

Context-Awareness in Human-Robot Interaction: Approaches and Challenges

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I. ORGANIZERS

Author 1

Pauline Chevalier is a post-doctoral researcher at the Italian Institute of Technology (Italy), under the MINDED programme. Her work investigates sensory sensitivity of children diagnosed with ASD, with the approach of robot-assisted intervention techniques.

Author 2

Bob Schadenberg is a post-doctoral researcher in Human Media Interaction at the University of Twente (The Netherlands). His research focuses on understanding and designing the behavioural aspects of human-robot interaction in healthcare settings.

Author 3

Amir Aly is a lecturer (assistant professor) in artificial intelligence and robotics at the University of Plymouth (UK). His expertise covers a wide range of topics in social and cognitive robotics. Prior to joining Plymouth University, Dr. Aly was a senior research scientist at Ritsumeikan University in Japan and ENSTA-ParisTech in France.

Author 4

Angelo Cangelosi is Professor of Machine Learning and Robotics at the University of Manchester (UK). His main research expertise is on language grounding and embodiment in humanoid robots, developmental robotics, human-robot interaction, and on the application of neuromorphic systems for robot learning.

Author 5

Adriana Tapus is a Full Professor at ENSTA Paris, Institut Polytechnique de Paris (France). She pioneered the development of socially assistive robotics, also participating to activity in machine learning, human sensing, and human-robot interaction.

II. OVERVIEW OF THE WORKSHOP

To be seamlessly integrated in human-centered environments, robots are expected to have **intelligent social capabilities** on top of their physical abilities. To this end, research in artificial intelligence and human-robot interaction face two major challenges. Firstly, **robots need to cope with uncertainty during interaction**, especially when dealing with factors that are not fully observable and hard to infer (latent variables) such as the states representing the dynamic environment and human behavior (e.g., intents, goals, preferences). Secondly, **robots need to communicate their behaviors to agents** (humans and other robots in the environment) **in a clear and understandable manner**. Therefore, robots need to be **context-aware**: being able to perceive and understand their surroundings, and adapt their functionalities accordingly.

Context-awareness can provide a system with the ability of **adaptation** (adjusting its behavior according to a context), **personalization** (adjusting the behavior according to the user preferences, habits, and skills), and **proactivity** (to be able to infer and predict the dynamic states of humans and the environment so as to act accordingly) [1], [2]. To meet this target, different computational models have been used with the objective of taking robots a step further towards context-awareness such as cognitive architectures and the Partially Observable Markov Decision Process (POMDP) - among others - that can help in the decision-making process of robots leading to **proactive** and **trustworthy** behaviors that could

be evaluated objectively through the models and subjectively through human users, thanks to **User studies**¹.

Our workshop aims at gathering the latest theoretical and practical research studies and expertise in intelligent social robotics at the intersection of different rapidly growing communities, including artificial intelligence, machine learning, and human-robot interaction. Besides, the workshop will allow participants and renowned researchers from academia and industry to discuss, in a multidisciplinary panel discussion, the current and long-term challenges for context-awareness in human-robot interactions.

List of topics (but are not limited to)

- Robot behavior adaption and personalization
- Decision-making under uncertainty
- AI and machine learning approaches applied to human-robot interaction
- Perception for human-robot interaction
- Modeling human behaviour
- User studies and evaluation
- Adaptive robot behavior generation
- Cognitive architectures for interactive robots
- Trustworthy human-robot interaction
- Situation awareness for context-dependent human-robot interaction

Activities of the workshop and proposed schedule

The workshop will include a series of **high-level talks** by renowned keynote speakers from **academia** and **industry** and a significant interaction from the participants through their contributed talks. The workshop will foster interactive discussions during the panel session, where the keynote speakers / panelists and the participants will address current challenging topics in this rapidly growing research area. In Table I is a tentative program of the workshop.

As the workshop will be held for an **hybrid attendance**, the accepted papers can be presented either in the morning or afternoon session to accommodate the different time zones. All participants will be asked to provide video presentation of their work to accommodate the hybrid setting of the workshop. Online conference solutions (e.g., Zoom, Teams) will be used to host the activities, and leisure time during break sessions will be organized as well in physical meetings as in virtual settings (e.g., Breaking rooms in Zoom, Gather town). For the physical venue, an estimated number of ten poster boards would be needed. A strong WiFi connection at the venue will be necessary to connect the physical and virtual participants together.

¹User studies investigate which parameters of robots' behavior can be tuned. For example, design studies focus on how to create and develop robot behaviors (e.g., expression of emotion, eye contact/gaze, speech, gestures, body postures, personality, adjust social distance/proxemics etc) and how those are perceived by a certain group of users. Moreover, these studies are used to evaluate the robot behavior, its way of execution, and its consequences on the environment.

