International Journal of Social Robotics (2023) 15:1261–1263
https://doi.org/10.1007/s12369-023-01032-x

EDITORIAL

Editorial of the Special Issue on Human-like Behavior and Cognition in Robots

Marwen Belkaid[1,2] · Giorgio Metta[3] · Tony Prescott[4] · Agnieszka Wykowska[2]

Published online: 27 July 2023

One of the ever-present goals in robotics has been to design robots capable of thinking and behaving like humans. This goal has gained increasing significance due to the expanding range of applications where robots interact closely with humans. The scope of such applications extends beyond expert users and trained professionals to include inexperienced users, children, the elderly, or clinical populations. Such applications require creation of robots that can effectively interact and engage with humans in various social contexts. Whether such robots need to be human-like and to what degree remains an open question.

This Special Issue on 'Human-like Behavior and Cognition in Robots' stems from the eponymous workshop we organized at the 2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2021). The workshop brought together experts from diverse fields, including cognitive robotics, humanoid robotics, human-robot interaction, psychology, and cognitive neuroscience. The broad range of backgrounds among the speakers and participants fostered fruitful discussions on a wide array of topics, such as how to design brain-inspired cognitive architectures for robots, how to create robots that mimic specific aspects of human behavior, how to control the degree of human-likeness in robots, how to measure human reception of human-likeness of robots.

This Special Issue comprises 11 articles continuing and enriching the discussions initiated during the 2021 IROS workshop, including articles from some of the workshop attendees as well as from new contributors. Embracing the multidisciplinarity and complexity of the topic of human-like robots, these articles offer complementary perspectives on the subject, focusing either on the robot side on the one hand – their design, their ability to learn and behave in autonomy or around humans – or on the human side on the other – the perception of and attitude toward human-likeness in robots.

A series of papers in this issue investigate how to model human-like cognitive and social capabilities in robots. Two of them are on the topic of imitation learning. The first paper reviews the literature on both robot and human learning to provide insights about the question of who the robot should imitate considering both outcome and efficacy expectations, respectively, defined as the anticipated learning gain and the anticipated costs of performing actions. The second paper presents a neurocognitive reasoning architecture that combines bottom-up abductive inference with top-down predictive verification to produce generalizable and human-readable explanations for demonstrated behavior.

Humans have the ability to adapt their behavior according to their own performance with limited cognitive effort. The third paper proposes a human-inspired architecture alternating between model-free and model-based strategies, two forms of reinforcement learning which are thought to be performed by the brain, according to a trade-off between efficiency and computational cost. Using a robot navigation tasks as well as two simulated human-robot tasks, the authors show that combining these strategies achieves the best performance while reducing computational cost.

Human-like social attention is another aspect that might be interesting to implement in robots. The fourth paper proposes a saliency prediction model integrating visual and auditory cues which reproduce similar results to the study they conducted in which the performance of human participants in the same social attention task was higher

✉ Marwen Belkaid
marwen.belkaid@ensea.fr

1 ETIS UMR 8051, CY Paris Cergy Université, ENSEA, CNRS, Cergy F95000, France

2 Social Cognition in Human-Robot Interaction Unit, Istituto Italiano di Tecnologia, Genova, Italy

3 Istituto Italiano di Tecnologia, Genova, Italy

4 Department of Computer Science, University of Sheffield, Sheffield, UK

when visual and auditory cues were congruent compared to incongruent.

Focusing on the topic of robot design, The fifth paper addresses human-likeness from the perspective of the robot's morphology. The Authors propose a new method to quantify the functional anthropomorphism of robotic hand-arm systems by comparing relative workspace coverage and manipulability of the robot arm and fingers with those of the humans'. This method enables objectively comparing different system designs which can be complementary to approaches using subjective assessments.

Highly relevant for human-robot interaction is people's ability to predict robot's actions according to its shape or appearance. This topic is the focus of two papers in this issue. The sixth paper reports a series of experiments in which participants observed goal-directed and non-goal directed spatial cues in the form of gaze shifts made by human and robot agents or directional cues displayed by a triangle. Their results show that the human-like shape of an agent and its physical capabilities facilitate the prediction of an upcoming action. Similarly, the seventh paper presents a study showing no difference in anticipatory gaze behaviors of infants in response to actions performed by a human or a humanoid robot. As previous studies had reported opposite results with robotic arms, these results suggest that human-like appearance might be crucial for humans' ability to predict and anticipate robots' actions and goals.

