to value creation. An extended model – the SARM - is presented that highlights the crucial role of value-in-context, representing a novel element to be

added to social-emotional, functional, and relational elements. The SARM offers a more complete understanding of users' perception regarding robots by including context-specific reasons that serve as important linkages between functional, emotional, and relational features regarding robot acceptance or rejection.

13:25-13:35 TuT34.5

Social Robot As a Tool to Involve Student in Museum Edutainment Programs (I), pp. 1-6

Del Vacchio, Erica	University of Naples "Federico II"
Laddaga, Cesare	University of Naples "Federico II"
Bifulco, Francesco	University of Naples "Federico II"

With a focus on the service potential of social robots for the cultural and tourism industry, the purpose of this document is to study how social robots are used as a new tool to involve students in the design of new edutainment applications in museums. We conducted an empirical analysis on multiple case studies. The results confirm that the use of the social robot in museum edutainment programs concern in the involvement of the young public and in the experimentation of new forms of entertainment. Moreover, concrete details are offered complementing the results already proposed by other scholars [18]. From a practical perspective, manager should encourage the implementation of social robot in edutainment museum programs to achieve higher efficiency and better results in terming of involving new age groups.

Technical Program for Wednesday September 2, 2020

WeT41 Room 1

Applications of Social Robots / Social Intelligence for Robots (II) (Regular Session)

Chair: Shibuya, Koji — Ryukoku University

Co-Chair: Frederiksen, Morten Roed — IT-University of Copenhagen

12:45-12:55 WeT41.1

Bright and Dark Timbre Expressions with Sound Pressure and Tempo Variations by Violin-Playing Robot, pp. 1-6

Shibuya, Koji — Ryukoku University

Kosuga, Kento — Ryukoku University

Fukuhara, Hiroshi — Ryukoku University

This study aims to build a violin-playing robot that can automatically determine how to perform based on the information included in musical scores. In this paper, we discuss the design of the variation pattern for the tempo of every bar and the sound pressure of every musical note to produce sounds that can convey bright and dark impressions. First, we present the analytical results of a trained violinist's performance, in which we found that the tempo of the bright timbre is faster than that of the dark timbre, and the bright performance includes several steep variations in the sound pressure pattern. We then propose a design method for the performance to express bright and dark timbres based on the analytical results. In the experiments, sounds were produced by our anthropomorphic violin-playing robot, which can vary the sound pressure by varying a wrist joint angle. The sounds produced by the robot were analyzed, and we confirmed that the patterns of the produced sound pressure for the bright performance are similar to those of the designed one. The sounds were also evaluated by ten subjects, and we found that they distinguished the bright performances from the dark ones when the sound pressure and tempo variations were included.

12:55-13:05 WeT41.2

On the Causality between Affective Impact and Coordinated Human-Robot Reactions, pp. 1-7

Frederiksen, Morten Roed — IT-University of Copenhagen

Stoy, Kasper — IT University of Copenhagen

In an effort to improve how robots function in social contexts, this paper investigates if a robot that actively shares a reaction to an event with a human alters how the human perceives the robot's affective impact. To verify this, we created two different test setups. One to highlight and isolate the reaction element of affective robot expressions, and one to investigate the effects of applying specific timing delays to a robot reacting to a physical encounter with a human. The first test was conducted with two different groups (n=84) of human observers, a test group and a control group both interacting with the robot. The second test was performed with 110 participants using increasingly longer reaction delays for the robot with every ten participants. The results show a statistically significant change ($p<.05$) in perceived affective impact for the robots when they react to an event shared with a human observer rather than reacting at random. The result also shows for shared physical interaction, the near-human reaction times from the robot are most appropriate for the scenario. The paper concludes that a delay time around 200ms may render the biggest impact on human observers for small-sized non-humanoid robots. It further concludes that a slightly shorter reaction time around 100ms is most effective when the goal is to make the human observers feel they made the biggest impact on the robot.

13:05-13:15 WeT41.3

Multiple-Robot Mediated Discussion System to Support Group Discussion, pp. 1-8

Ikari, Shogo — Osaka University

Yoshikawa, Yuichiro — Osaka University

Ishiguro, Hiroshi — Osaka University

Deep discussions on topics without definite answers are important for society, but they are also challenging to facilitate. Recently, advances in the technology of using robots to facilitate discussions have been made. In this study, we developed a multiple-robot mediated discussion system (m-RMDS) to support discussions by having multiple robots assert their own points and lead a dialogue in a group of human participants. The robots involved the participants in a discussion through asking them for advice. We implemented the m-RMDS in discussions on difficult topics with no clear answers. A within-subject experiment with 16 groups (N=64) was conducted to evaluate the contribution of the m-RMDS. The participants completed a questionnaire about their discussion skills and their self-confidence. Then, they participated in two discussions, one facilitated by the m-RMDS and one that was unfacilitated. They evaluated and compared both experiences across multiple aspects. The participants with low confidence in conducting a discussion evaluated the discussion with m-RMDS as easier to move forward than the discussion without m-RMDS. Furthermore, they reported that they heard more of others' frank opinions during the facilitated discussion than during the unfacilitated one. In addition, regardless of their confidence level, the participants tended to respond that they would like to use the system again. We also review necessary improvements to the system and suggest future applications.

13:15-13:25 WeT41.4

Do You Move Unconsciously? Accuracy of Social Distance and Line of Sight between a Virtual Robot Head and Humans, pp. 1-6

Minegishi, Tomoya — University of Tsukuba

Osawa, Hirotaka — University of Tsukuba

In this paper, we examine the effectiveness of the social distance between a virtual agent and users, and the gaze instruction using a display that can be viewed stereoscopically without using any wearable devices. An actual robot cannot always maintain an appropriate interpersonal distance, through nonverbal gestures owing to its limited range of motion. Because large movements may harm humans, the nonverbal gestures of robots are limited in the real world. In this work, 14 participants were asked how far they wanted to move from a robot posing as a museum guide agent. They were also asked to identify the point at which they felt the agent was gazing. There was a significant distance between the initial position and the position to which the participants moved in the first task under two-dimensional (2D) and three-dimensional (3D) scenarios. The participants moved a significant distance in the first task. In the gaze estimation task, however, the error between the 3D and 2D evaluations was significantly lesser, at a point far from the agent.

13:25-13:35 WeT41.5

Impact of Trajectory Generation Methods on Viewer Perception of Robot Approaching Group Behaviors, pp. 1-8

Yang, Fangkai — KTH Royal Institute of Technology

Yin, Wenjie — KTH

Björkman, Mårten — KTH

Peters, Christopher — Royal Institute of Technology

Mobile robots that approach free-standing conversational groups to join them should behave in a safe and socially-acceptable way. Existing trajectory generation methods focus on collision avoidance with pedestrians, and the models that generate approach behaviors into groups are evaluated in simulation. However, it is challenging to generate approach and join trajectories that avoid collisions with group members while also ensuring that they do not invoke feelings of discomfort. In this paper, we conducted an experiment to examine the impact of three trajectory generation methods for a mobile robot to approach groups from multiple directions: a Wizard-of-Oz (WoZ) method, a procedural social-aware navigation model (PM) and a novel generative adversarial model imitating human approach behaviors (IL). Measures also compared two camera viewpoints and static versus quasi-dynamic groups. The latter refers to a group whose members change orientation and position throughout the approach task, even though the group entity remains static in the environment. This represents a more realistic but challenging scenario for the robot. We evaluate three methods with objective measurements and subjective measurements from viewer perception, and results show that WoZ and IL have comparable performance, and both perform better than PM under most conditions.

WeT42 Room 2

Motion Planning and Navigation in Human-Centered Environments (I) (Regular Session)

Chair: Mainprice, Jim — Max Planck Institute
Co-Chair: Alami, Rachid — CNRS

12:45-12:55 WeT42.1

Pedestrian Density Based Path Recognition and Risk Prediction for Autonomous Vehicles, pp. 1-8

Mokhtari, Kasra — The Pennsylvania State University
Surendran, Vidullan — Pennsylvania State University
Ayub, Ali — Penn State University
Wagner, Alan Richard — Penn State University

Human drivers continually use social information to inform their decision making. We believe that incorporating this information into autonomous vehicle decision making would improve performance and importantly safety. This paper investigates how information in the form of pedestrian density can be used to identify the path being travelled and predict the number of pedestrians that the vehicle will encounter along that path in the future. We present experiments which use camera data captured while driving to evaluate our methods for path recognition and pedestrian density prediction. Our results show that we can identify the vehicle's path using only pedestrian density at 92.4% accuracy and we can predict the number of pedestrians the vehicle will encounter with an accuracy of $70.45%. These results demonstrate that pedestrian density can serve as a source of information both perhaps to augment localization and for path risk prediction.

12:55-13:05 WeT42.2

Hierarchical Motion Planning Framework for Manipulators in Human-Centered Dynamic Environments, pp. 1-8

Wittmann, Jonas — Technical University of Munich
Jankowski, Julius — Idiap Research Institute
Wahrmann, Daniel — Technische Universität München
Rixen, Daniel — Technische Universität München

Collaborating robots face rising challenges with respect to autonomy and safety as they are deployed in flexible automation applications. The ability to perform the required tasks in the presence of humans and obstacles is key for the integration of these machines in industry. In this work we introduce a framework for motion planning of manipulators that builds upon the most promising existing approaches by combining them in an advantageous way. It includes a new Obstacle-related Sampling Rejection Probabilistic Roadmap planner (ORSR-PRM) that represents the free workspace in an efficient way. Using this representation, dynamic obstacles can be avoided in real-time using an attractor-based online trajectory generation. The resulting motions satisfy kinematic and dynamic joint limits, ensuring a safe human-robot interaction. We validate the functionality and performance of the presented framework in simulations and experiments.

13:05-13:15 WeT42.3

Where Can I Help? Human-Aware Placement of Service Robots, pp. 1-6

Bruckschen, Lilli — University of Bonn
Bungert, Kira — University of Bonn
Wolter, Moritz — University of Bonn
Krumpen, Stefan — University of Bonn
Weinmann, Michael — University of Bonn
Klein, Reinhard — University of Bonn
Bennewitz, Maren — University of Bonn

As service robots are entering more and more homes it gets evermore important to find behavior strategies that ensure a harmonic coexistence between those systems and their users. In this paper, we present a novel approach to enable a mobile robot to provide timely assistance to a user moving in its environment, while simultaneously avoiding unnecessary movements as well as interferences with the user. We developed a framework that uses information about the last object interaction to predict possible future movement destinations of the user and infer where they might need assistance based on prior knowledge. Given this prediction, the robot chooses the best position for itself that minimizes the time until assistance can be provided as well as avoids interferences with other activities of the user. We evaluated our approach in comparison to state-of-the-art methods in simulated environments and performed a user study in a virtual reality environment. Our evaluation demonstrates that our approach is able to decrease both the time until assistance is provided and the travel distance of the robot as well as increases the average distance between the user and the robot in comparison to state-of-the-art systems. Additionally, the robot behavior generated by our method is rated as more pleasant by our study participants than comparable literature approaches.

13:15-13:25 WeT42.4

Social Drone Sharing to Increase the UAV Patrolling Autonomy in Emergency Scenarios, pp. 1-8

Morando, Luca — Università Degli Studi Di Genova
Recchiuto, Carmine Tommaso — University of Genova
Sgorbissa, Antonio — University of Genova

Unmanned Aerial Vehicles (UAVs) popularity is increased in recent years, and the domain of application of this new technology is continuously expanding. However, although UAVs may be extremely useful in monitoring contexts, the operational aspects of drone patrolling services have not yet been extensively studied. Specifically, patrolling and inspecting with UAVs different targets distributed over a large area is still an open problem, due to battery constraints and other practical limitations. In this work, we propose a deterministic algorithm for patrolling large areas in a pre- or post-critical event scenario. The autonomy range of UAVs is extended with the concept of Social Drone Sharing: citizens may offer their availability to take care of the UAV if it lands in their private area, being thus strictly involved in the monitoring process. The proposed approach aims at finding optimal routes in this context, minimizing the patrolling time and respecting the battery constraints. Simulation experiments have been conducted, giving some insights about the performance of the proposed method.

13:25-13:35 WeT42.5

An Interior Point Method Solving Motion Planning Problems with Narrow Passages, pp. 1-6

Mainprice, Jim — Max Planck Institute
Ratliff, Nathan — Lula Robotics Inc
Toussaint, Marc — Tu Berlin
Schaal, Stefan — Google X

Algorithmic solutions for the motion planning problem have been investigated for five decades. Since the development of A* in 1969 many approaches have been investigated, traditionally classified as either grid decomposition, potential fields or sampling-based. In this work, we focus on using numerical optimization, which is understudied for solving motion planning problems. This lack of interest in the favor of sampling-based methods is largely due to the non-convexity introduced by narrow passages. We address this shortcoming by grounding the solution in differential geometry. We demonstrate through a series of experiments on 3 Dofs and 6 Dofs narrow passage problems, how modeling explicitly the underlying Riemannian manifold leads to an efficient interior point non-linear programming solution.

WeT43 Room 3

Robots in Education, Therapy and Rehabilitation (I) (Regular Session)

Chair: Kose, Hatice — Istanbul Technical University
Co-Chair: Belgiovine, Giulia — Istituto Italiano Di Tecnologia

12:45-12:55 WeT43.1

A Humanoid Social Agent Embodying Physical Assistance Enhances Motor Training Experience, pp. 1-8

Belgiovine, Giulia — Istituto Italiano Di Tecnologia
Rea, Francesco — Istituto Italiano Di Tecnologia
Zenzeri, Jacopo — Istituto Italiano Di Tecnologia

Sciutti, Alessandra — Italian Institute of Technology

Skilled motor behavior is critical in many human daily life activities and professions. The design of robots that can effectively teach motor skills is an important challenge in the robotics field. In particular, it is important to understand whether the involvement in the training of a robot exhibiting social behaviors impacts on the learning and the experience of the human pupils. In this study, we addressed this question and we asked participants to learn a complex task - stabilizing an inverted pendulum - by training with physical assistance provided by a robotic manipulandum, the Wristbot. One group of participants performed the training only using the Wristbot, whereas for another group the same physical assistance was attributed to the humanoid robot iCub, who played the role of an expert trainer and exhibited also some social behaviors. The results obtained show that participants of both groups effectively acquired the skill by leveraging the physical assistance, as they significantly improved their stabilization performance even when the assistance was removed. Moreover, learning in a context of interaction with a humanoid robot assistant led subjects to increased motivation and more enjoyable training experience, without negative effects on attention and perceived effort. With the experimental approach presented in this study, it is possible to investigate the relative contribution of haptic and social signals in the context of motor learning mediated by human-robot interaction, with the aim of developing effective robot trainers.

12:55-13:05 WeT43.2

Understanding Human-Robot Collaboration for People with Mobility Impairments at the Workplace, a Thematic Analysis, pp. 1-6

Arevalo Arboleda, Stephanie — Westphalian University of Applied Sciences
Pascher, Max — Westphalian University of Applied Sciences
Lakhnati, Younes — Westphalian University of Applied Sciences
Gerken, Jens — Westphalian University of Applied Sciences

Assistive technologies such as human-robot collaboration, have the potential to ease the life of people with physical mobility impairments in social and economic activities. Currently, this group of people has lower rates of economic participation, due to the lack of adequate environments adapted to their capabilities. We take a closer look at the needs and preferences of people with physical mobility impairments in a human-robot cooperative environment at the workplace. Specifically, we aim to design how to control a robotic arm in manufacturing tasks for people with physical mobility impairments. We present a case study of a sheltered-workshop as a prototype for an institution that employs people with disabilities in manufacturing jobs. Here, we collected data of potential end-users with physical mobility impairments, social workers, and supervisors using a participatory design technique (Future-Workshop). These stakeholders were divided into two groups, primary (end-users) and secondary users (social workers, supervisors), which were run across two separate sessions. The gathered information was analyzed using thematic analysis to reveal underlying themes across stakeholders. We identified concepts that highlight underlying concerns related to the robot fitting in the social and organizational structure, human-robot synergy, and human-robot problem management. In this paper, we present our findings and discuss the implications of each theme when shaping an inclusive human-robot cooperative workstation for people with physical mobility impairments.

13:05-13:15 WeT43.3

Towards an Affective Robot Companion for Audiology Rehabilitation: How Does Pepper Feel Today?, pp. 1-6

Uluer, Pinar — Galatasaray University
Kose, Hatice — Istanbul Technical University
Oz, Bulent Koray — Istanbul Technical University
Aydinalev, Turgut Can — Istanbul Technical University
Erol Barkana, Duygun — Yeditepe University

The motivation of this work is to develop an affective robot companion for audiology rehabilitation and to test the system with the deaf or hard of hearing children. Two robot modules are developed which are the multimodal ``stress/emotion/motivation" recognition module for the robot to ``understand" how the children feel, and behaviour and feedback module of the robot to show the children how the robot ``feels". In this study we only focus on the behaviour and feedback module of the robot. The selected affective/affirmative behaviours are tested by means of tablet games and employed on the robot during an audiology test, as a feedback mechanism. Facial data are used together with the surveys to evaluate the children's perception of the robot and the behaviour set.

13:15-13:25 WeT43.4

Integrating a Social Robot in Higher Education – a Field Study, pp. 1-7

Donnermann, Melissa — Julius-Maximilians University Wuerzburg
Schaper, Philipp — University of Wuerzburg
Lugrin, Birgit — University of Wuerzburg

The benefits of social robots in educational contexts were mainly investigated with children, but also bear great potential to support learners and teachers in higher education. To further explore the potential of social robots in the context of university teaching, we implemented a robot-supported learning environment as a complementary training to a university course. To learn more about the students' perspective and attitudes towards the integration of robots in their education, we conducted a field study with qualitative interviews as data collection method. Our results show a clear positive perception of the robot-supported learning environment, and indicate a positive impact on the learning outcomes. Most students suppose an additional value in the presence of the robot compared to an on-screen scenario or self-study, and perceived the robot to increase their motivation, attention and concentration. We found a clear interest of the students to use the learning environment again in the future. However, more individualized feedback was desired.

13:25-13:35 WeT43.5

Autonomous Mobile Gait Training Robot for Orthopedic Rehabilitation in a Clinical Environment, pp. 1-8

Trinh, Thanh Quang — Ilmenau University of Technology
Vorndran, Alexander — Ilmenau University of Technology
Schuetz, Benjamin — Ilmenau University of Technology
Jaeschke, Bianca — Ilmenau University of Technology
Mayfarth, Anke — MetraLabs GmbH
Scheidig, Andrea — Ilmenau Technical University
Gross, Horst-Michael — Ilmenau University of Technology

Successful rehabilitation after surgery in hip endoprosthetics comprises self-training of the lessons taught by physiotherapists. While doing so, immediate feedback to the patient about deviations from physiological gait patterns during training is very beneficial. In the research project ROGER, a mobile socially assistive robot (SAR), which supports patients after surgery in hip endoprosthetics during their self-training, was developed. The robot employs task-specific, user-centered navigation and autonomous, real-time gait feature classification techniques to enrich the self-training through companionship and timely corrective feedback. This paper presents technical and usability results obtained during four weeks of user tests at our partner hospital "Waldkliniken Eisenberg" in Germany.

WeT44 — Room 4

Machine Learning and Adaptation / Programming by Demonstration (II) (Regular Session)

Chair: Eiband, Thomas — German Aerospace Center (DLR)
Co-Chair: Martinez-Hernandez, Uriel — University of Bath

12:45-12:55 WeT44.1

An Experimental Study of the Accuracy vs Inference Speed of RGB-D Object Recognition in Mobile Robotics, pp. 1-8

Pereira, Ricardo — University of Coimbra, Institute of Systems and Robotics
Barros, Tiago — Institute of Systems and Robotics - University of Coimbra

Garrote, Luís Carlos	Institute of Systems and Robotics, University of Coimbra
Lopes, Ana	ISR-UC
Nunes, Urbano J.	Instituto De Sistemas E Robotica

This paper presents a study in terms of accuracy and inference speed using RGB-D object detection and classification for mobile platform applications. The study is divided in three stages. In the first, eight state-of-the-art CNN-based object classifiers (AlexNet, VGG16-19, ResNet18-50-101, DenseNet, and MobileNetV2) are used to compare the attained performances with the corresponding inference speeds in object classification tasks. The second stage consists in exploiting YOLOv3/YOLOv3-tiny networks to be used as Region of Interest generator method. In order to obtain a real-time object recognition pipeline, the final stage unifies the YOLOv3/YOLOv3-tiny with a CNN-based object classifier. The pipeline evaluates each object classifier with each Region of Interest generator method in terms of their accuracy and frame rate. For the evaluation of the proposed study under the conditions in which real robotic platforms navigate, a non-object centric RGB-D dataset was recorded in Institute of Systems and Robotics facilities using a camera on-board the ISR-InterBot mobile platform. Experimental evaluations were also carried out in Washington and COCO datasets. Promising performances were achieved by the combination of YOLOv3-tiny and ResNet18 networks on the embedded hardware Nvidia Jetson TX2.