TABLE I
TENTATIVE PROGRAM FOR A FULL-DAY WORKSHOP

Time	Description
09:00-09:10	Opening
09:10-09:50	Invited Speaker 1
09:50-10:30	Invited Speaker 2
10:30-10:40	Break
10:40-11:20	Contributed Talks / Poster Spotlight
11:20-12:00	Invited Speaker 3
12:00-13:00	Lunch Break
13:00-13:40	Invited Speaker 4
13:40-14:20	Contributed Talks / Poster Spotlight
14:20-14:30	Break
14:30-15:10	Contributed Talks / Poster Spotlight
15:10-16:00	Interactive Session
16:00-17:00	Panel Discussion
17:00	Closing

List of speakers (Confirmed)

- 1) Henny Admoni (Carnegie Mellon University, USA)
- 2) Takayuki Kanda (Kyoto University, Japan)
- 3) Bilge Mutlu (University of Wisconsin–Madison, USA)
- 4) Paulo Alvaro (IDMind, Portugal)

Target audience

This workshop aims to attract the latest research studies and expertise in human-robot interaction and collaboration at the intersection of rapidly growing communities, including but not restricting to social and cognitive robotics, machine learning, and artificial intelligence, to present novel approaches aiming at learning, producing and evaluating context-aware robot behavior. Furthermore, it will provide a venue to discuss the limitations of the current approaches and future directions towards creating intelligent human-aware robot behaviors.

Expected number of participants

We are aiming at attracting an audience of 60 participants in average following the attendance of the previous workshops organized by Dr. Aly such as (**Robot Behavior Adaptation to Human Social Norms**) in conjunction with Ro-Man 2021 (<https://tsar2021.ai.vub.ac.be>) and (**Robotics for People: Perspectives on Interaction, Learning, and Safety**) in conjunction with RSS 2021 (<https://sites.google.com/view/r4p2021/>). We expect to reach numerous participants as the subject of the workshop covers various research lines. In addition, the quality of our confirmed keynote speakers may attract participants to register to our workshop.

Approach for recruiting participants

The organizers will issue a call for contributed papers and at a later stage a call for participation via relevant mailing lists, e.g. Robotics Worldwide, HRI Announcements, Agents, etc. Additionally, the organizers will make use of the website created for the purpose of the workshop and of social media, e.g. Twitter, and LinkedIn.

We will aim at attracting audience from less represented and poorer communities. We will build on a previous collaboration between Dr. Aly, co-organizer of the workshop, Prof. David Vernon the coordinator of the IEEE-RAS Technical

Committee on Cognitive Robotics, and Prof. Vijayakumar Bhagavatula from CMU (Carnegie Mellon University Rwanda) Africa, where 2 students from the university attended - with full scholarships - an event hosted by Dr. Aly in 2019 in Japan (<https://inic8.bitbucket.io/SoAIR19/index.html>). We are aiming at encouraging participation of students from this university so as to guarantee that our workshop will be running in a **diverse and inclusive environment**.

Plan for documenting the workshop

The workshop will be documented by means of a dedicated website and workshop proceedings. We plan to publish the proceedings through the dedicated website of the workshop, open archives (e.g., HAL archive, OSF), and the CEUR Workshop Proceedings (<http://ceur-ws.org/>). The organizers are planning to edit a special issue following the proceedings of the workshop. The workshop will be recorded and the recordings will be made publicly available afterward to ensure that the presented ideas and discussions are also available to people who were not able to attend the workshop or with bad internet connection so as to guarantee that our workshop will be running in an **inclusive environment**. The participants' video presentations will be available for the participants (e.g., workshop's website).

150–250 word abstract suitable for advertising the workshop in HRI 2022

To be seamlessly integrated in human-centered environments, robots are expected to have intelligent social capabilities on top of their physical abilities. To this end, research in artificial intelligence and human-robot interaction face two major challenges. Firstly, robots need to cope with uncertainty during interaction, especially when dealing with factors that are not fully observable and hard to infer such as the states representing the dynamic environment and human behavior (e.g., intents, goals, preferences). Secondly, robots need to communicate their behaviors to agents (humans and other robots in the environment) in a clear and understandable manner. Therefore, robots need to be context-aware: being able to perceive and understand their surroundings, and adapt their functionalities accordingly.

Our workshop aims at gathering the latest theoretical and practical research studies and expertise in intelligent social robotics that investigate the applications and challenges of bringing the ability to robots to perceive and understand their environment in the context of Human-Robot interactions. Besides, the workshop will allow participants and renowned researchers from academia and industry to discuss, in a multidisciplinary panel discussion, the current and long-term challenges for context-awareness in human-robot interactions.

ACKNOWLEDGEMENTS

This work was made possible through funding from the European Union's Horizon 2020 research and innovation program under grant agreement no: 688835 (HARMONY), and the innovation program under the Marie Skłodowska-Curie grant agreement no: 754490 (MINDED project). The content of this work reflects the authors' view only and the EU Agency is not responsible for any use that may be made of the information it contains.

REFERENCES

- [1] Makkonen, J., Avdoueviski, I., Kerminen, R., & Visa, A. (2009). Context awareness in human-computer interaction. IntechOpen.
- [2] Pichler M. Bodenhofer U. Schwinger W. 2004 Context-awareness and artificial intelligence. OGAI Journal, 23 1 4 11 , 0254-4326.