



# Editorial: Knowledge, Learning, Planning and Human Behavior Modeling for Autonomous Social Robots

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Today, with the advance of artificial intelligence (AI) and other methods in robotics, there is a growing trend to use 'intelligent algorithms' enabled by AI in robots for human-robot interaction to perform a wide range of diverse tasks combining the best abilities of humans and robots to achieve success. AI includes all these subfields of research: knowledge modeling and reasoning, learning, planning and decision-making, and human behavior modeling for autonomous social robots. The problem is that social interaction is complex, as it depends not only on physical but also on a multitude of psychological, sociological, and other factors. This makes reasoning and learning about social interaction incredibly challenging. Therefore, nowadays, most researchers in human-robot interaction (HRI) are improving their methods with more advanced techniques or creating collaborations between them to achieve complex behaviors that cover different research fields.

This special issue originated from the work at the “Artificial Intelligence for Social Robots Interacting with Humans in the Real World” IROS2022 workshop and the Artificial Intelligence for Human-Robot Interaction Trilateral Project lead from LAAS-CNRS, France by Aurélie Clodic; HRI

Lab., Kyoto University, Japan by Takayuki Kanda; and IAI, Bremen University, Germany by Michael Beetz. The goal of the AI4HRI project is to combine joint action planning and execution, social interaction learning, and knowledge reasoning and representation into a unified architecture for human-robot interaction. In this way, more intelligent robot behaviors can be achieved for human-robot collaboration to accomplish joint goals.

Therefore, this special issue accepted papers from various areas related to AI for HRI, embedded in social robots or realistic simulations of them. The general topic of this special issue is knowledge, learning, planning, and human behavior modeling for autonomous social robots interacting with humans in any type of environment (realistic simulation, laboratories, and field studies) using various methods. These interactions can be between single or multiple humans and robots, and short- or long-term HRI. The call for this special issue included, but were not limited to: human-robot joint action planning and execution, supervision systems and error management for HRI, detection or use of human social practices for HRI, knowledge representation and reasoning for HRI, human behavior modeling for

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HRI, modeling the human's perspective for HRI, learning of social interaction behaviors for HRI, evaluation of the quality of the autonomous collaboration between robot and human; human-robot collaboration models for autonomous "intelligent" social robots, realistic simulation systems for collaborative HRI, autonomous human-like social communication to facilitate or enhance the robot's "intelligent" behavior, and any human-like intelligent behavior and cognition for autonomous social robots in lab, real and/or virtual environments.

All submissions included in the current special issue have undergone a rigorous review process, maintaining the high standards of this journal. 34 manuscripts were submitted, of which 18 were accepted.

The articles featured in this issue cover various aspects within the field of AI for HRI, including human-biologically inspired robotic cognitive architectures, demonstrating that AI-communication is a key element for effective HRI inside different scenarios, recognition of emotions using nonverbal and verbal cues for demonstrating strong potential to improve HRI by allowing robots to better respond to human emotions, robot's assessing mental states of humans and humans creating mental models about social robots through architecture transparency, learning through human-robot interaction to customize robot's behaviors, and creating human-robot collaborative behaviors to extract their level of human acceptance. The articles presented in the current special issue highlight the potential of AI-driven architectures to enhance human-robot interaction. All of them in human-in-the-loop simulators or real-world evaluation of social robots, showing a trend to pass from conventional simulation to more immersive simulation and real-world environments for AI-robots.

In our capacity as guest editors we sincerely thank all contributing authors for their valuable contributions to this special issue. We are also grateful to the reviewers for their extensive and insightful comments that helped enhance the quality of the papers, and to the IJSR editorial team for their invaluable support during all the time that this special issue was extended. Above all, thank you to all, because over the years we have truly met wonderful people in the authors, editors, and reviewers. We thank the authors for their patience during the review process, due to the high standards of this journal. Moreover, this work has been supported by the Artificial Intelligence for Human-Robot Interaction (AI4HRI) project ANR-20-IADJ-0006 until December 2023, and for Ely Repiso from January 2024 until September 2025 by the UPC. Finally, being editors of this special issue has been an experience that has made us grow as researchers by seeing a part of the research that is not usually recognized, but should be, because regular journal publications could not exist without this invisible work.

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**Ely Repiso Polo** is a Lecturer Professor at Universitat Politècnica de Catalunya (UPC) inside the ESAIL department, and in the research groups SAC and CS2AC. He was Postdoc at LAAS during 2.5 years working in the trilateral project of Artificial Intelligence for Human Robot Interaction (AI4HRI) at LAAS-CNRS of Toulouse, France. She received her Ph.D. in Collaborative Social Robot Navigation in Accompanying and Approaching Tasks from the Doctorat en Automàtica, Robòtica i Visió (ARV) of the Universitat Politècnica de Catalunya (UPC) in 2020, with international mention and qualification of Excellent Cum Laude; and one of the 3 finalists for the CEA awards about the best doctoral thesis. During her Ph.D., she did a research stay at the ATR of Japan under the supervision of Takayuki Kanda. She has teaching experience at UPC during 4 academic-courses, the first two as assistant professor, and 12 years of research experience. Her research interests include people-tracking, people prediction, robot navigation, robot-human collaborative navigation, robot supervision and task planning along or collaborative, sociological and psychological theories applied to HRI, machine learning techniques applied to HRI and general HRI. She took part in 12 international conferences, 5 national projects (one in Japan) and 6 international projects, 3 organization of workshops (1 as main organizer), 1 ROSCon, 1 Main Guest editor of a special issue in the IJSR (Q1 journal) and is associated with 6 national and international research committees. She has published 10 conference articles, 4 Q1 journal articles, 2 workshops, and 1 book chapter; and serves as a reviewer for several international journals and conferences.