12:55-13:05 WeT44.2

Hand Pose-Based Task Learning from Visual Observations with Semantic Skill Extraction, pp. 1-8

Qiu, Zeju	Technical University of Munich
Eiband, Thomas	German Aerospace Center (DLR)
Li, Shile	Technische Universität München
Lee, Dongheui	Technical University of Munich

Learning from Demonstrations is a promising technique to transfer task knowledge from a user to a robot. We propose a framework for task programming by observing the human hand pose and object locations solely with a depth camera. By extracting skills from the demonstrations, we are able to represent what the robot has learned, generalize to unseen object locations and optimize the robotic execution instead of replaying a non-optimal behavior. A two-staged segmentation algorithm that employs skill template matching via Hidden Markov Models has been developed to extract motion primitives from the demonstration and gives them semantic meanings. In this way, the transfer of task knowledge has been improved from a simple replay of the demonstration towards a semantically annotated, optimized and generalized execution. We evaluated the extraction of a set of skills in simulation and prove that the task execution can be optimized by such means.

13:05-13:15 WeT44.3

TIRL: Enriching Actor-Critic RL with Non-Expert Human Teachers and a Trust Model, pp. 1-8

Rutard, Felix	Sorbonne Université, Institut Des Systèmes Intelligents Et De Ro
Chetouani, Mohamed	Sorbonne University
Sigaud, Olivier	Université Pierre Et Marie Curie - Paris 6

Reinforcement learning (RL) algorithms have been demonstrated to be very attractive tools to train agents to achieve sequential tasks. However, these algorithms require too many training data to converge to be efficiently applied to physical robots. By using a human teacher, the learning process can be made faster and more robust, but the overall performance heavily depends on the quality and availability of teacher demonstrations or instructions. In particular, when these teaching signals are inadequate, the agent may fail to learn an optimal policy. In this paper, we introduce a trust-based interactive task learning approach. We propose an RL architecture able to learn both from environment rewards and from various sparse teaching signals provided by non-expert teachers, using an actor-critic agent, a human model and a trust model. We evaluate the performance of this architecture on 4 different setups using a maze environment with different simulated teachers and show that the benefits of the trust model.

13:15-13:25 WeT44.4

Coping with the Variability in Humans' Reward During Simulated Human-Robot Interactions through the Coordination of Multiple Learning Strategies, pp. 1-6

Dromnelle, Rémi	Sorbonne Université
Girard, Benoit	Cnrs / Su
Renaudo, Erwan	University of Innsbruck
Chatila, Raja	ISIR
Khamassi, Mehdi	Cnrs / Upmc

An important current challenge in Human-Robot Interaction (HRI) is to enable robots to learn on-the-fly from human feedback. However, humans show a great variability in the way they reward robots. We propose to address this issue by enabling the robot to combine different learning strategies, namely model-based (MB) and model-free (MF) reinforcement learning. We simulate two HRI scenarios: a simple task where the human congratulates the robot for putting the right cubes in the right boxes, and a more complicated version of this task where cubes have to be placed in a specific order. We show that our existing MB-MF coordination algorithm previously tested in robot navigation works well here without retuning parameters. It leads to the maximal performance while producing the same minimal computational cost as MF alone. Moreover, the algorithm gives a robust performance no matter the variability of the simulated human feedback, while each strategy alone is impacted by this variability. Overall, the results suggest a promising way to promote robot learning flexibility when facing variable human feedback.

13:25-13:35 WeT44.5

Designing Context-Sensitive Norm Inverse Reinforcement Learning Framework for Norm-Compliant Autonomous Agents, pp. 1-8

Guo, Yue	Carnegie Mellon University
Wang, Boshi	ShanghaiTech University
Hughes, Dana	Carnegie Mellon University
Lewis, Michael	University of Pittsburgh
Sycara, Katia	Carnegie Mellon University

Human behaviors are often prohibited, or permitted by social norms. Therefore, if autonomous agents interact with humans, they also need to reason about various legal rules, social and ethical social norms, so they would be trusted and accepted by humans. Inverse Reinforcement Learning (IRL) can be used for the autonomous agents to learn social norm-compliant behavior via expert demonstrations. However, norms are context-sensitive, i.e. different norms get activated in different contexts. For example, the privacy norm is activated for a domestic robot entering a bathroom where a person may be present, whereas it is not activated for the robot entering the kitchen. Representing various contexts in the state space of the robot, as well as getting expert demonstrations under all possible tasks and contexts is extremely challenging. Inspired by recent work on Modularized Normative MDP (MNMDP) and early work on context-sensitive RL, we propose a new IRL framework, Context-Sensitive Norm IRL (CNIRL). CNIRL treats states and contexts separately, and assumes that the expert determines the priority of every possible norm in the environment, where each norm is associated with a distinct reward function. The agent chooses the action to maximize its cumulative rewards. We present the CNIRL model and show that its computational complexity is scalable in the number of norms. We also show via two experimental scenarios that CNIRL can handle problems with changing context spaces.

WeT45 Room 5

Stakeholders' Views on Social Robots in Education (Special Session)

Chair: Tolksdorf, Nils Frederik	Paderborn University
Co-Chair: Siebert, Scarlet	TH Köln University of Applied Sciences
Organizer: Smakman, Matthijs	Vrije Universiteit Amsterdam
Organizer: Siebert, Scarlet	TH Köln University of Applied Sciences
Organizer: Tolksdorf, Nils Frederik	Paderborn University

12:45-12:55 WeT45.1

Deployment of a Social Robot into a Classroom of Remote Teaching by Elderly People to School Children: A Case Report, pp. 1-8

Okamura, Erina — University of Tsukuba
Tanaka, Fumihide — University of Tsukuba

A humanoid robot combined with a classroom SNS (social networking service) was introduced into a classroom of remote teaching by elderly persons (aged 78, 83, and 91 years) to school children (aged between 12 to 15 years). The goal was to carry out an ethnographic participatory development of an education support system for elderly teachers and school children. The development formed part of a weekly club activity in an elementary school over the course of six months and consisted of iterating three phases (the experience, reflection, and implementation phases). Through this ethnographic participatory development, we aimed to reveal potential utility and issues in using a social robot combined with a classroom SNS to support remote educational activities between elderly people and children. In addition, the significance of leveraging elderly people in aging societies, especially in education, is highlighted.

12:55-13:05 WeT45.2

Parents' Views on Using Social Robots for Language Learning (I), pp. 1-7

Tolksdorf, Nils Frederik — Paderborn University
Rohlfing, Katharina — Paderborn University

Research in human–robot interaction envisions applications in a variety of areas. In one of them, robots can be used to improve educational performance. However, most scientific investigations focus on learning outcomes without considering the social implications of a robot available as a learning companion. Therefore, the identification of the underlying challenges and issues faced by different stakeholders involved in the technology implementation processes is still sparse. This paper is concerned with parents as a key stakeholder group that is almost overlooked in the existing literature. We present results of a study on child–robot interaction for language learning, in which parents accompanied their children and evaluated the robot after four sessions of experiencing it within a laboratory setting. The results suggest that parents recognize the robots' potential for language learning within a playful interaction with their children. However, as parents reported, the technical challenges for an adaptive and smooth interaction might impede children's learning gains in the long-term.

13:05-13:15 WeT45.3

"Oh No, My Instructions Were Wrong!" an Exploratory Pilot towards Children's Trust in Social Robots (I), pp. 1-6

Stower, Rebecca — Jacobs University
Kappas, Arvid — Jacobs University Bremen

Whilst there has been growing interest in the use of social robots in educational settings, the majority of this research focuses on learning outcomes, with less emphasis on the social processes surrounding these interactions. One such understudied factor is children's trust in the robot as a teacher. Trust is a relevant domain in that if and how children trust a robot could influence their subsequent learning outcomes. The extent to which the robot's behaviour (including making errors) influences trust is yet to be fully explored. Consequently, the goal of this research is to determine the role of trust in children's learning from social robots. We report a pilot study investigating the conceptualisation and measurement of children's trust in robots. 33 children aged between 4-9 completed a computational thinking learning task with a NAO robot at a Science Festival. Observations of the interactions in terms of developing tasks and measurements for child robot interaction are discussed. The findings tentatively suggest children's trust in the robot can be divided into two parts: social affiliation towards the robot, and perceived competence/reliability of the robot.

13:15-13:25 WeT45.4

The Impact of Social Robots in Education: Moral Considerations of Dutch Educational Policymakers (I), pp. 1-6

Smakman, Matthijs — Vrije Universiteit Amsterdam
Berket, Jimmy — Institute for Design and Engineering, HU University of Applied S
Konijn, Elly A. — Dept. of Communication Science, Media Psychology Program, Vrije

Social robots are increasingly studied and applied in the educational domain. Although they hold great potential for education, they also bring new moral challenges. In this study, we explored the moral considerations related to social robots from the perspective of Dutch educational policymakers by first identifying opportunities and concerns and then mapping them onto (moral) values from the literature. To explore their moral considerations, we conducted focus group sessions with Dutch Educational Policymakers (N = 20). Considerations varied from the potential to lower the workload of teachers, to concerns related to the increased influence of commercial enterprises on the educational system. In total, the considerations of the policymakers related to 15 theoretical values. We identified the moral considerations of educational policymakers to gain a better understanding of a governmental attitude towards the use of social robots. This helps to create the necessary moral guidelines towards a responsible implementation of social robots in education.

WePIP Main Room

Poster Session 1 (Regular Session)

\- WePIP.1

Robot-On-Robot Gossiping to Improve Sense of Human-Robot Conversation, pp. 1-6

Mitsuno, Seiya — Osaka University
Yoshikawa, Yuichiro — Osaka University
Ishiguro, Hiroshi — Osaka University

In recent years, a substantial amount of research has been aimed at realizing a social robot that can maintain long-term user interest. One approach is using a dialogue strategy in which the robot makes a remark based on previous dialogues with users. However, privacy problems may occur owing to private information of the user being mentioned. We propose a novel dialogue strategy whereby a robot mentions another robot in the form of gossiping. This dialogue strategy can improve the sense of conversation, which results in increased interest while avoiding the privacy issue. We examined our proposal by conducting a conversation experiment evaluated by subject impressions. The results demonstrated that the proposed method could help the robot to obtain higher evaluations. In particular, the perceived mind was improved in the Likert scale evaluation, whereas the robot empathy and intention to use were improved in the binary comparison evaluation. Our dialogue strategy may contribute to understanding the factors regarding the sense of conversation, thereby adding value to the field of human-robot interaction.

\- WePIP.2

Effect of Robot Agents on Teaching against Pseudoscience, pp. 1-6

Matsui, Tetsuya — Seikei University
Yamada, Seiji — National Institute of Informatics

One of the most important problems in science education is teaching about the risks associated with pseudoscience. In this research, we focused on virtual teachers (VTs) that give lessons on pseudoscience. In prior research, the effect of robot teachers in scientific education was demonstrated, and the appearance of VTs was an important factor. Also, it was shown that the effect of logical persuasion and emotional persuasion changed on the basis of the context. Thus, we hypothesize that both the appearance of VTs and their persuasion strategy significantly affects the effect of the lessons through the interaction of the two. To verify this hypothesis, we conducted two-factor and two-levels experiments. One factor was the appearance of the VT: human-like or robot-like. Another was the persuasion strategy: emotional persuasion or logical one. As a result, a significant interaction was shown between the perceived persuasiveness of the VTs and their appearance. When the topic was minus ions' positive effect, the robot-like VT expressing emotional persuasion was perceived as less persuasive than the other VT. However, when the topic was UFOs, the robot-like VT expressing logical persuasion was perceived as less persuasive than the robot-like VT expressing emotional persuasion.

\- WePIP.3

Recurrent Neural Networks for Inferring Intentions in Shared Tasksfor

Industrial Collaborative Robots, pp. 1-6

Maceira, Marc	CSIC-UPC
Olivares-Alarcos, Alberto	CSIC-UPC
Alenyà, Guillem	CSIC-UPC

Industrial robots are evolving to work closely with humans in shared spaces. Hence, robotic tasks are increasingly shared between humans and robots in collaborative settings. To enable a fluent human robot collaboration, robots need to predict and respond in real-time to worker's intentions. We present a method for early decision using force information. Forces are provided naturally by the user through the manipulation of a shared object in a collaborative task. The proposed algorithm uses a recurrent neural network to recognize operator's intentions. The algorithm is evaluated in terms of action recognition on a force dataset. It excels at detecting intentions when partial data is provided, enabling early detection and facilitating a quick robot reaction.

15:15-16:15 WePIP.4

The Intraneural Electrical Stimulation of Human Median Nerve: A Simulation Study, pp. 1-6

Stefano, Mattia	Campus Bio-Medico University of Rome
Cordella, Francesca	University Campus Biomedico of Rome
Zollo, Loredana	Università Campus Bio-Medico Di Roma

Restoring tactile sensations in upper limb neuroprosthetic users is an important challenge to improve amputee quality of life. Neural prostheses are based on neural interfaces that allow delivering direct stimuli to the nerve fibers. Different kinds of neural electrodes, characterized by different properties as regards geometry or current stimulation parameters, were proposed in the literature. Studying the interaction between electrode stimulation and nerve fibers is fundamental for evaluating its ability to activate axon fibers and the electric potential distribution in the nerve. In this paper, the ds-FILE electrode is considered in the FEM simulation to study its interaction with the nerve fibers. The results can be very useful for the advancement of more realistic tactile sensations in amputee subjects from two point of view: the efficacy of the stimulation, that is related to the activation of axons subjected to the electrical stimulation, and the safety of the stimulation, related from a first consideration to the current intensity and waveform used. So in this paper are considered the results of three type of waveform that are the more safety as reported in literature and they are compared. The research aims to study, by means of a FEM-Neuron computational model, the axon fibers activation by means of the intraneural stimulation using different types of stimulus waveforms. The obtained results show that, using a biphasic charge unbalanced stimulus, the threshold to activate all the fibers considered in a location near an active site of the electrode is lower than the threshold found using biphasic charge balanced stimuli. This is an important result because the stimulation is equally efficient using low current amplitude.

15:15-16:15 WePIP.5

Towards a Context-Based Bayesian Recognition of Transitions in Locomotion Activities, pp. 1-6

Martinez-Hernandez, Uriel	University of Bath
Meng, Lin	University of Glasgow
Zhang, Dingguo	University of Bath
Rubio-Solis, Adrian	University of Sheffield

This paper presents a context-based approach for the recognition of transition between activities of daily living (ADLs) using wearable sensor data. A Bayesian method is implemented for the recognition of 7 ADLs with data from two wearable sensors attached to the lower limbs of subjects. A second Bayesian method recognises 12 transitions between the ADLs. The second recognition module uses both, data from wearable sensors and the activity recognised from the first Bayesian module. This approach analyses the next most probable transitions based on wearable sensor data and the context or current activity being performed by the subject. This work was validated using the ENABL3S Database composed of data collected from 7 ADLs and 12 transitions performed by participants walking on two circuits composed of flat surfaces, ascending and descending ramps and stairs. The recognition of activities achieved an accuracy of 98.3%. The recognition of transitions between ADLs achieved an accuracy of 98.8%, which improved the 95.3% accuracy obtained when the context or current activity is not considered for the recognition process. Overall, this work proposes an approach capable of recognising transitions between ADLs, which is required for the development of reliable wearable assistive robots.

15:15-16:15 WePIP.6

Robot-Assisted Mindfulness Practice: Analysis of Neurophysiological Responses and Affective State Change, pp. 1-7

Alimardani, Maryam	Tilburg University
Kemmeren, Linda	Tilburg University
Okumura, Kazuki	The University of Tokyo
Hiraki, Kazuo	University of Tokyo

Mindfulness is the state of paying attention to the present moment on purpose and meditation is the technique to obtain this state. This study aims to develop a robot assistant that facilitates mindfulness training by means of a Brain-Computer Interface (BCI) system. To achieve this goal, we collected EEG signals from two groups of subjects engaging in a meditative vs. non-meditative human-robot interaction (HRI) and evaluated cerebral hemispheric asymmetry, which is recognized as a well-defined indicator of emotional states. Moreover, using self-reported affective states, we strived to explain asymmetry changes based on pre- and post-experiment mood alterations. We found that unlike earlier meditation studies, the fronto-central activations in alpha and theta frequency bands were not influenced by robot-guided mindfulness practice, however there was a significantly greater right-sided activity in the occipital gamma band of Meditation group, which is attributed to increased sensory awareness and open monitoring. In addition, there was a significant main effect of Time on participant's self-reported affect, indicating an improved mood after interaction with the robot regardless of the interaction type. Our results suggest that EEG responses during robot-guided meditation hold promise in real-time detection and neurofeedback of mindful state to the user, however the experienced neurophysiological changes may differ based on the meditation practice and recruited tools. This study is the first to report EEG changes during mindfulness practice with a robot. We believe that our findings driven from an ecologically valid setting, can be used in development of future BCI systems that are integrated with social robots for health applications.

15:15-16:15 WePIP.7

An Iterative Interaction-Design Method for Multi-Modal Robot Communication, pp. 1-8

Saad, Elie	Delft University of Technology (TU Delft)
broekens, joost	Leiden University
Neerincx, Mark	TNO

The design space of human-robot interaction is large and multi-dimensional. A sound design requires a systematic theory-driven exploration, specification and refinement of design variables. There is a need for a practical method and tool to iteratively specify the content of the dialogue (e.g., speech acts) with the accompanying expressive behavior (e.g., gesture openness) as prescribed by social science theory, e.g., task- and person-oriented communication. This paper presents an iterative interaction-design (ID) method for multi-modal robot communication. Following the ID-method, a designer first creates his/her own individual design and, subsequently, provides an iteration to the evolving iterative design. To support the design method, we developed an ID-tool (available for download). The tool support entails (a) selecting the theory-based communication style; (b) creating and linking the dialogue act components for the concerning use case; and (c) setting the associated expression parameters. We conducted a study with Industrial Design students (N=13) who followed the ID-method and used our tool to design person- and task-oriented communications for a reception robot. Our method produced distinctive task- and person-oriented dialogue styles, i.e., provided the predicted theory-based multi-modal communicative behaviors. The task-oriented style showed a more formal, shorter and less chatty communication. Overall, there was a rather smooth design convergence process, in which the individual designs were harmonized into the iterative design. For the selected design problem, the ID-tool had a satisfactory

usability. Next steps include validation of the communication styles in an empirical study and, subsequently, identification of reusable design patterns.

15:15-16:15 WePIP.8

Towards a Real-Time Cognitive Load Assessment System for Industrial Human-Robot Cooperation, pp. 1-8

Rajavenkatanarayanan, Akilesh	The University of Texas at Arlington
Nambiappan, Harish Ram	University of Texas at Arlington
Kyrarini, Maria	University of Texas at Arlington
Makedon, Fillia	University of Texas at Arlington

Robots are increasingly present in environments shared with humans. Robots can cooperate with human teammates to achieve common goals and complete tasks. This paper focuses on developing a real-time framework that assesses the cognitive load of a human while cooperating with a robot to complete a collaborative assembly task. The framework uses multi-modal sensory data from Electrocardiography (ECG) and Electrodermal Activity (EDA) sensors, extracts novel features from the data and utilizes machine learning methodologies to detect high or low cognitive load. The developed framework was evaluated on a collaborative assembly scenario with a user study. The results show that the framework is able to reliably recognize high cognitive load and it is a first step in enabling robots to understand better about their human teammates.

15:15-16:15 WePIP.9

Human Social Feedback for Efficient Interactive Reinforcement Agent Learning, pp. 1-7

Lin, Jinying	Ocean University of China
Zhang, Qilei	Ocean University of China, Institute of Information Science And
Gomez, Randy	Honda Research Institute Japan Co., Ltd
Nakamura, Keisuke	Honda Research Institute Japan Co., Ltd
He, Bo	Ocean University of China
Li, Guangliang	Ocean University of China

As a branch of reinforcement learning, interactive reinforcement learning mainly studies the interaction process between humans and agents, allowing agents to learn from the intentions of human users and adapt to their preferences. In most of the current studies, human users need to intentionally provide explicit feedback via pressing keyboard buttons or mouse clicks. However, in our paper, we proposed an interactive reinforcement learning method that facilitates an agent to learn from human social signals --- facial feedback via a ordinary camera and gestural feedback via a leap motion sensor. Our method provides a natural way for ordinary people to train agents how to perform a task according to their preferences. We tested our method in two reinforcement learning benchmarking domains --- LoopMaze and Tetris, and compared to the state of the art --- the TAMER framework. Our experimental results show that when learning from facial feedback the recognition of which is very low, the TAMER agent can get a similar performance to that of learning from keypress feedback with slightly more feedback. When learning from gestural feedback with a more accurate recognition, the TAMER agent can obtain a similar performance to that of learning from keypress feedback with much less feedback received. Moreover, our results indicate that the recognition error of facial feedback has a large effect on the agent performance in the beginning training process than in the later training stage. Finally, our results indicate that with enough recognition accuracy, human social signals can effectively improve the learning efficiency of agents with less human feedback.