In addition to appearance, humans' attitude toward robots may depend on other aspects of human-likeness like motion quality. The eighth paper shows that human-like, smooth movements led to higher perception of human-likeness for a non-humanoid industrial robot arm in an observational setting. Moreover, the ninth paper reports that motion human-likeness and the display of feedback gesture influence participants' subjective trust in an interaction decision task. These two papers evaluate participants' attitude toward robots using questionnaires, i.e., subjective measures. More implicit measures can also be used. For instance, changing one's mind following an advice can be a proxy of one's trust toward the advice giver. The tenth paper employed a paradigm based on this idea to measure participants' trust toward the robot. While previous studies revealed that the smell of the hexanal molecule increase trust in human-human interaction, the authors show that this molecule did not influence trust in human-robot interaction, suggesting the effect might be context-dependent. Last, combining questionnaires and a sorting task, the eleventh paper compared implicit and explicit attitudes toward robots between a Japanese and a Dutch cohort. The authors show that Japanese individuals have a more positive attitude toward robots only at the explicit level, but no evidence of such a difference was found at the implicit level.

Research around human-like robots seeks to bridge the gap between humans and machines. Endowing robots with human-like qualities may improve their cognitive and behavioral capabilities. This may in turn enable more natural and intuitive human-robot communication and cooperation. Ultimately, the development of human-like robots holds the potential to revolutionize the way humans interact with machines and facilitate seamless integration of robots into our daily lives. We are still far from knowing how to design such machines and from understanding how human users would respond to them. We also need to be aware of potential ethical consequences such blurring of the distinction between humans and machines might entail. Yet, we believe the articles of this Special Issue provide valuable insights toward designing human-like features in robots. We are thankful to the contributors, reviewers, editors and staff who made this Special Issue possible and we hope that it will generate interest in the community and stimulate further research on this topic.

Marwen Belkaid is a junior professor and researcher in neuroscience and robotics. He obtained his doctorate at the Université de Cergy-Pontoise in December 2016. Then, from 2017 to 2022, he was a postdoctoral fellow at Sorbonne Université in Paris, France, then at the Istituto Italiano di Tecnologia in Genoa, Italy. In 2022, he obtained a Junior Professor Chair in Neuroscience and Robotics at CY Cergy Paris Université. His research combines computational modeling with a wide array of experimental work ranging from robot experiments to animal and human studies. His work aims to use robots to study, model, and better understand the brain, as well as to draw inspiration from the brain to develop more intelligent machines.

Giorgio Metta is the Scientific Director of the Istituto Italiano di Tecnologia (IIT). He holds a MSc cum laude (1994) and PhD (2000) in electronic engineering both from the University of Genoa. From 2001 to 2002, Giorgio was postdoctoral associate at the MIT AI-Lab. He was previously with the University of Genoa and from 2012 to 2019 Professor of Cognitive Robotics at the University of Plymouth (UK). His research activities are in the fields of biologically motivated and humanoid robotics and, in particular, in developing humanoid robots that can adapt and learn from experience. Giorgio Metta is author of more than 300 scientific publications. He has been working as principal investigator and research scientist in about a dozen international research as well as industrial projects.

Tony Prescott received the M.A. degree in psychology from the University of Edinburgh, U.K., the M.Sc. degree in applied artificial intelligence from the University of Aberdeen, U.K., and the Ph.D. degree in machine learning from the University of Sheffield, UK. He is a currently a Professor of Cognitive Robotics with the Department of Computer Science, University of Sheffield. He is also a co-founder and the current Director of Sheffield Robotics, a cross-disciplinary institute across both universities in Sheffield. He has authored over 200 publications in robotics, computational modeling, cognitive science, and computational neuroscience.

Agnieszka Wykowska leads the unit "Social Cognition in Human-Robot Interaction" at the Italian Institute of Technology (Genoa, Italy), and is an adjunct professor of engineering psychology at the Luleå University of Technology as well as visiting professor at the University of Manchester. She graduated in neuro-cognitive psychology (2006, LMU Munich), obtained PhD in psychology (2008) and the German "Habilitation" (2013) from LMU Munich. In 2016 she was awarded the ERC Starting grant "InStance: Intentional Stance for Social Attunement". In her research, she combines cognitive neuroscience methods with human-robot interaction in order to understand the human brain mechanisms in interaction with natural and artificial agents.