**Malcolm Doering** is an affiliated researcher at the Human-Robot Interaction Laboratory, Kyoto University. His research focuses on data-driven imitation learning methods for human-robot interaction. More specifically, he researches how robots can learn interactive social behaviors automatically from data using machine learning, with minimal input from human designers or expensive manual annotation. More generally, He is interested in artificial intelligence, robotics, and linguistics.

**Aurélien Clodic** is Research Engineer at LAAS (PhD in robotics (2007), Bachelor in Psychology (2018)). Her research aims to study human-robot collaborative task achievement as well as robotics architecture design (focused on decision-making and supervision). Her recent contributions involved on-line quality of interaction measurement, knowledge base reasoning through ontology management as well as situation assessment. She is the principal investigator of the "toward a Framework for Joint Action" workshop series (la.sciencesconf.org). Where she leads a dialog with psychologists and philosophers. She is part of the ANITI institute where she is responsible for the Robotics theme. She contributed in several national (ANR MaRDi, JointAction4HRI) and European (COGNIRON (FP6), SAPHARI (FP7), MuMMER (H2020)) projects. She is the french PI of the ANR trilateral German-French-Japanese AI4HRI project. She is responsible for LAAS of the ANR PRCI ELSA (Effective Learning of Social Affordance) and ANR ASTRID DISCUTER (about Interactive Dialog) projects.

**Guillaume Sarthou** is a Postdoctoral researcher in Robotics at the Institute for Artificial Intelligence of Bremen, Germany. He received his PhD in robotics in 2021 for which he focused on knowledge representation and exploitation for Human-Robot Interaction. The work of his thesis was included in several projects: JointAction4HRI from the ANR-16-CE33-0017 and the MultiModal Mall Entertainment Robot (MuMMER Project) from Horizon 2020 program. His research interests are about cognitive architecture applied to Human-Robot Interaction in general going from the assessment of the situation to symbolic task planning with a strong link to the knowledge representation of both the robot and the humans it interacts with.

**Dražen Bršćić** is an associate professor at the Department of Social Informatics at Kyoto University, Kyoto, Japan. He received his PhD degree from Tokyo University, Tokyo, Japan. He was Senior Research Assistant at Institute of Automatic Control Engineering of Technische Universität München, Munich, Germany (from 2008 to 2010). He was Research Scientist at the Intelligent Robotics and Communication Laboratories (IRC) of the Advanced Telecommunications Research Institute International (ATR), Kyoto, Japan (from 2011–2016). He was Assistant Professor of the University of Rijeka, Faculty of Engineering (from 2016–2019). He was Assistant Professor at the Kyoto University, Graduate School of Informatics, Department of Social Informatics (from 2019–2020). His research interests include, People-tracking, Localization, Mobile Robotics and Human-Robot Interaction.

**Takayuki Kanda** is a professor in Informatics at Kyoto University, Japan. He is also a Visiting Group Leader at ATR Intelligent Robotics and Communication Laboratories, Kyoto, Japan. He received his B. Eng, M. Eng, and Ph.D. degrees in computer science from Kyoto University, Kyoto, Japan, in 1998, 2000, and 2003, respectively. He is one of the starting members of Communication Robots project at ATR. He has developed a communication robot, Robovie, and applied it in daily situations, such as as peer-tutor in an elementary school and a museum exhibit guide. His research interests include human-robot interaction, interactive humanoid robots, and field trials.

**Mona Abdel-Keream** is a Ph.D. student at Institute of Artificial Intelligence (IAI) in Bremen University, Bremen, Germany. She received her Masters degree from Fachhochschule Technikum Vienna, Austria in 2017. She did several Internships, at CogVis (Cognitive Computer vision) active and assisted living technology, Vienna, Austria (Jan – May 2015); and at Artificial Hands Lab, The BioRobotics Institute, Scuola Superiore Sant’Anna, Pisa, Italy (Dec – May 2017). Her research interests are development and learning from Human-Robot Interaction (HRI) in simulation, Virtual reality HRI development, AI Reasoning for HRI, cognitive robotics and HRI.

**Michael Beetz** is a professor of Computer Science at the Faculty for Mathematics & Informatics of the University Bremen and head of the Institute for Artificial Intelligence (IAI). IAI investigates AI-based control methods for robotic agents, with a focus on human-scale everyday manipulation tasks. With his openEASE, a web-based knowledge service providing robot and human activity data, Michael Beetz aims at improving interoperability in robotics and lowering the barriers for robot programming. Due to this the IAI group provides most of its results as open-source software, primarily in the ROS software library. Michael Beetz received his diploma degree in Computer Science with distinction from the University of Kaiserslautern. His MSc, MPhil, and PhD degrees were awarded by Yale University in 1993, 1994, and 1996 and his Venia Legendi from the University of Bonn in 2000. Michael Beetz was a member of the steering committee of the European network of excellence in AI planning (PLANET) and coordinating the research area “robot planning”. He is associate editor of the AI Journal and the coordinator of the German collaborative research centre EASE (Everyday Activity Science and Engineering, since 2017). His research interests include plan-based control of robotic agents, knowledge processing and representation for robots, integrated robot learning, and cognitive perception. In 2019, he received an honorary degree from the University of Örebro for his longstanding cooperation and exceptional, international research.