15:15-16:15 WePIP.10

Model Mediated Teleoperation with a Hand-Arm Exoskeleton in Long Time Delays Using Reinforcement Learning, pp. 1-8

Beik Mohammadi, Hadi	Bosch Center for Artificial Intelligence
Kerzel, Matthias	Uni Hamburg
Pleintinger, Benedikt	Institute of Robotics andMechatronics, GermanAerospaceCenter (DLR
Hulin, Thomas	German Aerospace Center (DLR)
Reisich, Philipp	German Aerospace Center (DLR)
Schmidt, Annika	Technical University of Munich (TUM)
Pereira, Aaron	German Aerospace Center (DLR)
Wermter, Stefan	University of Hamburg
Lii, Neal Y.	German Aerospace Center (DLR)

Telerobotic systems must adapt to new environmental conditions and deal with high uncertainty caused by long-time delays. As one of the best alternatives to human-level intelligence, Reinforcement Learning (RL) may offer a solution to cope with these issues. This paper proposes to integrate RL with the Model Mediated Teleoperation (MMT) concept. The teleoperator interacts with a simulated virtual environment, which provides instant feedback. Whereas the data from the real environment is delayed. The MMT is realized in combination with an intelligent system with two layers. The first layer utilizes Dynamic Movement Primitives (DMP) which accounts for certain changes in the slave environment. And, the second layer addresses the problems caused by uncertainty in the model using RL methods. Augmented reality was also provided to fuse the slave device and virtual environment models for the teleoperator. Implemented on DLR's Exodex Adam hand-arm haptic exoskeleton, the results show RL methods are able to find different solutions when changes are applied to the object position after the demonstration. The results also show DMPs to be effective at adapting to new conditions where there is no uncertainty involved.

15:15-16:15 WePIP.11

Education for New Human–Robot Coexistence: Countereffect and "Paragmatism" for the Weak Robot, pp. 1-6

Shimoyama, Hiroya	Nagoya University of Arts

In this research, I consider the education experience with robots philosophically. First, I analyze Japanese opinion and thinking in the information society, by which people learn the passing and instantaneous effects in society; this thinking of effects leads to a misunderstood interpretation of pragmatism. Then, by referring to famous pragmatist John Dewey, I show that education is the process of solving the proposed question. The question represents a mediation between the teacher and the student, creating a new to teach–to be taught relationship. From this point, I reconsider the moral philosophy of Immanuel Kant, which is also a kind of education—it is the process of finding "Otherness" inside. Then, I criticize the attempt of Wallach and Allen "to teach ethics to robots," or the learning of machines. Finally, I propose the new concept of "paragmatism" as criticizing various forms of pragmatic thought and Kant's philosophy and offer a methodology to oppose information society by new thinking and coexistence with robots. Taking Michio Okada's "weak robot" as an example, I show the way to counter the present tendency, which aims for a temporary and facile effect. Robots can give us clues to question our experience and become our partners for new thinking and reality.

15:15-16:15 WePIP.12

A Novel DMP Formulation for Global and Frame Independent Spatial Scaling in the Task Space, pp. 1-6

Koutras, Leonidas	Aristotle University of Thessaloniki
Doulgeri, Zoe	Aristotle University of Thessaloniki

In this work we study the DMP spatial scaling in the Cartesian space. The DMP framework is claimed to have the ability to generalize learnt trajectories to new initial and goal positions, maintaining the desired kinematic pattern. However we show that the existing formulations present problems in trajectory spatial scaling when used in the Cartesian space for a wide variety of tasks and examine their cause. We then propose a novel formulation alleviating these problems. Trajectory generalization analysis, is performed by deriving the trajectory tracking dynamics. The proposed formulation is compared with the existing ones through simulations and experiments on a KUKA LWR 4+ robot.

15:15-16:15 WePIP.13

Recognizing the Waving Gesture in the Interaction with a Social

Robot, pp. 1-6

Castellano, Giovanna	University of Bari Aldo Moro
Cervelione, Antonio	Università Degli Studi Di Bari
Cianciotta, Marco	University of Bari
De Carolis, Berardina Nadja	University of Bari
Vessio, Gennaro	University of Bari

Humans use a wide range of non-verbal social signals while communicating with each other. Gestures are part of these signals and social robots should be able to recognize them for responding appropriately during a dialogue and being more socially believable. Gesture recognition is a hot topic in Computer Vision since a long time. This is particularly due to the fact that the segmentation of foreground objects from a cluttered background is a challenging problem, especially if it has to be performed in real-time. In this paper, we propose a vision-based framework for making social robots capable of recognizing and responding in real-time to a specific greeting gesture, namely the hand waving. The framework is based on a Convolutional Neural Network model trained to recognize hand gestures. Preliminary experiments in a lab setup with the social robot Pepper indicate that the robot correctly recognizes the wave gesture 90% of the times and answers appropriately in real-time by waving itself, thus increasing its social believability.

15:15-16:15 WePIP.14

Students Participate and Evaluate the Design and Development of a Social Robot, pp. 1-6

Christodoulou, Panagiota	University of Western Macedonia
Reid, Alecia Adelaide May	University of Cadiz
Pnevmatikos, Dimitris	University of Western Macedonia
Rioja, Carlos	University of Cadiz
Fachantidis, Nikoloas	University of Macedonia

Scholars have highlighted the importance of the humanoid appearance and the integration of various social cues for the design of Socially Assistive Robots for Education (SAR). However, designing a SAR for education omitting the stakeholders that will exploit it might prove a risky task. The aim of the current study, on the one hand, was to present the design of a SAR for Science Technology Engineering and Mathematics (STEM) education developed through stakeholders' involvement in various steps of the approach. On the other hand, the study aimed to present the evaluation of the prototype robot through a STEM-oriented robot-assisted collaborative online teaching-learning sequence. Preliminary results indicate that participants endorsed the appearance and non-verbal behavior of the robot above chance level, while gender and age-related differences were revealed regarding the most appealing feature of the robot. Implications for Human-Robot Interaction are discussed.

15:15-16:15 WePIP.15

ARI: The Social Assistive Robot and Companion, pp. 1-7

Cooper, Sara	PAL Robotics
Di Fava, Alessandro	PAL Robotics SL
Vivas, Carlos	PAL Robotics
Marchionni, Luca	Pal Robotics SL
Ferro, Francesco	PAL Robotics

With the world population aging and the number of healthcare users with multiple chronic diseases increasing, healthcare is becoming more costly, and as such, the need to optimise both hospital and in-home care is of paramount importance. This paper reviews the challenges that the older people, people with mobility constraints, hospital patients and isolated healthcare users face, and how socially assistive robots can be used to help them. Related promising areas and limitations are highlighted. The main focus is placed on the newest PAL Robotics' robot: ARI, a high-performance social robot and companion designed for a wide range of multi-modal expressive gestures, gaze and personalised behaviour, with great potential to become part of the healthcare community by applying powerful AI algorithms. ARI can be used to help administer first-care attention, providing emotional support to people who live in isolation, including the elderly population or healthcare users who are confined because of infectious diseases such as Covid-19. The ARI robot technical features and potential applications are introduced in this paper.

15:15-16:15 WePIP.16

Discovering SOCIABLE: Using a Conceptual Model to Evaluate the Legibility and Effectiveness of Backchannel Cues in an Entertainment Scenario, pp. 1-8

Andriella, Antonio	IRI, CSIC-UPC
Huertas, Rubén	Universitat De Barcelona
Forgas, Santiago	Universitat De Barcelona
Torras, Carme	Csic - Upc
Alenyà, Guillem	CSIC-UPC

Robots are expected to become part of everyday life. However, while there have been important breakthroughs during the recent decades in terms of technological advances, the ability of robots to interact with humans intuitively and effectively is still an open challenge. In this paper, we aim to evaluate how humans interpret and leverage backchannel cues exhibited by a robot which interacts with them in an entertainment context. To do so, a conceptual model was designed to investigate the legibility and the effectiveness of a designed social cue, called SOCial ImmediAcy BackchanneL cuE (SOCIABLE), on participant's performance. In addition, user's attitude and cognitive capability were integrated into the model as an estimator of participants' motivation and ability to process the cue. In working toward such a goal, we conducted a two-day long user study (N=114) at an international event with untrained participants who were not aware of the social cue the robot was able to provide. The results showed that participants were able to perceive the social signal generated from SOCIABLE and thus, they benefited from it. Our findings provide some important insights for the design of effective and instantaneous backchannel cues and the methodology for evaluating them in social robots.

15:15-16:15 WePIP.17

Integrating an Observer in Interactive Reinforcement Learning to Learn Legible Trajectories, pp. 1-8

Bied, Manuel	Sorbonne University
Chetouani, Mohamed	Sorbonne University

An important aspect of Human-Robot-cooperation is that the robot is capable of clearly communicating its intentions to its human collaborator. This communication of intentions often requires the generation of legible motion trajectories. The concept of legible motion is usually not studied together with machine learning. Studying these fields together is an important step towards better Human-Robot cooperation. In this paper, we investigate interactive robot learning approaches with the aim of developing models that are able to generate legible motions by taking observer feedback into account. We explore how to integrate the observer feedback into a Reinforcement Learning (RL) framework. We do this by proposing three different observer algorithms as observer strategies in an interactive RL scheme and compare with one non-interactive RL algorithm as baseline. For the observer strategies we vary the method how the observer estimates how likely the agent is going for the target goal. We evaluate our approach on five environments and calculate the legibility of the learned trajectories. The results show that the legibility of the learned trajectories is significantly higher while integrating the feedback from the observer compared with a standard Q-Learning algorithm not using the observer feedback.

15:15-16:15 WePIP.18

Effects of Social Touch from an Agent in Virtual Space: Comparing Visual Stimuli and Virtual-Tactile Stimuli, pp. 1-7

Higashino, Kana	Doshisha University
Kimoto, Mitsuhiko	Keio University
Iio, Takamasa	University of Tsukuba / JST PRESTO
Shimohara, Katsunori	Doshisha University
Shiomi, Masahiro	ATR

Although social touch in physical space has been scrutinized for its positive effects on people, the effects of social touch in virtual space has been neglected. In virtual space, two types of social touch can be designed, a touch with only visual stimuli and a touch with both visual and tactile stimuli. This paper investigates the effects of the two types of agent's social touch on users in the context where the agent praises

their performance of a task in virtual space. Based on past studies of social touch, we hypothesized that the two types of agent's social touch in virtual space would improve the user's task motivation, task performance, and the agent's likability. We experimentally tested our hypotheses by comparing those variables among notouch, visual-touch, and visual-tactile touch groups. Since our results showed no significant differences among these groups, our hypotheses were not supported. However, a post-hoc analysis by gender suggests that the agent's social touch with both visual and tactile stimuli while praising male users increased their task motivation in virtual space.

15:15-16:15 WePIP.19

Acceptance of a Minimal Design of a Human Infant for Facilitating Affective Interaction with Older Adults: A Case Study Toward Interactive Doll Therapy, pp. 1-6

Sumioka, Hidenobu	ATR
Shiomi, Masahiro	ATR
Yamato, Nobuo	Japan Advanced Institute of Science and Technology
Ishiguro, Hiroshi	Osaka University

We introduce a minimal design approach to achieve a robot for interactive doll therapy. Our approach aims for positive interactions with older adults with dementia by just expressing the most basic elements of human-like features and relying on the user's imagination to supplement the missing information. Based on this approach, we developed HIRO, a baby-sized robot with abstract body representation and without facial expressions. The recorded voice of a real human infant emitted by robots enhance human-like features of the robot and then facilitate emotional interaction between older people and the robot. A field study showed that HIRO was accepted by older adults with dementia and facilitated positive interaction by stimulating their imagination.

15:15-16:15 WePIP.20

Learning to Grasp 3D Objects Using Deep Residual U-Nets, pp. 1-7

Li, Yikun	University of Groningen
Schomaker, Lambert R.B.	University of Groningen
Kasaei, Hamidreza	University of Groningen

Grasp synthesis is one of the challenging tasks for any robot object manipulation task. In this paper, we present a new deep learning-based grasp synthesis approach for 3D objects. In particular, we propose an end-to-end 3D Convolutional Neural Network to predict the objects' graspable areas. We named our approach Res-U-Net since the architecture of the network is designed based on U-Net structure and residual network-styled blocks. It devised to plan 6-DOF grasps for any desired object, be efficient to compute and use, and be robust against varying point cloud density and Gaussian noise. We have performed extensive experiments to assess the performance of the proposed approach concerning graspable part detection, grasp success rate, and robustness to varying point cloud density and Gaussian noise. Experiments validate the promising performance of the proposed architecture in all aspects. A video showing the performance of our approach in the simulation environment can be found at http://youtu.be/5_yAJCc8owo.

15:15-16:15 WePIP.21

Studying Drink-Serving Service Robots in the Real World, pp. 1-6

Langedijk, Rosalyn Melissa	University of Southern Denmark
odabasi, cagatay	Fraunhofer IPA
Fischer, Kerstin	University of Southern Denmark
Graf, Birgit	Fraunhofer IPA

Field studies where robots are tested in real life settings bring different challenges for researchers, robotics scientists and users. In this paper, we address some of the challenges we encountered when testing two different drink-serving service robots in the wild. We collect challenges from three different experiments. Two experiments were conducted in elderly care facilities, while a third experiment took place in the lobby of a concert hall. We focus on the challenges that researchers face during the preparation phase and the on-set deployment phase when testing robots in the wild. We point to potential difficulties that may arise and present some practical solutions to the issues encountered. Our results suggest that lab studies do not sufficiently prepare the researcher for research 'in the wild.'

15:15-16:15 WePIP.22

Performing Human Robot Interaction User Studies in Virtual Reality, pp. 1-6

Wijnen, Luc Bernardus Jozef	University of Bristol, University of the West of England, Bristo
Bremner, Paul	University of the West of England
Lemaignan, Séverin	University of the West of England
Giuliani, Manuel	University of the West of England, Bristol

This study investigated whether virtual reality could be used as platform for conducting human-robot interaction user studies. It was investigated whether user studies performed in virtual reality elicited realistic responses from participants. To answer this question, a real world study was replicated as closely as possible in virtual reality, where a robot tour guide asked participants to keep a secret. The experiment consisted of a virtual museum tour where the robot acted as the tour guide while displaying either social or non-social behaviour. The measurements taken in this study were the objective measurement whether the participants kept the robot's secret or not. Questionnaires were taken to investigate participants' perception of the robot and its feelings, as well as their experienced level of presence and their tendency to become immersed in the virtual environment. Results show that the participants responded differently in the virtual reality study when compared to the original real world study, where the secret was kept more often for the non-social robot, but less often for the social robot. In both the original and replicated study a strong, positive correlation was found between participants' perception of the robot as a social being and their tendency to keep the robot's secret. These inconclusive findings, some changes that were required for the virtual environment compared to the original study, and different participant demographics indicate that more work is needed to determine whether virtual reality can be used as a tool to conduct human-robot interaction experiments.

15:15-16:15 WePIP.23

Training Human Teacher to Improve Robot Learning from Demonstration: A Pilot Study on Kinesthetic Teaching, pp. 1-7

Sakr, Maram	University of British Columbia
Freeman, Martin	Stanford University
Van der Loos, H.F. Machiel	University of British Columbia (UBC)
Croft, Elizabeth	Monash University

Robot Learning from Demonstration (LfD) allows robots to implement autonomous manipulation by observing the movements executed by a demonstrator. As such, LfD has been established as a key element for useful user interactions in everyday environments. Kinesthetic teaching, a teaching technique within LfD, entails guiding the robot to implicitly model the desired task through physical demonstration. When demonstrating complex actions on a multi-DoF manipulator, novice users typically encounter difficulties with trajectory continuity and joint orientation, necessitating training by an expert. A comparison between kinesthetic, observational and discovery-learning is conducted in a study of nine novice users. The kinesthetic method utilizes record and playback functions implemented on a 7-DoF Barrett Technology WAM robot. A novice user passively holds the arm as an expert's trajectory is replayed. A visual demonstration by the expert is used for the observational training group, while the discovery-learning group does not receive a demonstration and is left to creatively produce the trajectory on their own. Task-space performance is evaluated pre- and post-training for each user to determine the relative and absolute performance improvements of the groups across the three training approaches. Absolute performance improvements are compared to the performance of an expert and a minimum-jerk trajectory to gauge how skillful the participant becomes with respect to the expert. The kinesthetic approach shows superior indicators of performance in trajectory similarity to the minimum-jerk trajectory with 39% and 13% over the observational and discovery methods, while observational training shows higher improvement in terms of the smoothness of the velocity profile.

15:15-16:15 WePIP.24

A Hand Motion-Guided Articulation and Segmentation Estimation, pp.

1-7

Hartanto, Richard Sahala	The University of Tokyo
Ishikawa, Ryoichi	The University of Tokyo
Roxas, Menandro	The University of Tokyo
Oishi, Takeshi	The University of Tokyo

In this paper, we present a hand-motion-based method for simultaneous articulation-model estimation and segmentation of objects in RGB-D images. The hand-motion information is first used to calculate an initial guess of the articulated model (prismatic or revolute joint) of the target object. Subsequently, the hand trajectory is used as a constraint to optimize the articulation parameters during the ICP-based alignment of the sequential point clouds of the object from the RGB-D images. Finally, the target regions are selected from the cluster of aligned point clouds that move symmetrically with respect to the detected articulation model. The experimental results demonstrate the robustness of the proposed method for various types of objects.

15:15-16:15 WePIP.25

Would You Take Advice from a Robot? Developing a Framework for Inferring Human-Robot Trust in Time-Sensitive Scenarios, pp. 1-7

Xu, Jin	Georgia Institute of Technology
Howard, Ayanna	Georgia Institute of Technology

Trust is a key element for successful human-robot interaction. One challenging problem in this domain is the issue of how to construct a formulation that optimally models this trust phenomenon. This paper presents a framework for modeling human-robot trust based on representing the human decision-making process as a formulation based on trust states. Using this formulation, we then discuss a generalized model of human-robot trust based on Hidden Markov Models and Logistic Regression. The proposed approach is validated on datasets collected from two different human subject studies in which the human is provided the ability to take advice from a robot. Both experimental scenarios were time-sensitive, in that a decision had to be made by the human in a limited time period, but each scenario featured different levels of cognitive load. The experimental results demonstrate that the proposed formulation can be utilized to model trust, in which the system can predict whether the human will decide to take advice (or not) from the robot. It was found that our prediction performance degrades after the robot made a mistake. The validation of this approach on two scenarios implies that this model can be applied to other interactive scenarios as long as the interaction dynamics fits into the proposed formulation. Directions for future improvements are discussed.

15:15-16:15 WePIP.26

Older Adults' Opinion on Social Robots As Companion, pp. 1-6

FakhrHosseini, Shabnam	Massachusetts Institute of Technology
Lee, Chaiwoo	Massachusetts Institute of Technology
Miller, Julie	MIT AgeLab
Patskanick, Taylor	Massachusetts Institute of Technology
Coughlin, Joseph	Massachusetts Institute of Technology

During the last decade, attention towards using social robots as a potential technology to improve the older adults' life quality has increased. Loneliness, caregiving, medication management, and activities of daily living are some of the topics that researchers are trying to address with the social robots. Although research has uncovered important factors in acceptance of social robots, older adults, especially the oldest old population who are 85 years old and older, have been underrepresented in these studies. In this study, a panel of older adults 85 years of age and older were recruited to address this gap by understanding their attitudes towards and experiences with smart technologies and social robots. The panel engagement included three parts. First, participants completed a questionnaire about technology adoption, trust in technology, and acceptance of social robots. An in-person meeting was then convened with the participants. During the meeting, participants were presented an overview and a demonstration of social robots and smart virtual assistants. Lastly, participants discussed their opinions about technology in general and social robots specifically in smaller focus groups assigned based on level of technology experience. Results show that older adults' acceptance of social robots as companions was positively impacted by their experience of seeing the robots and their limited interaction with it. However, this impact only has been seen in early and middle-of-the-road adopter groups. Findings have been discussed with the role of important variables on older adults' acceptance of social robots as their companions.

Technical Program for Thursday September 3, 2020

ThPIP Main Room

Poster Session 2 (Regular Session)

11:30-12:30 ThPIP.1

Multi-Camera Torso Pose Estimation Using Graph Neural Networks, pp. 1-6

Rodriguez-Criado, Daniel — Aston University
Bachiller, Pilar — University of Extremadura
Bustos, Pablo — Universidad De Extremadura
Vogiatzis, George — Aston University
Manso, Luis J. — Aston University

Estimating the location and orientation of humans is an essential skill for service and assistive robots. To achieve a reliable estimation in a wide area such as an apartment, multiple RGBD cameras are frequently used. Firstly, these setups are relatively expensive. Secondly, they seldom perform an effective data fusion using the multiple camera sources at an early stage of the processing pipeline. Occlusions and partial views make this second point very relevant in these scenarios. The proposal presented in this paper makes use of graph neural networks to merge the information acquired from multiple camera sources, achieving a mean absolute error below 125mm for the location and 10º for the orientation using low-resolution RGB images. The experiments, conducted in an apartment with three cameras, benchmarked two different graph neural network implementations and a third architecture based on fully connected layers. The software used has been released as open-source in a public repository.

11:30-12:30 ThPIP.2

Social Bonding Increases Unsolicited Helpfulness towards a Bullied Robot, pp. 1-6

Kühnlenz, Barbara — Coburg University of Applied Sciences and Arts
Kühnlenz, Kolja — Coburg University of Applied Sciences and Arts

This paper is a first step towards the investigation of civil courage in human-robot interaction (HRI). The main research question is if human users would help a robot being bullied by other humans. Previous work showed that pro-social behavior can be induced in human users towards a robot pro-actively asking for their help in order to accomplish a specific task by applying mechanisms of social bonding. In contrast, this paper investigates unsolicited helpful behavior towards a robot being bullied by a third person subsequent to an interaction task. To this end, social bonding in terms of small talk including explicit emotional adaptation to induce a feeling of similarity is applied to a human-robot dialog scenario in a user study. As an interaction context, a cooperative object classification task is chosen, where a robot reads objects from a list needed by the robot to fulfill another task later. To induce bullying behavior, the list is took away from the robot by a disturbing third person after the completed interaction. The two experimental conditions of the study differ in whether or not social bonding is applied prior to the interaction. According to previous work, results showed increased ratings for social presence and anthropomorphism, as well as increased unsolicited helpfulness of the participants in the social bonding condition. Surprisingly, unsolicited help occurred only verbally and directed towards the robot and none of the human users took action against the bullying third person. It is discussed, that this may be due to social-psychological side-effects caused by the passive presence of the human experimental examiner and that additional channels of emotional adaptation by the robot may be required.

11:30-12:30 ThPIP.3

Living-Lab and Experimental Workshops for Design of I-RobEka Assistive Shopping Robot: ELSI Aspects with MEESTAR, pp. 1-6

Fink, Vera — HCI Media Informatics
Börner, Andy — Technische Universitaet Chemnitz
Eibl, Maximilian — Technische Universitaet Chemnitz

If robotic assistance is to be used in the near future by aging adults, it must have an acceptable design. In the process of applying a MEESTAR model in project to measure, predict, and justify the acceptance of robot assistants in a supermarket setting, we investigated the ethical ramifications of these robots. The method used was very well suited for participatory technology development. Does the appearance of the robot affect acceptance? The aim of the exploratory workshops was to gain insights into this question before evaluation in tangible environment. Our research approach, in addition to the construction of the robot, poses a significant difference to the traditional design and evaluation procedure.

11:30-12:30 ThPIP.4

Human-Robot Artistic Co-Creation: A Study in Improvised Robot Dance, pp. 1-6

Thorn, Oscar — Orebro University
Knudsen, Peter — Orebro University
Saffiotti, Alessandro — Orebro University

Joint artistic performance, like music, dance or acting, provides an excellent domain to observe the mechanisms of human-human collaboration. In this paper, we use this domain to study human-robot collaboration and co-creation. We propose a general model in which an AI system mediates the interaction between a human performer and a robotic performer. We then instantiate this model in a case study, implemented using fuzzy logic techniques, in which a human pianist performs jazz improvisations, and a robot dancer performs classical dancing patterns in harmony with the artistic moods expressed by the human. The resulting system has been evaluated in an extensive user study, and successfully demonstrated in public live performances.

11:30-12:30 ThPIP.5

Robot Player Adaptation to Human Opponents in Physical, Competitive Robogames, pp. 1-6

Bonarini, Andrea — Politecnico Di Milano
Boriero, Stefano — Politecnico Di Milano
Lopes Silva de Oliveira, Ewerton — Politecnico Di Milano

A key issue for a device involved in a competitive game is to be able to match the ability of the opponent, thus making the game interesting. When the game is played by a human player against a machine, this should be able to adapt online to the opponent's ability, which may change during the game. When the playing machine is a robot, and the game involves physical activity, adaptation should consider the player's ability, but also other aspects directly related to the physical nature of the game. Adaptation could be obtained either intrinsically, by designing the interaction, or explicitly, by modeling aspects of the opponent that can enable to estimate performance, behaviors, and strategies. We present in this paper different approaches to design the two types of adaptation, together with two competitive, physically interactive robogames exploiting them.

11:30-12:30 ThPIP.6

Autonomous Initiation of Human Physical Assistance by a Humanoid, pp. 1-6

Bolotnikova, Anastasia — SoftBank Robotics Europe, Univerisy of Montpellier
Courtois, Sébastien — Soft Bank Robotics Europe
Kheddar, Abderrahmane — CNRS-AIST

We study the use of humanoid robot technology for physical assistance in motion for a frail person. A careful design of a whole-body controller for a humanoid robot needs to be developed in order to ensure efficient, intuitive and secure interaction between humanoid-assistant and human-patient. Here, we present a design and implementation of a whole-body controller that enables a humanoid robot with a mobile base to autonomously reach a person, perform audiovisual communication of intent, and establish several physical contacts for initiating physical assistance. Our controller uses (i) visual human perception as a feedback for navigation and (ii) joint residual signal based contact detection for closed-loop physical contact creation. We assess the developed controller on a healthy subject and report on the experiments achieved and the results.

11:30-12:30 ThPIP.7

Investigating Reward/Punishment Strategies in the Persuasiveness of Social Robots, pp. 1-6

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

This paper presents the results of a user study designed to investigate persuasiveness of social robots. In this design, the robot attempts to persuade users in two different conditions comparing to a control condition. In one condition, the robot aims at persuading users by giving them a reward. In the second condition, the robot tries to persuade by punishing users. The results indicated that the robot succeeded to persuade the users to select a less-desirable choice comparing to a better one. However, no difference found in the perception of the robot comparing the two strategies. The results suggest that social robots are capable to persuade users objectively, but further investigation is required to investigate persuasion subjectively.

11:30-12:30 ThPIP.8

Towards Designing Privacy-Compliant Social Robots for Use in Private Households: A Use Case Based Identification of Privacy Implications and Potential Technical Measures for Mitigation, pp. 1-8

Horstmann, Björn	University of Bielefeld
Diekmann, Niels	FH Bielefeld University of Applied Sciences
Buschmeier, Hendrik	Bielefeld University
Hassan, Teena	Bielefeld University

Social robots are expected to increasingly appear in private households. The deployment of social robots in the private spheres of humans raises concerns regarding privacy protection. This paper analyses some of the legal implications of using social robots in private households on the basis of four practical use cases. It identifies the privacy concerns associated with each use case and proposes potential technical measures in the form of an initial concept for a companion privacy-app that could resolve or mitigate these concerns, and thereby enhance privacy compliance. The proposed app concept was evaluated in an exploratory study with ten participants. The preliminary results are encouraging and show that this concept has the potential to support the maintenance of privacy and provide control over the user's personal data and the robot's functions.

11:30-12:30 ThPIP.9

Migratable AI: Effect of Identity and Information Migration on Users' Perception of Conversational AI Agents, pp. 1-8

Tejwani, Ravi	MIT
Moreno Santana, Felipe Ignacio	MIT Media Lab
Jeong, Sooyeon	MIT
Park, Hae Won	MIT
Breazeal, Cynthia	MIT

Conversational AI agents are proliferating, embodying a range of devices such as smart speakers, smart displays, robots, cars, and more. We can envision a future where a personal conversational agent could migrate across different form factors and environments to always accompany and assist its user to support a far more continuous, personalized, and collaborative experience. This opens the question of what properties of a conversational AI agent migrate across forms, and how it would impact user perception. To explore this, we developed a Migratable AI system where a user's information and/or the agent's identity can be preserved as it migrates across form factors to help its user with a task. We validated the system by designing a 2x2 between-subjects study to explore the effects of information migration and identity migration on user perceptions of trust, competence, likeability, and social presence. Our results suggest that identity migration had a positive effect on trust, competence, and social presence, while information migration had a positive effect on trust, competence, and likeability. Overall, users report the highest trust, competence, likeability, and social presence towards the conversational agent when both identity and information were migrated across embodiments.

11:30-12:30 ThPIP.10

Operation Identification by Shared Tactile Perception Based on Skin Vibration, pp. 1-6

Katagiri, Takumi	Nagoya Institute of Technology
Tanaka, Yoshihiro	Nagoya Institute of Technology
Sugiura, Shimpei	Nagoya Institute of Technology
Minamizawa, Kouta	Keio University
Watanabe, Junji	NTT Communication Science Laboratories
Prattichizzo, Domenico	University of Siena

Tactile sensation contributes to sensory-motor control and facilitates skillful manipulation of objects. If the tactile sensation can be shared between two partners, the state of each partner can be partially observed by the other, and the possibilities for cooperative work may be expanded. Recently, examples of utilizing tactile sensation in human-robot cooperative work have been proposed. For cooperative work between people, it is necessary to investigate the basic ability of humans to identify other person's motions and operations by tactile presentation. To avoid hindering work performed with the hands and fingertips, the sensation must be presented elsewhere. This study investigates the possibility of identifying other person's tool operations by presenting tactile information induced on his/her finger with a wearable vibrator on the arm. A wearable skin vibration sensor was employed to acquire tactile information during an experiment in which five different tool operations were tested. This sensor measures skin vibration while directly touching the target. We proposed a non-linear signal processing function to adjust the intensity of the skin vibration to within the range of human sensitivity for tactile presentation. We compared vibrotactile stimulation between the non-linear and linear corrections, and then conducted experiments on identifying operations. The results showed that the non-linear correction increased small signals and enhanced the variance of large signals, and that operations were significantly identified by tactile presentation to the arm.

11:30-12:30 ThPIP.11

Robust Real-Time Hand Gestural Recognition for Non-Verbal Communication with Tabletop Robot Haru, pp. 1-8

Brock, Heike	Honda Research Inst. Japan Co., Ltd
Sabanovic, Selma	Indiana University Bloomington
Nakamura, Keisuke	Honda Research Institute Japan Co., Ltd
Gomez, Randy	Honda Research Institute Japan Co., Ltd

In this paper, we present our work in close-distance non-verbal communication with tabletop robot Haru through hand gestural interaction. We implemented a novel hand gestural understanding system by training a machine-learning architecture for real-time hand gesture recognition with the Leap Motion. The proposed system is activated based on the velocity of a user's palm and index finger movement, and subsequently labels the detected movement segments under an early classification scheme. Our system is able to combine multiple gesture labels for recognition of consecutive gestures without clear movement boundaries. System evaluation is conducted on data simulating real human-robot interaction conditions, taking into account relevant performance variables such as movement style, timing and posture. Our results show robustness in hand gesture classification performance under variant conditions. We furthermore examine system behavior under sequential data input, paving the way towards seamless and natural real-time close-distance hand-gestural communication in the future.

11:30-12:30 ThPIP.12

Exercising with an "Iron Man": Design for a Robot Exercise Coach for Persons with Dementia, pp. 1-7

Cooney, Martin	Halmstad University

Orand, Abbas	Halmstad University
Larsson, Hanna	Halmstad University
Pihl, Jacob	Halmstad University
Aksoy, Eren Erdal	Halmstad University

Socially assistive robots are increasingly being designed to interact with humans in various therapeutical scenarios. We believe that one useful scenario is providing exercise coaching for Persons with Dementia (PWD), which involves unique challenges related to memory and communication. We present a design for a robot that can seek to help a PWD to conduct exercises by recognizing their behaviors and providing appropriate feedback, in an online, multimodal, and engaging way. Additionally, following a mid-fidelity prototyping approach, we report on some observations from an exploratory user study using a Baxter robot; although limited by the sample size and our simplified approach, the results suggested the usefulness of the general scenario, and that the degree to which a robot provides feedback--occasional or continuous--could moderate impressions of attentiveness or fun. Some possibilities for future improvement are outlined, touching on richer recognition and behavior generation strategies based on deep learning and haptic feedback, toward informing next designs.

11:30-12:30 ThPIP.13

*Improving Quality of Life with a Narrative Robot Companion: II – Creating Group Cohesion Via Shared Narrative Experience**, pp. 1-8

Uchida, Takahisa	Osaka University
Ishiguro, Hiroshi	Osaka University
Dominey, Peter Ford	INSERM Stem Cell & Brain Research Institute

One of the most difficult things for social robots is to enter the realm of human social relations. Here, we exploit recent advances in natural language processing (NLP) that provide robots access to human experience, which can allow them to enter into human social relations. When people are put together in arbitrary conditions, as in a home for the elderly, it can be difficult for them to share experience. To address this, we use recent advances in NLP to allow the robot to discover shared narratives between such group members. Our narrative companion extends the human capability to make social narrative links for building group coherence through sharing experience. Requirements are identified for a narrative companion to allow individuals within a group to focus their interactions on shared experiences and interests, to improve group coherence. The system should collect and organize members' experiences, and should discover semantic similarity between different members' experiences in order to create a group narrative. It should then accompany the group in their cohesion-enhancing experience of this narrative. Based on these requirements, and extending our previous work, we implement the V2.0 narrative companion on the Pepper robot. The system is validated in a case study where participants provide 5 favorite photographs and short answers to questions. The Narrative Semantic Similarity Analysis System (NarSim) generates a meaningful trajectory of narrative linking people and events depicted in the photographs. With this, Pepper then accompanies the group and prompts group members to enrich the shared narrative, to further enhance the group pleasure and cohesion. Results are presented, and future applications for improved quality of life are discussed.

11:30-12:30 ThPIP.14

Usability Test of Master Devices for Robotic Vascular Intervention Procedure, pp. 1-6

Song, HwaSeob	Hanyang.University
Woo, Jaehong	Hanyang University
Won, Jong Yun	Yonsei University, College of Medicine
Yi, Byung-Ju	Hanyang University

Conventional VIR presents a few challenges to overcome, which are radiation exposure issue during VIR under X-ray, physical and mental burdens to the operator in handling catheter and guidewire. We propose a robotic approach to resolve such problems. Specifically, this paper deals with usability test of master devices to control four degrees of freedom (4-DOF) robotic vascular intervention system. The usability of two master devices was measured in terms of task completion time and NASA-TLX index. Both novice and expert group participated in master-slave vascular intervention procedure based on abdominal blood vessel phantom. We found that position to velocity based master device is much effective compared to position to position based master device.

11:30-12:30 ThPIP.15

Motion Trajectory Estimation of a Flying Object and Optimal Reduced Impact Catching by a Planar Manipulator, pp. 1-6

Paing, Min Set	Toyohashi University of Technology
Nshama, Enock William	Toyohashi University of Technology
Uchiyama, Naoki	Toyohashi University of Technology

Throwing and catching are fundamental motions for human beings, and may be applied for advanced human and robot collaborative tasks. Since catching motion is more difficult than throwing for a robot, this study deals with reduced impact catching of a flying object by a planar manipulator. The estimation of the object's trajectory is improved by the Kalman filter and the least squares fitting is proposed to accurately predict the catching time, position and velocity of the manipulator. To achieve reduced impact catching, the minimization of the total impact force in x and y-directions is proposed as an optimization problem. The fifth degree non-periodic B-spline curve is implemented to achieve smooth and continuous trajectories in the joint space. The effectiveness of the proposed approaches are demonstrated by simulation and experiment.

11:30-12:30 ThPIP.16

On the Expressivity of a Parametric Humanoid Emotion Model, pp. 1-6

Prajod, Pooja	Universität Augsburg
Hindriks, Koen	Vrije Universiteit Amsterdam

Emotion expression is an important part of human-robot interaction. Previous studies typically focused on a small set of emotions and a single channel to express them. We developed an emotion expression model that modulates motion, poses and LED features parametrically, using valence and arousal values. This model does not interrupt the task or gesture being performed and hence can be used in combination with functional behavioural expressions. Even though our model is relatively simple, it is just as capable of expressing emotions as other more complicated models that have been proposed in the literature. We systematically explored the expressivity of our model and found that a parametric model using 5 key motion and pose features can be used to effectively express emotions in the two quadrants where valence and arousal have the same sign. As paradigmatic examples, we tested for happy, excited, sad and tired. By adding a second channel (eye LEDs), the model is also able to express high arousal (anger) and low arousal (relaxed) emotions in the two other quadrants. Our work supports other findings that it remains hard to express moderate arousal emotions in these quadrants for both negative (fear) and positive (content) valence.

11:30-12:30 ThPIP.17

Context Dependent Trajectory Generation Using Sequence-To-Sequence Models for Robotic Toilet Cleaning, pp. 1-6

YANG, PIN-CHU	Waseda University, Cutieroid Project
Koganti, Nishanth	GEP Worldwide Inc
Garcia Ricardez, Gustavo Alfonso	Nara Institute of Science and Techonology (NAIST)
Yamamoto, Masaki	Panasonic
Takamatsu, Jun	Nara Institute of Science and Technology
Ogasawara, Tsukasa	Nara Institute of Science and Technology

A robust, easy-to-deploy robot for service tasks in a real environment is difficult to construct. Record-and-playback (R&P) is a method used to teach motor-skills to robots for performing service tasks. However, R&P methods do not scale to challenging tasks where even slight changes in the environment, such as localization errors, would either

require trajectory modification or a new demonstration. In this paper, we propose a Sequence-to-Sequence (Seq2Seq) based neural network model to generate robot trajectories in configuration space given a context variable based on real-world measurements in Cartesian space. We use the offset between a target pose and the actual pose after localization as the context variable. The model is trained using a few expert demonstrations collected using teleoperation. We apply our proposed method to the task of toilet cleaning where the robot has to clean the surface of a toilet bowl using a compliant end-effector in a constrained toilet setting. In the experiments, the model is given a novel offset context and it generates a modified robot trajectory for that context. We demonstrate that our proposed model is able to generate trajectories for unseen setups and the executed trajectory results in cleaning of the toilet bowl.

11:30-12:30 ThPIP.18

Relevant Perception Modalities for Flexible Human-Robot Teams, pp. 1-6

Höllerich, Nico — University of Bayreuth
Henrich, Dominik — University of Bayreuth

Robust and reliable perception plays an important role when humans engage into cooperation with robots in industrial or household settings. Various explicit and implicit communication modalities and perception methods can be used to recognize expressed intentions. Depending on the modality, different sensors, areas of observation, and perception methods need to be utilized. More modalities increase the complexity and costs of the setup. We consider the scenario of a cooperative task in a potentially noisy environment, where verbal communication is hardly feasible. Our goal is to investigate the importance of different, non-verbal communication modalities for intention recognition. To this end, we build upon an established benchmark study for human cooperation and investigate which input modalities contribute most towards recognizing the expressed intention. To measure the detection rate, we conducted a second study. Participants had to predict actions based on a stream of symbolic input data. Findings confirm the existence of a common gesture dictionary and the importance of hand tracking for action prediction when the number of feasible actions increases. The contribution of this work is a usage ranking of gestures and a comparison of input modalities to improve prediction capabilities in human-robot cooperation.

11:30-12:30 ThPIP.19

Social Robot Navigation Adapted to Time-Dependent Affordance Spaces: A Use Case for Caregiving Centers, pp. 1-6

Calderita, Luis V. — University of Extremadura
Vega, Araceli — University of Extremadura
Bustos, Pablo — Universidad De Extremadura
Núñez, Pedro — University of Extremadura

The use of socially assistive robots in real environments, such as nursing homes or geriatric residences, is spreading in recent years. Social robot navigation in these complex environments, with multiple users and dynamic objects, is an essential task for the next generation of service robots. This navigation must respect social rules, for example not to interrupt an interaction between two people or between a person and an object. Current navigation frameworks in robotics literature do not take into account the social complexity of the scenarios like, for example, the relation of the objects and their use by people with time. This article presents an approach to the idea of time-dependent social mapping. The main novelty is the definition and development of time-dependent affordance spaces. Each object has a zone that vary in function of time and the activities scheduled by the center's staff. Therefore, the planning of the best path by the robot takes into consideration this variation on time achieving a higher degree of social navigation. Several use cases have been performed in a simulated scenario to asses the robustness and validity of the proposal using these temporal variables.

11:30-12:30 ThPIP.20

The Use of Affective Care Robots Calls Forth Value-Based Consideration, pp. 1-6

Turja, Tuuli — Tampere University
Parviainen, Jaana — University of Tampere

Care work robotization is socially constructed by several mechanisms, including the law and the codes of ethics shared by occupational groups. Using the dichotomy of effective and affective robots, this study brings novel information to robot acceptance and, particularly, to the values and norms behind care workers' intentions to use care robots in the future. Data from 407 care workers with care-robot experience were analyzed in regression models. Robots of an effective design were highly accepted by care workers in hospitals and social housing but not as much in home care. Personal values were a significant factor only in the intention to use affective robots, whereas subjective norm had explanatory power regarding affective and effective robots. Thus, as the most consistent result, those respondents who found robot use compatible with the shared norms in their workplaces were more willing to use care robots as a part of their work. Personal values correlated with attitudes toward robots in general, while subjective norm was more strongly and specifically associated with care-robot acceptance. However, considering the maturity of today's care-robot technology, value-based assessments do not necessarily include anti-technology attitudes but, instead, call for better suiting technology applications.

11:30-12:30 ThPIP.21

When Would You Trust a Robot? a Study on Trust and Theory of Mind in Human-Robot Interactions, pp. 1-7

Mou, Wenxuan — University of Manchester
Ruocco, Martina — University of Manchester
Zanatto, Debora — University of Bristol
Cangelosi, Angelo — University of Manchester

Trust is a critical issue in human–robot interactions (HRI) as it is the core of human desire to accept and use a non-human agent. Theory of Mind (ToM) has been defined as the ability to understand the beliefs and intentions of others that may differ from one's own. Evidences in psychology and HRI suggest that trust and ToM are interconnected and interdependent concepts, as the decision to trust another agent must depend on our own representation of this entity's actions, beliefs and intentions. However, very few works take ToM of the robot into consideration while studying trust in HRI. In this paper, we investigated whether the exposure to the ToM abilities of a robot could affect humans' trust towards the robot. To this end, participants played a Price Game with a humanoid robot (Pepper) that was presented having either low-level ToM or high-level ToM. Specifically, the participants were asked to accept the price evaluations on common objects presented by the robot. The willingness of the participants to change their own price judgement of the objects (i.e., accept the price the robot suggested) was used as the main measurement of the trust towards the robot. Our experimental results showed that robots possessing a high-level of ToM abilities were trusted more than the robots presented with low-level ToM skills.

11:30-12:30 ThPIP.22

Development of a Shared Indoor Smart Mobility Platform Based on Semi-Autonomous Driving, pp. 1-8

Kang, Donghun — UNIST
Park, Haeun — UNIST
Kwak, Yoon Joung — UNIST
Kim, Byeongjin — Ulsan National Institute of Science and Technology
Kim, Seong Beom — Ulsan National Institute of Science and Technology
Kim, Donghyun — Ulsan National Institute of Science and Technology, UNIST
Lee, SeongJae — Ulsan National Institute of Science and Technology (UNIST)
kim, byounghern — Ulsan National Institute of Science and Technology
Lee, Hui Sung — UNIST (Ulsan National Institute of Science and Technology)

This paper details the development of a Shared Indoor Smart Mobility device called AngGo. As a precursor to the development process, we conducted user research on three kinds of outdoor personal mobility. Our goal was to determine the major differences between outdoor and indoor personal mobility and to ensure that AngGo would meet the requirements of indoor personal mobility in a practical way, as informed by the results of surveys and interviews. Tests were conducted on the

time-of-flight sensors to be used for indoor autonomous driving. Manual mode as well as the experiment based equations governing the sensors were optimized through user testing. Our observational experiments, which were carried out in the lobby of a building, showed that both autonomous and manual modes functioned as designed. This study makes a contribution to the literature by describing how our AngGo device features an autonomous driving platform that can transport riders around an indoor environment.

11:30-12:30 ThPIP.23

The Role of Social Cues for Goal Disambiguation in Human-Robot Cooperation, pp. 1-7

Vinanzi, Samuele	The University of Manchester
Cangelosi, Angelo	University of Manchester
Goerick, Christian	Honda Research Inst. Europe GmbH

Social interaction is the new frontier in contemporary robotics: we want to build robots that blend with ease into our daily social environments, following their norms and rules. The cognitive skill that bootstraps social awareness in humans is known as "intention reading" and it allows us to interpret other agents' actions and assign them meaning. Given its centrality for humans, it is likely that intention reading will foster the development of robotic social understanding. In this paper, we present an artificial cognitive architecture for intention reading in human-robot interaction (HRI) that makes use of social cues to disambiguate goals. This is accomplished by performing a low-level action encoding paired with a high-level probabilistic goal inference. We introduce a new clustering algorithm that has been developed to differentiate multi-sensory human social cues by performing several levels of clustering on different feature-spaces, paired with a Bayesian network that infers the underlying intention. The model has been validated through an interactive HRI experiment involving a joint manipulation game performed by a human and a robotic arm in a toy block scenario. The results show that the artificial agent was capable of reading the intention of its partner and cooperate in mutual interaction, thus validating the novel methodology and the use of social cues to disambiguate goals, other than demonstrating the advantages of intention reading in social HRI.

11:30-12:30 ThPIP.24

Robot Gesture Sonification to Enhance Awareness of Robot Status and Enjoyment of Interaction, pp. 1-8

Zahray, Lisa	Georgia Institute of Technology
Savery, Richard	Georgia Inst. of Technology
Syrkett, Liana	Georgia Institute of Technology
Weinberg, Gil	Georgia Inst. of Technology

We present a divergent approach to robotic sonification with the goal of improving the quality and safety of human-robot interactions. Sonification (turning data into sound) has been underutilized in robotics, and has broad potential to convey robotic movement and intentions to users without requiring visual engagement. We design and evaluate six different sonifications of movements for a robot with four degrees of freedom. Our sonification techniques include a direct mapping from each degree of freedom to pitch and timbre changes, emotion-based sound mappings, and velocity-based mappings using different types of sounds such as motors and music. We evaluate these sonifications using metrics for ease of use, enjoyment/appeal, and conveyance of movement information. Based on our results, we make recommendations to inform decisions for future robot sonification design. We suggest that when using sonification to improve safety of human-robot collaboration, it is necessary not only to convey sufficient information about movements, but also to convey that information in a pleasing and even social way to to enhance the human-robot relationship.

11:30-12:30 ThPIP.25

A Survey of Robotics and Emotion: Classifications and Models of Emotional Interaction, pp. 1-8

Savery, Richard	Georgia Inst. of Technology
Weinberg, Gil	Georgia Inst. of Technology

As emotion plays a growing role in robotic research it is crucial to develop methods to analyze and compare among the wide range of approaches. To this end we present a survey of 1427 IEEE and ACM publications that include robotics and emotion. This includes broad categorizations of trends in emotion input analysis, robot emotional expression, studies of emotional interaction and models for internal processing. We then focus on 232 papers that present internal processing of emotion, such as using a human's emotion for better interaction or turning environmental stimuli into an emotional drive for robotic path planning. We conducted constant comparison analysis of the 232 papers and arrived at three broad categorization metrics - emotional intelligence, emotional model and implementation - each including two or three subcategories. The subcategories address the algorithm used, emotional mapping, history, the emotional model, emotional categories, the role of emotion, the purpose of emotion and the platform. Our results show a diverse field of study, largely divided by the role of emotion in the system, either for improved interaction, or improved robotic performance. We also present multiple future opportunities for research and describe intrinsic challenges common in all publications.

ThT51 Room 1

Applications of Social Robots / Social Intelligence for Robots (III) (Regular Session)

Chair: Sugaya, Midori	Shibaura Institute of Technology
Co-Chair: Hindriks, Koen	Vrije Universiteit Amsterdam

12:45-12:55 ThT51.1

Physiological Data-Based Evaluation of a Social Robot Navigation System, pp. 1-6

Kivrak, Hasan	Karabuk University, Istanbul Technical University
Uluer, Pinar	Galatasaray University
Kose, Hatice	Istanbul Technical University
Gümüşlü, Elif	Yeditepe University
Erol Barkana, Duygun	Yeditepe University
Cakmak, Furkan	Yıldız Technical University
YAVUZ, SIRMA	Yildiz Technical University

The aim of this work is to create a social navigation system for an affective robot that acts as an assistant in the audiology department of hospitals for children with hearing impairments. Compared to traditional navigation systems, this system differentiates between objects and human beings and optimizes several parameters to keep at a social distance during motion when faced with humans not to interfere with their personal zones. For this purpose, social robot motion planning algorithms are employed to generate human-friendly paths that maintain humans' safety and comfort during the robot's navigation. This paper evaluates this system compared to traditional navigation, based on the surveys and physiological data of the adult participants in a preliminary study before using the system with children. Although the self-report questionnaires do not show any significant difference between navigation profiles of the robot, analysis of the physiological data may be interpreted that, the participants felt comfortable and less threatened in social navigation case.

12:55-13:05 ThT51.2

Interviewing Style for a Social Robot to Engage a Museum Visitor in an Interview for Marketing Research, pp. 1-6

Schermer, Judith Naomi	Vrije Universiteit Amsterdam
Hindriks, Koen	Vrije Universiteit Amsterdam

We design and evaluate a robot interviewer for collecting visitor data in a museum for marketing purposes. We take inspiration from research on face-to-face human intercept interviews. We develop a personal interviewing style that is expected to motivate participants to answer more questions and compare this with a more formal style. We also evaluate whether a greeting ritual performed by the robot increases participation and whether taking a picture with the robot is an effective incentive for visitors to participate in an interview.

Our study is conducted ``in the wild'' and we analyse sessions with the robot and passersby in a museum. The independent variables were interviewing style and whether an incentive was offered or not. The dependent variables were participation and continuation rate, and museum ratings. Contrary to expectations, we find that the participation

rate is lower when the robot provides an incentive. Although we find that a personal style is perceived as more social, it does not influence the continuation rate. Museum ratings were also not affected by style. Our style manipulation may not have been strong enough to produce these effects.

Our study shows that social robots have a high potential for conducting intercept interviews. Willingness to participate in a robot interview is high, while this is one of the main challenges with intercept interviews. To improve data collection, people detection and speech recognition skills could be improved.

13:05-13:15 ThT51.3

Shared Robot Impression with a Virtual Agent According to Realtime Emotion from Biological Information (I), pp. 1-7

Suzuki, Shoudai	Shibaura Institute of Techonology
Bin Mohd Anuardi, Muhammad Nur Adilin	Shibaura Institute of Technology
Sripian, Peeraya	Shibaura Institute of Technology
Matsuhira, Nobuto	Shibaura Institute of Technology
Sugaya, Midori	Shibaura Institute of Technology

Communication robots are now getting popular. In particular, partner robots, which can perform personal services, are in high demand. However, they can be prohibitively expensive. Therefore, we considered a multi-user robot with a virtual agent service which could satisfy user demands. But, several issues need to be solved in order to achieve this purpose. Firstly, there is no general service platform for such robots. Secondly, even if we use the multi-user robot by executing the virtual agent service, the physical shape, and other characteristics of the multi-user robot sometimes creates a strong impression on users. Therefore, we proposed a virtual agent service platform, and the robot features modification for a multi-user robot. The robot can autonomously adjust its position according to each user's physiological signals, which based on emotion in real-time. We presented a preliminary evaluation to determine whether the proposed method could improve users' robot experience even for the users who are not familiar with the robot at all.

13:15-13:25 ThT51.4

Using Machine Theory of Mind to Learn Agent Social Network Structures from Observed Interactive Behaviors with Targets, pp. 1-7

Chuang, Yun-Shiuan	University of Wisconsin - Madison
Hung, Hsin-Yi	National Taiwan University
Gamborino, Edwinn	National Taiwan University
Goh, Joshua Oon Soo	National Taiwan University
Huang, Tsung-Ren	National Taiwan University
Chang, Yu-Ling	National Taiwan University
Yeh, Su-Ling	National Taiwan University
Fu, Li-Chen	National Taiwan University

Human social interactions are laden with behavioral preferences that stem from hidden social network representations. In this study, we applied an artificial neural network with machine theory of mind (ToMnet+) to learn and predict social preferences based on implicit information from the way agents and social targets interact behaviorally. Our findings have implications for machine applications that seek to infer hidden information structures solely from third-person observation of behaviors. We consider that social machines with such an ability would have an enhanced potential for more naturalistic human-machine interactions.

13:25-13:35 ThT51.5

How Social Robots Influence People's Trust in Critical Situations (I), pp. 1-6

Rossi, Alessandra	University of Hertfordshire
Dautenhahn, Kerstin	University of Waterloo
Koay, Kheng Lee	University of Hertfordshire
Walters, Michael Leonard	University of Hertfordshire

As we expect that the presence of autonomous robots in our everyday life will increase, we must consider that people will have not only to accept robots to be a fundamental part of their lives, but they will also have to trust them to reliably and securely engage them in collaborative tasks. Several studies showed that robots are more comfortable interacting with robots that respect social conventions. However, it is still not clear if a robot that expresses social conventions will gain more favourably people's trust. In this study, we aimed to assess whether the use of social behaviours and natural communications can affect humans' sense of trust and companionship towards the robots. We conducted a between-subjects study where participants' trust was tested in three scenarios with increasing trust criticality (low, medium, high) in which they interacted either with a social or a non-social robot. Our findings showed that participants trusted equally a social and non-social robot in the low and medium consequences scenario. On the contrary, we observed that participants' choices of trusting the robot in a higher sensitive task was affected more by a robot that expressed social cues with a consequent decrease of their trust in the robot.

ThT52 Room 2

Motion Planning and Navigation in Human-Centered Environments (II) (Regular Session)

Chair: Manso, Luis J.	Aston University
Co-Chair: Falotico, Egidio	Scuola Superiore Sant'Anna

12:45-12:55 ThT52.1

A Shared-Autonomy Approach to Goal Detection and Navigation Control of Mobile Collaborative Robots, pp. 1-7

Gholami, Soheil	Istituto Italiano Di Tecnologia (IIT)
Ruiz Garate, Virginia	Istituto Italiano Di Tecnologia
De Momi, Elena	Politecnico Di Milano
Ajoudani, Arash	Istituto Italiano Di Tecnologia

Autonomous goal detection and navigation control of mobile robots in remote environments can help to unload human operators from simple, monotonous tasks allowing them to focus on more cognitively stimulating actions. This can result in better task performances, while creating user-interfaces that are understandable by non-experts. However, full autonomy in unpredictable and dynamically changing environments is still far from becoming a reality. Thus, teleoperated systems integrating the supervisory role and instantaneous decision-making capacity of humans are still required for fast and reliable robotic operations. This work presents a novel shared-autonomy framework for goal detection and navigation control of mobile manipulators. The controller exploits human-gaze information to estimate the desired goal. This is used together with control-pad data to predict user intention, and to activate the autonomous control for executing a target task. Using the control-pad device, a user can react to unexpected disturbances and halt the autonomous mode at any time. By releasing the control-pad device (e.g., after avoiding an instantaneous obstacle) the controller smoothly switches back to the autonomous mode and navigates the robot towards the target. Experiments for reaching a target goal {in the presence of unknown obstacles are carried out} to evaluate the performance of the proposed shared-autonomy framework over seven subjects. The results prove the accuracy, time-efficiency, and ease-of-use of the presented shared-autonomy control framework.

12:55-13:05 ThT52.2

*A Measure to Match Robot Plans to Human Intent: A Case Study in Multi-Objective Human-Robot Path-Planning**, pp. 1-8

Shaikh, Meher T.	Brigham Young University
Goodrich, Michael A.	Brigham Young University

Measuring how well a potential solution to a problem matches the problem-holder's intent and detecting when a current solution no longer matches intent is important when designing resilient human-robot teams. This paper addresses intent-matching for a robot path-planning problem that includes multiple objectives and where human intent is represented as a vector in the multi-objective payoff space. The paper introduces a new metric called the intent threshold margin and shows that it can be used to rank paths by how close they match a specified intent. The rankings induced by the metric correlate with average human rankings (obtained in an MTurk study) of how closely different paths match a specified intent. The intuition of the intent threshold margin is that it represents how much the human's intent must be ``relaxed'' to match the payoffs for a specified path.

13:05-13:15 ThT52.3

Tradeoff-Focused Contrastive Explanation for MDP Planning, pp. 1-8

Sukkerd, Roykrong	Carnegie Mellon University
Simmons, Reid	Carnegie Mellon University
Garlan, David	Carnegie Mellon University

End-users' trust in automated agents is important as automated decision-making and planning is increasingly used in many aspects of people's lives. In real-world applications of planning, multiple optimization objectives are often involved. Thus, planning agents' decisions can involve complex tradeoffs among competing objectives. It can be difficult for the end-users to understand why an agent decides on a particular planning solution on the basis of its objective values. As a result, the users may not know whether the agent is making the right decisions, and may lack trust in it. In this work, we contribute an approach, based on contrastive explanation, that enables a multi-objective MDP planning agent to explain its decisions in a way that communicates its tradeoff rationale in terms of the domain-level concepts. We conduct a human subjects experiment to evaluate the effectiveness of our explanation approach in a mobile robot navigation domain. The results show that our approach significantly improves the users' understanding, and confidence in their understanding, of the tradeoff rationale of the planning agent.

13:15-13:25 ThT52.4

A Bistable Soft Gripper with Mechanically Embedded Sensing Andactuation for Fast Grasping, pp. 1-6

George Thuruthel, Thomas	Bio-Inspired Robotics Lab, University of Cambridge
Abidi, Syed Haider Jawad	Istituto Italiano Di Tecnologia
Cianchetti, Matteo	Scuola Superiore Sant'Anna
Laschi, Cecilia	Scuola Superiore Sant'Anna
Falotico, Egidio	Scuola Superiore Sant'Anna

Soft robotic grippers are shown to be high effectivefor grasping unstructured objects with simple sensing andcontrol strategies. However, they are still limited by their speed,sensing capabilities and actuation mechanism. Hence, theirusage have been restricted in highly dynamic grasping tasks.This paper presents a soft robotic gripper with tunable bistableproperties for sensor-less dynamic grasping. The bistable mech-anism allows us to store arbitrarily large strain energy in thesoft system which is then released upon contact. The mechanismalso provides flexibility on the type of actuation mechanismas the grasping and sensing phase is completely passive.Theoretical background behind the mechanism is presentedwith finite element analysis to provide insights into designparameters. Finally, we experimentally demonstrate sensor-lessdynamic grasping of an unknown object within 0.02 seconds,including the time to sense and actuate.

ThT53 Room 3

Robots in Education, Therapy and Rehabilitation (II) (Regular Session)

Chair: Bogliolo, Michela	Scuola Di Robotica
Co-Chair: Hellström, Thomas	Umeå University

12:45-12:55 ThT53.1

Design, Development, and Preliminary Evaluation of a Highly Wearable Exoskeleton, pp. 1-8

Malvezzi, Monica	University of Siena
Lisini Baldi, Tommaso	University of Siena
Villani, Alberto	University of Siena
Ciccarese, Federico	University of Siena
Prattichizzo, Domenico	Università Di Siena

We present the design of a highly wearable exoskeleton of hand fingers that can be used for rehabilitation applications. One of the main challenges in the design of this type of device is to reduce as much as possible the encumbrance and weight, and at the same time to guarantee performance suitable to provide a realistic and reliable motion to the user. In the proposed solution each finger is actuated by means of a single motor, and finger joint rotations are coupled to produce a natural and intuitive movement of the finger, for this reason, we exploited the concept of postural synergies. The paper presents the main design steps, the criteria adopted to choose the mechanical structure of the exoskeleton, and the features of its prototype. Compared to other solutions present in the literature, the device presented in this paper has limited weight (40 g per finger) with an interesting level of performance in terms of force (15N).

12:55-13:05 ThT53.2

Rate My Robot: The Effect of Word-Of-Mouth (WOM) on Perceptions of a Social Robot's Teaching Performance, pp. 1-6

Edwards, Chad	Western Michigan University
Edwards, Autumn	Western Michigan University
Rijhwani, Varun	MICA

The purpose of this experiment was to examine the impact of computer-mediated word-of-mouth communication (WOM) on perceptions of a social robot instructing students. We hypothesized that participants receiving positive WOM about the social robot instructor would rate the robot higher for perceived credibility, attraction (social and task), social presence, and report higher levels of affective learning and state motivation to learn versus those participants receiving negative WOM (or no WOM) about the same performance. Results demonstrated that there are some factors in evaluating robot performance that are beyond the actual abilities of the robot. Results are discussed in light of the Heuristic-Systematic Processing model, and the impact of WOM on perceptions of social robots in the environment. As a result of these findings, designers and practitioners need to be conscious of WOM.

13:05-13:15 ThT53.3

Towards Infant Kick Quality Detection to Support Physical Therapy and Early Detection of Cerebral Palsy: A Pilot Study, pp. 1-6

Emeli, Victor	Georgia Institute of Technology
Fry, Katelyn	Georgia Institute of Technology
Howard, Ayanna	Georgia Institute of Technology

The kicking patterns of infants can provide markers that may predict the trajectory of their future development. Atypical kicking patterns may predict the possibility of developmental disorders like Cerebral Palsy (CP). Early intervention and physical therapy that encourages the practice of proper kicking motions can help to improve the outcomes in these scenarios. The kicking motions of an infant are usually evaluated by a trained health professional and subsequent physical therapy is also conducted by a licensed professional. The automation of the evaluation of kicking motions and the administration of physical therapy is desirable for standardizing these processes. In this work, we attempt to develop a method to quantify metrics that can provide insight into the quality of baby kicking actions. We utilize a computer vision system to analyze infant kicking stimulated by parent-infant play and a robotic infant mobile. We utilize statistical techniques to estimate kick type (synchronous and non-synchronous), kick amplitude, kick frequency, and kick deviation. These parameters can prove helpful in determining an infant's kick quality and also measure improvements in physical therapy over time. In this paper, we detail the design of the system and discuss the statistical results.

13:15-13:25 ThT53.4

A Robot Instructor for the Prevention and Treatment of Sarcopenia in the Aging Population: A Pilot Study, pp. 1-6

Bogliolo, Michela	Scuola Di Robotica
Marchesi, Giorgia	University of Genoa
Germinario, Andrea	Madlab 2.0
Micheli, Emanuele	Scuola Di Robotica
Canessa, Andrea	University of Genova
Burlando, Francesco	University of Genoa
Pilotto, Alberto	Galliera Hospital
Vallone, Francesco	Galliera Hospital
Casadio, Maura	University of Genoa

Sarcopenia is the loss of skeletal muscle tone, mass and strength associated with aging and lack of exercise. Its incidence is increasing, due to the growth in the number and proportion of older persons in world's population. To prevent the onset of Sarcopenia and to contrast

its effects, it is important to perform on a regular basis physical exercises involving the upper and lower limbs. One of the main problems is to motivate elderly people to start a training routine, even better if in groups. This determines the need of innovative, stimulating solutions, targeting groups of people and easily usable. The primary objective of this study was to develop and test a new method for answering this need. We designed a platform where the humanoid robot Pepper guided a group of subjects to perform a set of physical exercises specifically designed to contrast Sarcopenia. The robot illustrated, demonstrated, and then performed the exercises simultaneously with the subjects' group. Moreover, by using an additional external camera Pepper controlled in real time the execution of the exercises, encouraging Participants who slow down or did not complete all the movements. The processing offline of the recorded data allowed estimating individual subjects performance. The platform has been tested with 8 volunteers divided into two groups. The preliminary results were encouraging: participants demonstrated a high degree of satisfaction for the robot-guided training. Moreover, participants moved with almost synchronously, indicating that all of them followed the robot, maintaining engagement and respecting the correct timing of the exercises.

ThT54 Room 4

Machine Learning and Adaptation / Programming by Demonstration (III) (Regular Session)

Chair: Kolathaya, Shishir	Indian Institute of Science
Co-Chair: Berenz, Vincent	Max Planck Institute for Intelligent Systems

12:45-12:55 ThT54.1

Learning Sensory-Motor Associations from Demonstration, pp. 1-7

Berenz, Vincent	Max Planck Institute for Intelligent Systems
Bjelic, Ahmed	University of Stuttgart
Herath, Herath M. Lahiru Sachith	University of Siegen
Mainprice, Jim	Max Planck Institute

We propose a method which generates reactive robot behavior learned from human demonstration. In order to do so, we use the Playful programming language which is based on the reactive programming paradigm. This allows us to represent the learned behavior as a set of associations between sensor and motor primitives in a human readable script. Distinguishing between sensor and motor primitives introduces a supplementary level of granularity and more importantly enforces feedback, increasing adaptability and robustness. As the experimental section shows, useful behaviors may be learned from a single demonstration covering a very limited portion of the task space.

12:55-13:05 ThT54.2

Learning by Demonstration for Constrained Tasks, pp. 1-6

Papageorgiou, Dimitrios	Aristotle University of Thessaloniki
Doulgeri, Zoe	Aristotle University of Thessaloniki

In many industrial applications robot's motion has to be subjected to spatial constraints imposed by the geometry of the task, e.g. motion of the end-effector on a surface. Current learning by demonstration methods encode the motion either in the Cartesian space of the end-effector, or in the configuration space of the robot. In those cases, the spatial generalization of the motion does not guarantee that the motion will in any case respect the spatial constraints of the task, as no knowledge of those constraints is exploited. In this work, a novel approach for encoding a kinematic behavior is proposed, which takes advantage of such a knowledge and guarantees that the motion will, in any case, satisfy the spatial constraints and the motion pattern will not be distorted. The proposed approach is compared with respect to its ability for spatial generalization, to two different dynamical system based approaches implemented on the Cartesian space via experiments.

13:05-13:15 ThT54.3

Learning Prohibited and Authorised Grasping Locations from a Few Demonstrations, pp. 1-7

Hélénon, François	Arts Et Métiers Institute of Technology
Bimont, Laurent	Arts Et Métiers Institute of Technology
Nyiri, Eric	Arts Et Métiers Institute of Technology
Thiery, Stéphane	Arts Et Métiers Institute of Technology
Gibaru, Olivier	Arts Et Métiers Institute of Technology

Our motivation is to ease robots' reconfiguration for pick and place tasks in an industrial context. This paper proposes a fast learner neural network model trained from one or a few demonstrations in less than 5 minutes, able to efficiently predict grasping locations on a specific object. The proposed methodology is easy to apply in an industrial context as it is exclusively based on the operator's demonstrations and does not require a CAD model, existing database or simulator. As predictions of a neural network can be erroneous especially when trained with very few data, we propose to indicate both authorised and prohibited locations for safety reasons. It allows us to handle fragile objects or to perform task-oriented grasping. Our model learns the semantic representation of objects (prohibited/authorised) thanks to a simplified data representation, a simplified neural network architecture and an adequate training framework. We trained specific networks for different objects and conducted experiments on a real 7-DOF robot which showed good performances (70 to 100% depending on the object), using only one demonstration. The proposed model is able to generalise well as performances remain good even when grasping several similar objects with the same network trained on one of them.

13:15-13:25 ThT54.4

Teaching Robots Novel Objects by Pointing at Them, pp. 1-6

Gubbi Venkatesh, Sagar	Indian Institute of Science
Upadrashta, Raviteja	Indian Institute of Science
Kolathaya, Shishir	Indian Institute of Science
Amrutur, Bharadwaj	Indian Institute of Science

Robots that must operate in novel environments and collaborate with humans must be capable of acquiring new knowledge from human experts during operation. We propose teaching a robot novel objects it has not encountered before by pointing a hand at the new object of interest. An end-to-end neural network is used to attend to the novel object of interest indicated by the pointing hand and then to localize the object in new scenes. In order to attend to the novel object indicated by the pointing hand, we propose a spatial attention modulation mechanism that learns to focus on the highlighted object while ignoring the other objects in the scene. We show that a robot arm can manipulate novel objects that are highlighted by pointing a hand at them. We also evaluate the performance of the proposed architecture on a synthetic dataset constructed using emojis and on a real-world dataset of common objects.

13:25-13:35 ThT54.5

Learning Stable Manoeuvres for Quadruped Robots from Expert Demonstrations, pp. 1-6

tirumala, sashank	IIT Madras
Gubbi Venkatesh, Sagar	Indian Institute of Science
Paigwar, Kartik	Robert Bosch Center for Cyber-Physical Systems, IISc
Sagi, Aditya Varma	Indian Institute of Science
Joglekar, Ashish	Robert Bosch Center for Cyber Physical Systems, Indian Institute
Bhatnagar, Shalabh	Indian Institute of Science, Bangalore
Ghosal, Ashitava	India Institute of Science (IISc
Amrutur, Bharadwaj	Indian Institute of Science
Kolathaya, Shishir	Indian Institute of Science

With the research into development of quadruped robots picking up pace, learning based techniques are being explored for developing locomotion controllers for such robots. A key problem is to generate leg trajectories for continuously varying target linear and angular velocities, in a stable manner. In this paper, we propose a two pronged approach to address this problem. First, multiple simpler policies are

trained to generate trajectories for a discrete set of target velocities and turning radius. These policies are then augmented using a higher level neural network for handling the transition between the learned trajectories. Specifically, we develop a neural network based filter that takes in target velocity, radius and transforms them into new commands that enable smooth transitions to the new trajectory. This transformation is achieved by learning from expert demonstrations. An application of this is the transformation of a novice user's input into an expert user's input, thereby ensuring stable manoeuvres regardless of the user's experience. Training our proposed architecture requires much less expert demonstrations compared to standard neural network architectures. Finally, we demonstrate experimentally these results in the in-house quadruped Stoch 2.

ThT55 Room 5

Cooperation and Collaboration in Human-Robot Teams (I) (Regular Session)

Chair: Ionescu, Tudor — Vienna Technical University
Co-Chair: Karami, Hossein — University of Genoa

12:45-12:55 ThT55.1

Meet Your Personal Cobot, but Don't Touch It Just Yet, pp. 1-6

Ionescu, Tudor — Vienna Technical University

This paper reports on a research project aimed at introducing a collaborative industrial robot into a makerspace (a public machine shop equipped with digital manufacturing technologies). Using an ethnographic approach, we observed how collaborations between researchers and non-experts are facilitated by makerspaces, how robot safety is being construed and negotiated by the actors involved in the project; and how knowledge about collaborative robot safety and applications is produced in a context previously unforeseen by the creators of the technology. The proposed analysis suggests that the sociotechnical configuration of the studied project resembles that of a trading zone, in which various types of knowledge and expertise are exchanged between the researchers from the interdisciplinary project team and makerspace members. As we shall argue, the trading zone model can be useful in the analysis and organization of participatory HRI research.

12:55-13:05 ThT55.2

Joint Mind Modeling for Explanation Generation in Complex Human-Robot Collaborative Tasks, pp. 1-8

Gao, Xiaofeng — UCLA
Gong, Ran — UCLA
Zhao, Yizhou — UCLA
Wang, Shu — UCLA
Shu, Tianmin — Massachusetts Institute of Technology
Zhu, Song-Chun — UCLA

Human collaborators can effectively communicate with their partners to finish a common task by inferring each other's mental states (e.g., goals, beliefs, and desires). Such mind-aware communication minimizes the discrepancy among collaborators' mental states, and is crucial to the success in human ad-hoc teaming. We believe that robots collaborating with human users should demonstrate similar pedagogic behavior. Thus, in this paper, we propose a novel explainable AI (XAI) framework for achieving human-like communication in human-robot collaborations, where the robot builds a hierarchical mind model of the human user and generates explanations of its own mind as a form of communications based on its online Bayesian inference of the user's mental state. To evaluate our framework, we conduct a user study on a real-time human-robot cooking task. Experimental results show that the generated explanations of our approach significantly improves the collaboration performance and user perception of the robot. Code and video demos are available on our project website: https://xfgao.github.io/xCookingWeb/.

13:05-13:15 ThT55.3

A Task Allocation Approach for Human-Robot Collaboration in Product Defects Inspection Scenarios, pp. 1-8

Karami, Hossein — University of Genoa
Darvish, Kourosh — Istituto Italiano Di Tecnologia
Mastrogiovanni, Fulvio — University of Genoa

The presence and coexistence of human operators and collaborative robots in shop-floor environments raises the need for assigning tasks to either operators or robots, or both. Depending on task characteristics, operator capabilities and the involved robot functionalities, it is of the utmost importance to design strategies allowing for the concurrent and/or sequential allocation of tasks related to object manipulation and assembly. In this paper, we extend the textsc{FlexHRC} framework presented in cite{darvish2018flexible} to allow a human operator to interact with multiple, heterogeneous robots at the same time in order to jointly carry out a given task. The extended textsc{FlexHRC} framework leverages a concurrent and sequential task representation framework to allocate tasks to either operators or robots as part of a dynamic collaboration process. In particular, we focus on a use case related to the inspection of product defects, which involves a human operator, a dual-arm Baxter manipulator from Rethink Robotics and a Kuka youBot mobile manipulator.

13:15-13:25 ThT55.4

Improving Human Performance Using Mixed Granularity of Control in Multi-Human Multi-Robot Interaction, pp. 1-8

Patel, Jayam — Worcester Polytechnic Institute
Pinciroli, Carlo — Worcester Polytechnic Institute

Due to the potentially large number of units involved, the interaction with a multi-robot system is likely to exceed the limits of the span of apprehension of any individual human operator. In previous work, we studied how this issue can be tackled by interacting with the robots in two modalities — environment-oriented and robot-oriented. In this paper, we study how this concept can be applied to the case in which multiple human operators perform supervisory control on a multi- robot system. While the presence of extra operators suggests that more complex tasks could be accomplished, little research exists on how this could be achieved efficiently. In particular, one challenge arises — the out-of-the-loop performance problem caused by a lack of engagement in the task, awareness of its state, and trust in the system and in the other operators. Through a user study involving 28 human operators and 8 real robots, we study how the concept of mixed granularity in multi-human multi-robot interaction affects user engagement, awareness, and trust while balancing the workload between multiple operators.

13:25-13:35 ThT55.5

Task Interdependence in Human-Robot Teaming, pp. 1-7

Zhao, Fangyun — University of Wisconsin-Madison
Henrichs, Curt — University of Wisconsin - Madison
Mutlu, Bilge — University of Wisconsin–Madison

Human-robot teaming is becoming increasingly common within manufacturing processes. A key aspect practitioners need to decide on when developing effective processes is the level of task *interdependence* between human and robot team members. Task interdependence refers to the extent to which one's behavior affects the performance of others in a team. In this work, we examine the effects of three levels of task interdependence---*pooled, sequential, reciprocal*---in human-robot teaming on human worker's mental states, task performance, and perceptions of the robot. Participants worked with the robot in an assembly task while their heart rate variability was being recorded. Results suggested human workers in the *reciprocal interdependence* level experienced less stress and perceived the robot more as a collaborator than other two levels. Task interdependence did not affect perceived safety. Our findings highlight the importance of considering task structure in human-robot teaming and inform future research on and industry practices for human-robot task allocation.

13:35-13:45 ThT55.6

Role Switching in Task-Oriented Multimodal Human-Robot Collaboration, pp. 1-7

Monaikul, Natawut — University of Illinois at Chicago
Abbasi, Bahareh — California State University - Channel Island
Rysbek, Zhanibek — University of Illinois at Chicago
Di Eugenio, Barbara — University of Illinois at Chicago
Zefran, Milos — University of Illinois at Chicago

In a collaborative task and the interaction that accompanies it, the participants often take on distinct roles, and dynamically switch the roles as the task requires. A domestic assistive robot thus needs to have similar capabilities. Using our previously proposed Multimodal Interaction Manager (MIM) framework, this paper investigates how role switching for a robot can be implemented. It identifies a set of primitive subtasks that encode common interaction patterns observed in our data corpus and that can be used to easily construct complex task models. It also describes an implementation on the NAO robot that, together with our original work, demonstrates that the robot can take on different roles. We provide a detailed analysis of the performance of the system and discuss the challenges that arise when switching roles in human-robot interactions.

Technical Program for Friday September 4, 2020

FrT61 Room 1

Detecting and Understanding Human Activity (I) (Regular Session)

Chair: Hughes, Dana	Carnegie Mellon University
Co-Chair: Kratzer, Philipp	University of Stuttgart

12:45-12:55 FrT61.1

Anticipating Human Intention for Full-Body Motion Prediction in Object Grasping and Placing Tasks, pp. 1-7

Kratzer, Philipp	University of Stuttgart
Balachandra Midlagajni, Niteesh	Technische Universität Darmstadt
Toussaint, Marc	Tu Berlin
Mainprice, Jim	Max Planck Institute

Motion prediction in unstructured environments is a difficult problem and is essential for safe and efficient human-robot space sharing and collaboration. In this work, we focus on manipulation movements in environments such as homes, workplaces or restaurants, where the overall task and environment can be leveraged to produce accurate motion prediction. For these cases we propose an algorithmic framework that accounts explicitly for the environment geometry based on a model of affordances and a model of short-term human dynamics both trained on motion capture data. We propose dedicated function networks for graspability and placebility affordances and we make use of a dedicated RNN for short-term motion prediction. The prediction of grasp and placement probability densities are used by a constraint-based trajectory optimizer to produce a full-body motion prediction over the entire horizon. We show by comparing to ground truth data that we achieve similar performance for full-body motion predictions as using oracle grasp and place locations.

12:55-13:05 FrT61.2

A Real-Time Tool for Human Ergonomics Assessment Based on Joint Compressive Forces, pp. 1-7

Fortini, Luca	Istituto Italiano Di Tecnologia
Lorenzini, Marta	Istituto Italiano Di Tecnologia
Kim, Wansoo	Istituto Italiano Di Tecnologia
De Momi, Elena	Politecnico Di Milano
Ajoudani, Arash	Istituto Italiano Di Tecnologia

The objective of this paper is to present a mathematical tool for real-time tracking of whole-body compressive forces induced by external physical solicitations. This tool extends and enriches our recently introduced ergonomics monitoring system to asses the level of risk associated with human physical activities. The methods developed so far only considered the effect of the external loads on joint torque variations. However, even for negligible values of the joint torque overloadings (e.g., in singular configurations), the effect of compressive forces, defined by the internal/pushing forces among body links, can be significant. In addition, our previous work did not take into consideration the task-dependent orientation of the interaction forces, which can influence the level of body compressive forces and the overloading joint torques. Accordingly, we propose the joint compressive forces as an additional real-time index for the assessing of human ergonomics. First, a simulation study is performed to validate the method. Next, a laboratory study on five subjects is provided to compare the trend of the joint compressive forces with muscle activities. Results demonstrate the significance of the proposed index in the development of a comprehensive human ergonomics monitoring framework. Based on such a framework, robotic strategies as well as feedback interfaces can be employed to guide the human movement toward more convenient body configurations thus avoiding pain and consequent injuries.

13:05-13:15 FrT61.3

Forces and Torque Measurements in the Interaction of Kitchen-Utensils with Food During Typical Cooking Tasks: Preliminary Test and Evaluation, pp. 1-7

Pereira, Debora	Scuola Superiore Sant'Anna
Morassut, Alessandro	Electrolux Professional Spa
Tiberi, Emidio	Electrolux Professional Spa
Dario, Paolo	Scuola Superiore Sant'Anna
Ciuti, Gastone	Scuola Superiore Sant'Anna

The study of cooking tasks, such as grilling, is hindered by several adverse conditions for sensors, such as the presence of humidity, fat, and heat. Still, robotics research could benefit from understanding the human control of forces and torques in important contact interactions of kitchen-utensils with food. This work presents a preliminary study on the dynamics of grilling tasks (i.e. food flipping movements). A spatula and kitchen-tweezers were instrumented to measure forces and torque in multiple directions. Furthermore, we designed an experimental setup to keep sensors distant from heat/humidity and to, simultaneously, hold the effects of grilling (stickiness/slipperiness) during the tasks execution and recording. This allowed a successful data collection of 1426 movements with the spatula (flipping hamburgers, chicken, zucchini and eggplant slices) and 660 movements with the tweezers (flipping zucchini and eggplant slices), performed by chefs and ordinary home cooks. Finally, we analyzed three dynamical characteristics of the tasks for the different food: bending force and torsion torque on the impact to unstick food, and maximum pinching with tweezers. We verified that bending on impact and maximum pinching are adjusted to the food by both chefs and home cooks.

13:15-13:25 FrT61.4

Inferring Non-Stationary Human Preferences for Human-Agent Teams, pp. 1-8

Hughes, Dana	Carnegie Mellon University
Agarwal, Akshat	Carnegie Mellon University
Guo, Yue	Carnegie Mellon University
Sycara, Katia	Carnegie Mellon University

One main challenge to robot decision making in human-robot teams involves predicting the intents of a human team member through observations of the human's behavior. Inverse Reinforcement Learning (IRL) is one approach to predicting human intent, however, such approaches typically assume that the human's intent is stationary. Furthermore, there are few approaches that identify when the human's intent changes during observations. Modeling human decision making as a Markov decision process, we address these two limitations by maintaining a belief over the reward parameters of the model (representing the human's preference for tasks or goals), and updating the parameters using IRL estimates from short windows of observations. We posit that a human's preferences can change with time, due to gradual drift of preference and/or discrete, step-wise changes of intent. Our approach maintains an estimate of the human's preferences under such conditions, and is able to identify changes of intent based on the divergence between subsequent belief updates. We demonstrate that our approach can effectively track dynamic reward parameters and identify changes of intent in a simulated environment, and that this approach can be leveraged by a robot team member to improve team performance.

FrT62 Room 2

Safe and Acceptable Human-Robot Collaboration (Special Session)

Chair: Orlandini, Andrea	National Research Council of Italy
Co-Chair: Bdiwi, Mohamad	Fraunhofer Institute for Machine Tools and Forming Technology IWU
Organizer: Bdiwi, Mohamad	Fraunhofer Institute for Machine Tools and Forming Technology IW
Organizer: Finzi, Alberto	University of Naples
Organizer: Orlandini, Andrea	National Research Council of Italy
Organizer: Pedrocchi, Nicola	National Research Council of Italy (CNR)

12:45-12:55 FrT62.1

Learning in Motion: Dynamic Interactions for Increased Trust in Human-Robot Interaction Games, pp. 1-4

Ye, Sean	Georgia Institute of Technology

Feigh, Karen — Georgia Institute of Technology
Howard, Ayanna — Georgia Institute of Technology

Embodiment of actions and tasks has typically been analyzed from the robot's perspective where the robot's embodiment helps develop and maintain trust. However, we ask a similar question looking at the interaction from the human perspective. Embodied cognition has been shown in the cognitive science literature to produce increased social empathy and cooperation. To understand how human embodiment can help develop and increase trust in human-robot interactions, we created conducted a study where participants were tasked with memorizing greek letters associated with dance motions with the help of a humanoid robot. Participants either performed the dance motion or utilized a touch screen during the interaction. The results showed that participants' trust in the robot increased at a higher rate during human embodiment of motions as opposed to utilizing a touch screen device.

12:55-13:05 FrT62.2

Towards the Exact Solution for Speed and Separation Monitoring for Improved Human-Robot Collaboration (I), pp. 1-6

Lacevic, Bakir — University of Sarajevo
Zanchettin, Andrea Maria — Politecnico Di Milano
Rocco, Paolo — Politecnico Di Milano

In this paper, we approach the problem of ensuring safety requirements within human-robot collaborative scenarios. The safety requirements considered herein are consistent with the paradigm of speed and separation monitoring. In such a setup, safety guarantees for human operators usually imply limited robot velocities and/or significant distance margins, which in turn may have adverse effects regarding the productivity of the robot. In this paper, we propose a novel approach that minimally affects the productivity while being consistent with such a safety prescription. A comprehensive simulation study shows that our method outperforms the current state of the art algorithm.

13:05-13:15 FrT62.3

Enabling Physical Human-Robot Collaboration through Contact Classification and Reaction (I), pp. 1-8

Lippi, Martina — Università Degli Studi Di Salerno
Marino, Alessandro — University of Cassino and Southern Lazio

In this paper, a scenario of physical human-robot collaboration is considered, in which a robot is able to both carry out autonomous tasks and to physically interact with a human operator to achieve a common objective. However, since human and robot share the same workspace both accidental and intentional contacts between them might arise. Therefore, a solution based on Recurrent Neural Networks (RNNs) is proposed to detect and classify the nature of the contact with the human, even in the case the robot is interacting with the environment because of its own task. Then, reaction strategies are defined depending on the nature of contact: human avoidance with evasive action in the case of accidental interaction, and admittance control in the case of intentional interaction. In regard to the latter, Control Barrier Functions (CBFs) are considered to guarantee the satisfaction of robot constraints, while endowing the robot with a compatible compliant behavior. The approach is validated on real data acquired from the interaction with a Kinova Jaco2.

13:15-13:25 FrT62.4

A Layered Control Approach to Human-Aware Task and Motion Planning for Human-Robot Collaboration (I), pp. 1-7

Faroni, Marco — National Research Council of Italy
Beschi, Manuel — National Research Council of Italy
Ghidini, Stefano — CNR
Pedrocchi, Nicola — National Research Council of Italy (CNR)
Umbrico, Alessandro — National Research Council of Italy
Orlandini, Andrea — National Research Council of Italy
Cesta, Amedeo — CNR -- National Research Council of Italy, ISTC

Combining task and motion planning efficiently in human-robot collaboration (HRC) entails several challenges because of the uncertainty conveyed by the human behavior. Tasks plan execution should be continuously monitored and updated based on the actual behavior of the human and the robot to maintain productivity and safety.

We propose control-based approach based on two layers, i.e., task planning and action planning. Each layer reasons at a different level of abstraction: task planning considers high-level operations without taking into account their motion properties; action planning optimizes the execution of high-level operations based on current human state and geometric reasoning.

The result is a hierarchical framework where the bottom layer gives feedback to top layer about the feasibility of each task, and the top layer uses this feedback to (re)optimize the process plan. The method is applied to an industrial case study in which a robot and a human worker cooperate to assemble a mosaic.

FrT63 — Room 3

Degrees of Autonomy and Teleoperation (Regular Session)

Chair: Green, Keith Evan — Cornell University
Co-Chair: Cavallo, Filippo — University of Florence

12:45-12:55 FrT63.1

Multidimensional Evaluation of Telepresence Robot: Results from a Field Trial, pp. 1-6

Fiorini, Laura — The BioRobotics Institute, Scuola Superiore Sant'Anna
Mancioppi, Gianmaria — Scuola Superiore Sant'Anna
Becchimanzi, Claudia — Università Degli Studi Di Firenze
Sorrentino, Alessandra — Scuola Superiore Sant'Anna
Mattia, Pistolesi — Università Degli Studi Di Firenze
Tosi, Francesca — Università Degli Studi Di Firenze
Cavallo, Filippo — University of Florence

The population around Europe is getting older; many elderlies would like to live independently in their homes as long as possible. In this context, a robotic telepresence service could support the frail persons in their homes, empowering their social relationships. In this work, 10 frail elderly were asked to live with a telepresence robot (i.e. Double Robot), through which the formal caregiver could remotely visit and chat with them. A total of 169 days of field-test trial was evaluated before (TO) and after (TF) the tests with a multidimensional framework, including acceptance, usability and expectation domains. The system was used for 2871 mins, and the results underline good usability- and acceptance- related domains (average score equals to 70.83 at TF) and expectation (average score equal to 67.01 at TF). Results remark that expectation could influence the potential usage and the real use of the robot. Additionally, a positive trend in the answers was identified between T0 and TF. Indeed, the evaluation of a system should envisage a complex, multidisciplinary and holistic approach, that may influence the success or failure of the robot's purpose, if not properly analysed during the evaluation and design phase.

12:55-13:05 FrT63.2

Virtual Reality Based Telerobotics Framework with Depth Cameras, pp. 1-6

Omarali, Bukeikhan — Queen Mary University of London
Denoun, Brice — Queen Mary University of London
Althoefer, Kaspar — Queen Mary University of London
Jamone, Lorenzo — Queen Mary University London
Valle, Maurizio — University of Genova
Farkhatdinov, Ildar — Queen Mary University of London

This work describes a virtual reality (VR) based robot teleoperation framework which relies on scene visualization from depth cameras and implements human-robot and human-scene interaction gestures. We suggest that mounting a camera on a slave robot's end-effector (an in-hand camera) allows the operator to achieve better visualization of the remote scene and improve task performance. We compared experimentally the operator's ability to understand the remote

environment in different visualization modes: single external static camera, in-hand camera, in-hand and external static camera, in-hand camera with OctoMap occupancy mapping. The latter option provided the operator with a better understanding of the remote environment whilst requiring relatively small communication bandwidth. Consequently, we propose suitable grasping methods compatible with the VR based teleoperation with the in-hand camera. Video demonstration: https://youtu.be/3vZaEykMS_E.

13:05-13:15 FrT63.3

Natural Gradient Shared Control, pp. 1-7

Oh, Yoojin — University of Stuttgart
Wu, Shao-Wen — Universität Stuttgart
Toussaint, Marc — Tu Berlin
Mainprice, Jim — Max Planck Institute

We propose a formalism for shared control, which is the problem of defining a policy that blends user control and autonomous control. The challenge posed by the shared autonomy system is to maintain user control authority while allowing the robot to support the user. This can be done by enforcing constraints or acting optimally when the intent is clear. Our proposed solution relies on natural gradients emerging from the divergence constraint between the robot and the shared policy. We approximate the Fisher information by sampling a learned robot policy and computing the local gradient to augment the user control when necessary. A user study performed on a manipulation task demonstrates that our approach allows for more efficient task completion while keeping control authority against a number of baseline methods.

13:15-13:25 FrT63.4

Are Space-Making Robots, Agents? Investigations on User Perception of an Embedded Robotic Surface, pp. 1-6

Wang, Yixiao — Cornell University
Guimbretière, François — Cornell University
Green, Keith Evan — Cornell University

Novel, “space-making” robots have potential to redefine physical space and the human activities occurring in it. Categorically distinct from many robots and far removed from humanoids, space-making robots are not objects in space, not anthropomorphic, not animal-like, not mobile, but instead, integral with the physical environment, embedded in or forming walls, ceilings, floors, partitions, vehicle interiors, and building envelopes. Given their distinctiveness, space-making robots offer a novel human-machine interaction. This paper investigates whether users perceive space-making robots as agents—artificial social actors characterized by the capacity for intelligence, recognition, and intention. Results of an in-lab experiment with 11 participants and an online, between-group experiment with 120 participants show that people attribute agency metrics of intelligence, intention, recognition, cooperation, collaboration, friendliness, and welcome to our reconfigurable robotic surface embedded in a wall partition. While space-making robots may become numerous in the built environment, our results are significant, moreover, for their broader implications for conceptualizing and designing human-machine interactions.

13:25-13:35 FrT63.5

Improving Efficiency and Safety in Teleoperated Robotic Manipulators Using Motion Scaling and Force Feedback, pp. 1-7

Cho, Yongmin — Georgia Institute of Technology
Hammond III, Frank L. — Georgia Institute of Technology

Recent surges in global construction spending are driving the need for safer, more efficient construction methods. One potential way of improving construction methods is to provide user interfaces that allow human operators to control machinery in a more intuitive and strategic manner. This paper explores the use of motion scaling and haptic feedback to improve task completion speed and force control during construction-related teleoperated robotic manipulation tasks. In this study, we design a bench-top Teleoperated Motion Scaling Robotic Arm (TMSRA) platform that allows the human operator to control the motion-mapping rate between the master (haptic console) and slave (robotic excavator) devices, while also providing force feedback and virtual safety functions to help prevent excessive force application by the slave device. We experimentally evaluated the impact of motion scaling and force feedback on human users' ability to perform simulated construction tasks. Experimental results from simulated robotic excavation and demolition tasks show that the maximum force applied to fictive buried utilities was reduced by 77.67% and 76.36% respectively due to the force feedback and safety function. Experimental results from simulated payload pushing/sliding tasks demonstrate that the provision of user-controlled motion scaling increases task efficiency, reducing completion times by at least 31.41%, and as much as 47.76%.

FrT64 — Room 4

Cooperation and Collaboration in Human-Robot Teams (II) (Regular Session)

Chair: Tian, Leimin — Monash University
Co-Chair: Rossi, Alessandra — University of Hertfordshire

12:45-12:55 FrT64.1

Would You Help a Sad Robot? Influence of Robots' Emotional Expressions on Human-Multi-Robot Collaboration, pp. 1-8

Zhou, Shujie — Monash University
Tian, Leimin — Monash University

With recent advancements in robotics and artificial intelligence, human-robot collaboration has drawn growing interests. In human collaboration, emotion can serve as an evaluation of events and as a communicative cue for people to express and perceive each other's internal states. Thus, we are motivated to investigate the influence of robots' emotional expressions on human-robot collaboration. In particular, we conducted experiments in which a participant interacted with two Cozmo robots in a collaborative game. We found that when the robots exhibited emotional expressions, participants were more likely to collaborate with them and achieved task success in shorter time. Moreover, participants perceived emotional robots more positively and reported to have a more enjoyable experience interacting with them. Our study provides insights on the benefit of incorporating artificial emotions in robots on human-robot collaboration and interaction.

12:55-13:05 FrT64.2

Defining Fairness in Human-Robot Teams, pp. 1-8

Chang, Mai Lee — University of Texas at Austin
Pope, Zachary — UT Austin
Short, Elaine Schaertl — Tufts University
Thomaz, Andrea Lockerd — University of Texas at Austin

We seek to understand the human teammate's perception of fairness during a human-robot physical collaborative task where certain subtasks leverage the robot's strengths and others leverage the human's. We conduct a user study (n=30) to investigate the effects of fluency (absent vs. present) and effort (absent vs. present) on participants' perception of fairness. Fluency controls if the robot minimizes the idle time between the human's action and robot's action. Effort controls if the robot performs tasks that it is least skilled at, i.e., most time-consuming tasks, as quickly as possible. We evaluated four human-robot teaming algorithms that consider different levels of fluency and effort. Our results show that effort and fluency help improve fairness without making a trade-off with efficiency. When the robot displays effort, this significantly increased participants' perceived fairness. Participants' perception of fairness is also influenced by team members' skill levels and task type. To that end, we propose three notions of fairness for effective human-robot teamwork: equality of workload, equality of capability, and equality of task type.

13:05-13:15 FrT64.3

Adaptive Leader-Follower Behavior in Human-Robot Collaboration, pp. 1-7

van Zoelen, Emma M. — TNO, TU Delft
Barakova, Emilia I. — Eindhoven University of Technology
Rauterberg, Matthias — Eindhoven University of Technology

As developments in artificial intelligence and robotics progress, more tasks arise in which humans and robots need to collaborate. With

changing levels of complementarity in their capabilities, leadership roles will constantly shift. The research presented explores how people adapt their behavior to initiate or accommodate continuous leadership shifts in human-robot collaboration and how this influences trust and understanding. We conducted an experiment in which participants were confronted with seemingly conflicting interests between robot and human in a collaborative task. This was embedded in a physical navigation task with a robot on a leash, inspired by the interaction between guide dogs and blind people. Explicit and implicit feedback factors from the task and the robot partner proved to trigger humans to reconsider when to lead and when to follow, while the outcome of this differed across participants. Overall the participants evaluated the collaboration more positively over time, while participants who took the lead more often valued the collaboration more negatively than other participants.

13:15-13:25 FrT64.4

Robotic Object Sorting Via Deep Reinforcement Learning: A Generalized Approach, pp. 1-8

Tagliapietra, Luca	University of Padova
Nicola, Giorgio	University of Padova
Tosello, Elisa	Dept. of Information Engineering, University of Padova
Navarin, Nicolò	University of Padova
Ghidoni, Stefano	University of Padova
Menegatti, Emanuele	The University of Padua

This work proposes a general formulation for the Object Sorting problem, suitable to describe any non-deterministic environment characterized by friendly and adversarial interference. Such an approach, coupled with a Deep Reinforcement Learning algorithm, allows training policies to solve different sorting tasks without adjusting the architecture or modifying the learning method. Briefly, the environment is subdivided into a clutter, where objects are freely located, and a set of clusters, where objects should be placed according to predefined ordering and classification rules. A 3D grid discretizes such environment: the properties of an object within a cell depict its state. Such attributes include object category and order. A Markov Decision Process formulates the problem: at each time step, the state of the cells fully defines the environment's one. Users can custom-define object classes, ordering priorities, and failure rules. The latter by assigning a non-uniform risk probability to each cell. Performed experiments successfully trained and validated a Deep Reinforcement Learning model to solve several sorting tasks while minimizing the number of moves and failure probability. Obtained results demonstrate the capability of the system to handle non-deterministic events, like failures, and unpredictable external disturbances, like human user interventions.

13:25-13:35 FrT64.5

Calibrating Trust in Human-Drone Cooperative Navigation, pp. 1-6

Okamura, Kazuo	The Graduate University for Advanced Studies (SOKENDAI)
Yamada, Seiji	National Institute of Informatics

Trust calibration is essential to successful cooperation between humans and autonomous systems such as those for self-driving cars and autonomous drones. If users over-estimate the capability of autonomous systems, over-trust occurs, and the users rely on the systems even in situations in which they could outperform the systems. On the contrary, if users under-estimate the capability of a system, under-trust occurs, and they tend not to use the system. Since both situations hamper cooperation in terms of safety and efficiency, it would be highly desirable to have a mechanism that facilitates users in keeping the appropriate level of trust in autonomous systems. In this paper, we first propose an adaptive trust calibration framework that can detect over/under-trust from users' behaviors and encourage them to keep the appropriate trust level in a ``continuous'' cooperative task. Then, we conduct experiments to evaluate our method with semi-automatic drone navigation. In experiments, we introduce ABA situations of weather conditions to investigate our method in bidirectional trust changes. The results show that our method adaptively detected trust changes and encouraged users to calibrate their trust in a continuous cooperative task. We believe that the findings of this study will contribute to better user-interface designs for collaborative systems.

13:35-13:45 FrT64.6

Detecting Human Motion Intention During pHRI Using Artificial Neural Networks Trained by EMG Signals, pp. 1-8

Sirintuna, Doganay	Koc University, College of Engineering, Turkey
Ozdamar, Idil	Koc University
Aydin, Yusuf	Koc University
Basdogan, Cagatay	Koc University

With the recent advances in cobot (collaborative robot) technology, we can now work with a robot side by side in manufacturing environments. The collaboration between human and cobot can be enhanced by detecting the intentions of human to make the production more flexible and effective in future factories. In this regard, interpreting human intention and then adjusting the controller of cobot accordingly to assist human is a core challenge in physical human-robot interaction (pHRI). In this study, we propose a classifier based on Artificial Neural Networks (ANN) that predicts intended direction of human movement by utilizing electromyography (EMG) signals acquired from human arm muscles. We employ this classifier in an admittance control architecture to constrain human arm motion along the intended direction and prevent undesired movements along other directions. The proposed classifier and the control architecture have been validated through a path following task by utilizing a KUKA LBR iiwa 7 R800 cobot. The results of our experimental study with 6 participants show that the proposed architecture provides an effective assistance to human during the execution of task and reduces undesired motion errors, while not sacrificing from the task completion time.

FrT71 Room 1

Detecting and Understanding Human Activity (II) (Regular Session)

Chair: Kühnlenz, Kolja	Coburg University of Applied Sciences and Arts
Co-Chair: Rossi, Silvia	Universita' Di Napoli Federico II

15:15-15:25 FrT71.1

Robocentric Conversational Group Discovery, pp. 1-6

Schmuck, Viktor	King's College London, United Kingdom
Sheng, Tingran	King's College London
Celiktutan, Oya	King's College London

Detecting people interacting and conversing with each other is essential to equipping social robots with autonomous navigation and service capabilities in crowded social scenes. In this paper, we introduced a method for unsupervised conversational group detection in images captured from a mobile robot's perspective. To this end, we collected a novel dataset called Robocentric Indoor Crowd Analysis (RICA). The RICA dataset features over 100,000 RGB, depth, and wide-angle camera images as well as LIDAR readings, recorded during a social event where the robot navigated between participants and captured interactions among groups using its on-board sensors. Using the RICA dataset, we implemented an unsupervised group detection method based on agglomerative hierarchical clustering. Our results show that incorporating the depth modality and using normalised features in the clustering algorithm improved group detection accuracy by a margin of 3% on average.

15:25-15:35 FrT71.2

The MuMMER Data Set for Robot Perception in Multi-Party HRI Scenarios, pp. 1-7

CANEVET, Olivier	Idiap Research Institute
He, Weipeng	Idiap Research Institute
Motlicek, Petr	Idiap Research Institute
Odobez, Jean-Marc	IDIAP

This paper presents the MuMMER data set, a data set for human-robot interaction scenarios that is available for research purposes. It comprises 1 h 29 min of multimodal recordings of people interacting with the social robot Pepper in entertainment scenarios, such as quiz, chat, and route guidance. In the 33 clips (of 1 to 4 min long) recorded from the robot point of view, the participants are interacting with the

robot in an unconstrained manner. The data set exhibits interesting features and difficulties, such as people leaving the field of view, robot moving (head rotation with embedded camera in the head), different illumination conditions. The data set contains color and depth videos from a Kinect v2, an Intel D435, and the video from Pepper. All the visual faces and the identities in the data set were manually annotated, making the identities consistent across time and clips. The goal of the data set is to evaluate perception algorithms in multi-party human/robot interaction, in particular the re-identification part when a track is lost, as this ability is crucial for keeping the dialog history. The data set can easily be extended with other types of annotations. We also present a benchmark on this data set that should serve as a baseline for future comparison. The baseline system, IHPER 2 (Idiap Human Perception system) is available for research and is evaluated on the MuMMER data set. We show that an identity precision and recall of ~80% and a MOTA score above 80% are obtained.

15:35-15:45 FrT71.3

Impact of Human Gaze Behavior and Robot Appearance on Motion Uncertainty During Cooperative Hand Movement Tasks, pp. 1-6

Kühnlenz, Kolja	Coburg University of Applied Sciences and Arts
Westermann, Max	Coburg University
Kühnlenz, Barbara	Coburg University of Applied Sciences and Arts

Results from a study on human gaze behavior during a synchronous human-robot arm movement task with incongruent motions and robot appearance variation are presented. %and its influence on motion uncertainty are presented. Significant interactions of human gaze behavior and robot appearance (presence or absence of a robot head) towards deviations of human hand movements from task direction are found. Depending on the level of humanoid embodiment, different gaze strategies lead to different deviations from task motion, which may be explained with different allocation of attention in pursuit and static point fixation behaviors. Besides a better understanding of gaze dependent impact of robot appearance on interaction, a practical implication is the potential for deriving respective situational uncertainty models of human motion in order to improve safety and efficiency of close human-robot interaction.

15:45-15:55 FrT71.4

An Adversarial Attacks Resistance-Based Approach to Emotion Recognition from Images Using Facial Landmarks, pp. 1-8

Shehu, Harisu Abdullahi	Victoria University of Wellington
Browne, Will	Victoria University of Wellington
Eisenbarth, Hedwig	Victoria University of Wellington

Emotion recognition has become an increasingly important area of research due to the increasing number of CCTV cameras in the past few years. Deep network-based methods have made impressive progress in performing emotion recognition-based tasks, achieving high performance on many datasets and their related competitions such as the ImageNet challenge. However, deep networks are vulnerable to adversarial attacks. Due to their homogeneous representation of knowledge across all images, a small change to the input image made by an adversary might result in a large decrease in the accuracy of the algorithm. By detecting heterogeneous facial landmarks using the machine learning library Dlib we hypothesize we can build robustness to adversarial attacks. The residual neural network (ResNet) model has been used as an example of a deep learning model. While the accuracy achieved by ResNet showed a decrease of up to 22%, our proposed approach has shown strong resistance to an attack and showed only a little(< 0.3%)or no decrease when the attack is launched on the data. Furthermore, the proposed approach has shown considerably less execution time compared to the ResNet model.

FrT72 Room 2

Creating Human-Robot Relationships (Regular Session)

Chair: Ros, Raquel	La Salle-Universitat Ramon Llull
Co-Chair: Lugrin, Birgit	University of Wuerzburg

15:15-15:25 FrT72.1

What If It Speaks Like It Was from the Village? Effects of a Robot Speaking in Regional Language Variations on Users' Evaluations, pp. 1-6

Lugrin, Birgit	University of Wuerzburg
Ströle, Elisabeth	Julius-Maximilians-Universität Würzburg
Obremski, David	University of Wuerzburg
Schwab, Frank	University of Würzburg (JMU)
Lange, Benjamin P.	Julius Maximilian University of Würzburg

The present contribution investigates the effects of spoken language varieties, in particular non-standard / regional language compared to standard language (in our study: High German), in social robotics. Based on (media) psychological and sociolinguistic research, we assumed that a robot speaking in regional language (i.e., dialect and regional accent) would be considered less competent compared to the same robot speaking in standard language (H1). Contrarily, we assumed that regional language might enhance perceived social skills and likability of a robot, at least so when taking into account whether and how much the human observers making the evaluations talk in regional language themselves. More precisely, it was assumed that the more the study participants spoke in regional language, the better their ratings of the dialect-speaking robot on social skills and likeability would be (H2). We also investigated whether the robot's gender (male vs. female voice) would have an effect on the ratings (RQ). H1 received full, H2 limited empirical support by the data, while the robot's gender (RQ) turned out to be a mostly negligible factor. Based on our results, practical implications for robots speaking in regional language varieties are suggested.

15:25-15:35 FrT72.2

Estimation of Mental Health Quality of Life Using Visual Information During Interaction with a Communication Agent, pp. 1-7

Nakagawa, Satoshi	The University of Tokyo
Yonekura, Shogo	The University of Tokyo
Kanazawa, Hoshinori	The University of Tokyo
Nishikawa, Satoshi	University of Tokyo
Kuniyoshi, Yasuo	The University of Tokyo

It is essential for a monitoring system or a communication robot that interacts with an elderly person to accurately understand the user's state and generate actions based on their condition. To ensure elderly welfare, quality of life (QOL) is a useful indicator for determining human physical suffering and mental and social activities in a comprehensive manner. We hypothesize that visual information is useful for extracting high-dimensional information on QOL. We propose a QOL estimation method to integrate facial expressions, head fluctuations, and eye movements that can be extracted as visual information during the interaction with an agent. Our goal is to implement multiple feature vectors learning estimator that incorporates convolutional 3D to learn spatiotemporal features. However, there is no database required for QOL estimation. Therefore, we implement a free communication agent and construct our database based on information collected through interpersonal experiments using the agent. To verify the proposed method, we focus on the “mental health” QOL scale, which is the most difficult to estimate among the eight scales that compose QOL based on a previous study. We compare the four estimation accuracies: single-modal learning using each of the three features and multiple feature vectors learning integrating all the three features. The results for evaluating the difference between the estimated QOL score and the actual QOL score calculated by the conventional method show that multiple feature vectors learning has fewer estimation errors than all the other single-modal learning and can estimate the QOL score. Therefore, we proposed a new approach for estimating human conditions that can improve the quality of human–robot interactions and personalized monitoring.

15:35-15:45 FrT72.3

Robot Mirroring: Promoting Empathy with an Artificial Agent by Reflecting the User's Physiological Affective States, pp. 1-6

Perusquia-Hernandez, Monica	NTT Communication Science Laboratories
Cuberos Balda, Marisabel	Independent
Gomez Jauregui, David	ESTIA

Antonio
Paez-Granados, Diego — EPFL - Swiss Federal School of Technology in Lausanne
Dollack, Felix — NTT Communication Science Laboratories
Salazar Luces, Jose Victorio — Tohoku University

Self-tracking aims to increase awareness, decrease undesired behaviors, and ultimately lead towards a healthier lifestyle. However, inappropriate communication of self-tracking results might cause the opposite effect. Subtle self-tracking feedback is an alternative that can be provided with the aid of an artificial agent representing the self. Hence, we propose a wearable pet that reflects the user's affective states through visual and haptic feedback. By eliciting empathy and fostering helping behaviors towards it, users would indirectly help themselves. A wearable prototype was built, and three user studies performed to evaluate the appropriateness of the proposed affective representations. Visual representations using facial and body cues were clear for valence and less clear for arousal. Haptic interoceptive patterns emulating heart-rate levels matched the desired feedback urgency levels with a saturation frequency. The integrated visuo-haptic representations matched to participants own affective experience. From the results, we derived three design guidelines for future robot mirroring wearable systems: physical embodiment, interoceptive feedback, and customization.

15:45-15:55 FrT72.4

The Maze of Realizing Empathy with Social Robots, pp. 1-6

García Corretjer, Marialejandra — Ramon Llull University - La Salle Campus
Ros, Raquel — La Salle-Universitat Ramon Llull
Martin Valcarcel, Fernando — La Salle - Universitat Ramon Llull
Miralles, David — Grup De Recerca En Tecnologies Mèdia, La Salle Campus Barcelona,

Current trends envisage an evolution of collaboration, engagement, and relationship between humans and devices, intelligent agents and robots in our everyday life. Some of the key elements under study are affective states, motivation, trust, care, and empathy. This paper introduces an empathy test-bed that serves as a case study for an existing empathy model. The model describes the steps that need to occur in the process to provoke meaning in empathy, as well as the variables and elements that contextualise those steps. Based on this approach we have developed a fun collaborative scenario where a user and a social robot work together to solve a maze. A set of exploratory trials are carried out to gather insights on how users perceive the proposed test-bed around attachment and trust, which are basic elements for the realisation of empathy.

15:55-16:05 FrT72.5

Warmth and Competence to Predict Human Preference of Robot Behavior in Physical Human-Robot Interaction, pp. 1-8

Marcus, Scheunemann — University of Hertfordshire
Cuijpers, Raymond — Eindhoven University of Technology
Salge, Christoph — University of Hertfordshire

A solid methodology to understand human perception and preferences in human-robot interaction (HRI) is crucial in designing real-world HRI. Social cognition posits that the dimensions Warmth and Competence are central and universal dimensions characterizing other humans. The Robotic Social Attribute Scale (RoSAS) proposes items for those dimensions suitable for HRI and validated them in a visual observation study. In this paper we complement the validation by showing the usability of these dimensions in a behavior based, physical HRI study with a fully autonomous robot. We compare the findings with the popular Godspeed dimensions Animacy, Anthropomorphism, Likeability, Perceived Intelligence and Perceived Safety. We found that Warmth and Competence, among all RoSAS and Godspeed dimensions, are the most important predictors for human preferences between different robot behaviors. This predictive power holds even when there is no clear consensus preference or significant factor difference between conditions.

FrT73 — Room 3

Towards Intelligent and Natural Human-Robot Interaction in Medical Robot Applications (Special Session)

Chair: Yang, Chenguang — University of the West of England
Co-Chair: Su, Hang — Politecnico Di Milano
Organizer: Su, Hang — Politecnico Di Milano
Organizer: Yang, Chenguang — University of the West of England

15:15-15:25 FrT73.1

A Framework for the Integration of Coarse Sensing Information and Environmental Constraints (I), pp. 1-6

Li, Rui — Chongqing University
Hu, Yingbai — Technische Universität München
Cao, Yanjun — École Polytechnique De Montréal (Université De Montréal)
Li, Mengyao — Shenzhen Institutes of Advanced Technology, Chinese Academy of S

A series of previous work has found that the environmental constraint (EC), which is the natural result of the contact of the robot and the interacting objects, is immensely helpful for the realization of high-precision robotic tasks. However, due to the existence of multifarious errors, such as mechanical error, modeling error and sensing error, there would be discrepancy between the actual constraints and the ideal models. In such case, it is hard to realize manipulation with EC-based strategies. Inspired by human, a preliminary framework which aims at the integration of the coarse sensing information and the environmental constraints is proposed for robotic manipulation. By mapping the sensing information into the new space, where the environmental constraint can be formally described, the region that integrates the sensing information and the environmental constraint is constructed and the conditions to achieve high-precision manipulation are derived. Based on the conditions, a motion planning strategy is proposed to achieve the required task. The effectiveness of this strategy is verified by case studies.

15:25-15:35 FrT73.2

Human-Robot Skill Transfer Systems for Mobile Robot Based on Multi Sensor Fusion (I), pp. 1-6

Chen, Dingping — Central South University
he, jilin — Central South University
Chen, Guanyu — Central South University
Yu, Xiaopeng — Central South University
he, miaolei — Central South University
Yang, Youwen — Central South University
Li, Junsong — Central South University
Zhou, Xuanyi — Central South University

Teaching by demonstration (TbD) is a powerful way to generalize the skills learned from human demonstrations to fulfill complex requirements. The mobile robot can learn new skills from interaction with human being in an intuitive way. In this paper, we propose a human-robot skill transfer system for a mobile robot that is instructed to follow a trajectory demonstrated by a human teacher wearing a motion capturing device while the Kinect sensor is recording the trajectory. With multi-modal sensor fusion, the position and velocity of the human teacher are enhanced for the correction and accuracy. A nonlinear system named a Dynamic Movement Primitive (DMP) is modeled by the trajectories data. The Gaussian mixture model is applied for the appraisal of DMP, so as to model numerous trajectories through the teaching of a demonstration. Further, to achieve the accuracy of the trajectory tracking, a novel nonlinear model predictive control (MPC) approach is proposed for motion control. By comparison with other obstacle avoidance works, the results show improved performances in terms of the time and length of the trajectory.

15:35-15:45 FrT73.3

Adaptive Impedance Control with Trajectory Adaptation for Minimizing Interaction Force (I), pp. 1-6

Luo, Jing — South China University of Technology

Yang, Chenguang — University of the West of England
burdet, etienne — Imperial College London
Li, Yanan — University of Sussex

In human-robot collaborative transportation and sawing tasks, the human operator physically interacts with the robot and directs the robot's movement by applying an interaction force. The robot needs to update its control strategy to adapt to the interaction with the human and to minimize the interaction force. To this end, we propose an integrated algorithm of robot trajectory adaptation and adaptive impedance control to minimize the interaction force in physical human-robot interaction (pHRI) and to guarantee the performance of the collaboration tasks. We firstly utilize the information of the interaction force to regulate the robot's reference trajectory. Then, an adaptive impedance controller is developed to ensure automatic adaptation of the robot's impedance parameters. While one can reduce the interaction force by using either trajectory adaptation or adaptive impedance control, we investigate the task performance when combining both. Experimental results on a planar robotic platform verify the effectiveness of the proposed method.

15:45-15:55 FrT73.4

Towards Personalized Interaction and Corrective Feedback of a Socially Assistive Robot for Post-Stroke Rehabilitation Therapy (I), pp. 1-8

Lee, Min Hun — Carnegie Mellon University
Siewiorek, Dan — Carnegie Mellon University
Smailagic, Asim — Carnegie Mellon University
Bernardino, Alexandre — IST - Técnico Lisboa
Bermúdez i Badia, Sergi — Universidade Da Madeira

A robotic exercise coaching system requires the capability of automatically assessing a patient's exercise to interact with a patient and generate corrective feedback. However, even if patients have various physical conditions, most prior work on robotic exercise coaching systems has utilized generic, pre-defined feedback.

This paper presents an interactive approach that combines machine learning and rule-based models to automatically assess a patient's rehabilitation exercise and tunes with patient's data to generate personalized corrective feedback. To generate feedback when an erroneous motion occurs, our approach applies an ensemble voting method that leverages predictions from multiple frames for frame-level assessment. According to the evaluation with the dataset of three stroke rehabilitation exercises from 15 post-stroke subjects, our interactive approach with an ensemble voting method supports more accurate frame-level assessment ($p < 0.01$), but also can be tuned with held-out user's unaffected motions to significantly improve the performance of assessment from 0.7447 to 0.8235 average F1-scores over all exercises ($p < 0.01$). This paper discusses the value of an interactive approach with an ensemble voting method for personalized interaction of a robotic exercise coaching system.

15:55-16:05 FrT73.5

A Virtual Reality-Based Framework for Enhancing Walking Abilities Using Exoskeleton (I), pp. 1-6

li, wenjie — Beijing Microelectronics Technology Institute
liu, jian — Beijing Institute of Radio Measurement
Ni, Feng — Beijing Microelectronics Technology Institute
rovetta, alberto — Politecnico
Guo, Chenguang — Northwestern Polytechnical University

This article is to develop virtual reality-based framework for enhancing walking abilities using exoskeleton robotics. China will face an ever-increasing and unprecedented demand for rehabilitation treatment and training for a long period of time in the future. backward and shortage of rehabilitation training resources urgently need to be rapidly upgraded through scientific and technological progress. A lightweight and intelligent system for indoor walking abilities rehabilitation training that combines virtual reality and exoskeleton robotics will effectively improve the rehabilitation conditions, efficiency and effects through scientific and technological means. Through tracking of the training plan, combined with the research results of gait theory, it uses 3D printed components as exoskeleton support structures, MEMS IMU, force sensors and angle encoders to obtain posture of patients, with UWB-based indoor system to measure locations. Meantime, virtual scenarios provide dynamic guidance and evaluation that meets the requirements of the training plan by wearing immersive VR glasses, with connecting real-time to cloud serve. The dynamic and precise basic perception data is fed through the control system in the exoskeleton robot, and interacts with the VR glasses via BT4.2, and after comprehensively processed, commands are given to guide the exoskeleton robot for further control. The article describes the sensing process, virtual scene establishment and presentation, human-robot interaction mechanism, virtual training and performance evaluation, and constraints. Large-scale system testing and data collection and analysis, and the heterogeneity of rehabilitation training with this method will be the focus of future research.

16:05-16:15 FrT73.6

Collaborative Suturing: A Reinforcement Learning Approach to Automate Hand-Off Task in Suturing for Surgical Robots (I), pp. 1-7

Varier, Vignesh Manoj — Worcester Polytechnic Institute
Kool Rajamani, Dhruv — Worcester Polytechnic Institute
Goldfarb, Nathaniel — Worcester Polytechnic Institute
Tavakkolmoghaddam, Farid — Worcester Polytechnic Institute
Munawar, Adnan — Johns Hopkins University
Fischer, Gregory Scott — Worcester Polytechnic Institute, WPI

Over the past decade, Robot-Assisted Surgeries (RAS), have become more prevalent in facilitating successful operations. Of the various types of RAS, the domain of collaborative surgery has gained traction in medical research. Prominent examples include providing haptic feedback to sense tissue consistency, and automating sub-tasks during surgery such as cutting or needle hand-off - pulling and reorienting the needle after insertion during suturing. By fragmenting suturing into automated and manual tasks the surgeon could essentially control the process with one hand and also circumvent workspace restrictions imposed by the control interface present at the surgeon's side during the operation. This paper presents an exploration of a discrete reinforcement learning-based approach to automate the needle hand-off task. Users were asked to perform a simple running suture using the da Vinci Research Kit. The user trajectory was learnt by generating a sparse reward function and deriving an optimal policy using Q-learning. Trajectories obtained from three learnt policies were compared to the user defined trajectory. The results showed a root mean-square error of [0.0044mm, 0.0027mm, 0.0020mm] in R^3. Additional trajectories from varying initial positions were produced from a single policy to simulate repeated passes of the hand-off task.

FrT74 — Room 4

When Robots Become Members of Human Communities They Must Face the Powerful Role of Norms (Special Session)

Chair: Malle, Bertram — Brown University
Co-Chair: Bello, Paul — Naval Research Laboratory
Organizer: Malle, Bertram — Brown University
Organizer: Bello, Paul — Naval Research Laboratory

15:15-15:25 FrT74.1

HRI for Legal Validation: On Embodiment and Data Protection, pp. 1-8

Weng, Yueh-Hsuan — Tohoku University
Gulyaeva, Svetlana — TU Dortmund University
Winter, Jana — University of Vienna
Slavescu, Andrei — University of Vienna
Hirata, Yasuhisa — Tohoku University

This paper investigates the potential of applying the study of Human-Robot Interaction (HRI) via a “Social System Design” approach to legal issues. A problem when considering AI legislation is that many existing laws were written before the development of AI technologies. To address this issue, we propose examining the effectiveness of laws through the Social System Design approach. Specifically, we will use

the General Data Protection Regulation (GDPR) to analyze if any legal gaps emerge when it is applied to social robots. To do so we will employ HRI experiments.

15:25-15:35 FrT74.2

A General Methodology for Teaching Norms to Social Robots (I), pp. 1-8

Malle, Bertram — Brown University
Rosen, Eric — Brown University
Chi, Vivienne Bihe — Brown University
Berg, Matthew — Brown University
Haas, Peter — Brown University

Human behavior is powerfully guided by social and moral norms. Robots that enter human societies must therefore behave in norm-conforming ways as well. However, there is currently no cognitive, let alone computational model available of how humans represent, activate, and learn norms. We offer first steps toward such a model and apply it to the design of a norm-competent social robot. We propose a general methodology for such a design, from empirical identification of relevant norms to computational implementations of norm learning to thorough and iterative evaluation of the robot's norm compliance by means of community feedback.

15:35-15:45 FrT74.3

Social Norms and Cooperation in a Collective-Risk Social Dilemma: Comparing Reinforcing Learning and Norm-Based Approaches (I), pp. 1-4

Payette, Nicolas — University of Oxford
Szekely, Aron — Collegio Carlo Alberto
Andrighetto, Giulia — CNR Institute of Cognitive Sciences and Technologies

Human cooperation is both powerful and puzzling. Large-scale cooperation among genetically unrelated individuals makes humans unique with respect to all other animal species. Therefore, learning how cooperation emerges and persists is a key question for social scientists. Recently, scholars have recognized the importance of social norms as solutions to major local and large-scale collective action problems, from the management of water resources to the reduction of smoking in public places to the change in fertility practices. Yet a well-founded model of the effect of social norms on human cooperation is still lacking. We present here a version of the Experience-Weighted Attraction (EWA) reinforcement learning model that integrates norm-based considerations into its utility function that we call EWA+Norms. We compare the behaviour of this hybrid model to the standard EWA when applied to a collective risk social dilemma in which groups of individuals must reach a threshold level of cooperation to avoid the risk of catastrophe. We find that standard EWA is not sufficient for generating cooperation, but that EWA+Norms is. Next step is to compare simulation results with human behaviour in large-scale experiments.

15:45-15:55 FrT74.4

Resolving Clashing Norms Using Tiered Utility (I), pp. 1-6

Welsh, Sean — University of Canterbury

There are times when norms clash in a given situation. One norm requires an agent to do X. Another requires an agent to not do X but to do Y or nothing (not X) instead. This paper describes a way to resolve clashes between norms using a concept of tiered utility that has the potential to be automated. Classical utility has polarity and magnitude. Tiered utility has polarity, magnitude and tiers. Tiers are used for lexicographic preference orderings that enable correct normative choices by robots.

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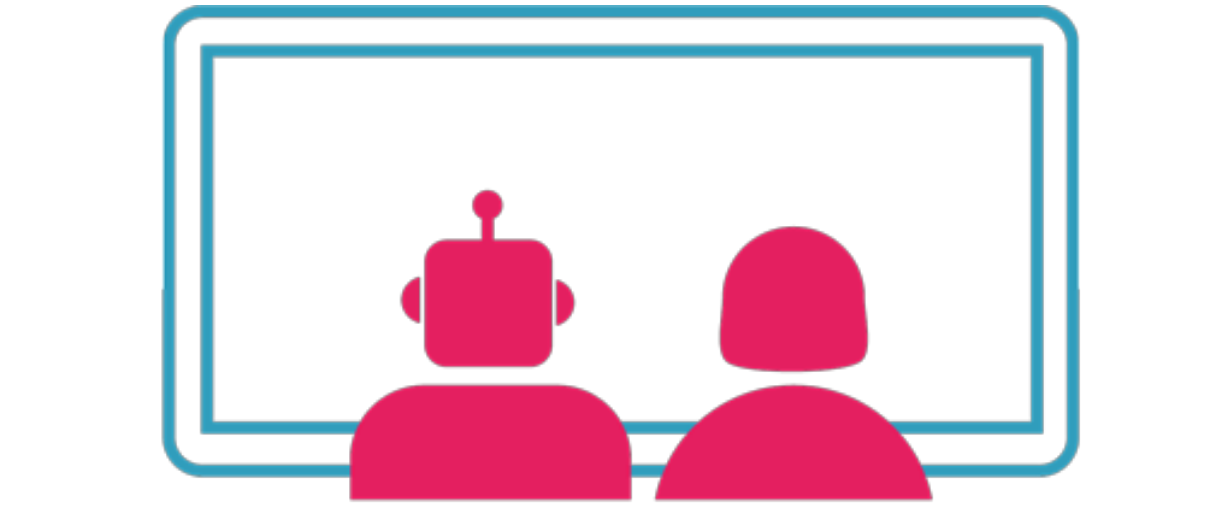

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