Introduction to the Special Issue on HRI System Studies

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Human-Robot Interaction (HRI) systems are often realized through a complex integration of relevant state-of-the-art algorithms, low-level software and robotic hardware. As such, advances in techniques and approaches for integrating components into a robotic system are essential to advance the field. To develop such techniques and systems requires one to address real-world challenges, particularly those arising from the complex nature of human-robot interaction embedded in a dynamic social and/or task environment. This special issue focuses on the concept of “systems”, highlighting the importance of building actual HRI systems to validate and drive the science and technology in the field.

This special issue is also unique, in that the authors of all papers will present their work at the 8th ACM/IEEE International Conference on Human-Robot Interaction in Tokyo, Japan. With this initiative we wish to draw attention to the systems approach to HRI, a perhaps underrepresented topic in the large and diverse HRI community.

This particular special issue generated a lot of interest, generating many submissions. After a rigorous multi-stage review process, we accepted seven contributions. **Chao and Thomaz** present a model for autonomously controlling turn-taking between a robot and a person. The model is based on a petri net, which represents and reasons about the asking, keeping or relinquishing of a turn in an interaction. The model is evaluated on a humanoid robot. It is shown how different parameter settings of the model not only are noticed by people, but that people adapt their behavior towards the robot and as such change the turn-taking social dynamics.

The paper by **Trafton et al.** argues that a cognitive architecture can be used to design better HRI. Cognitive architectures have a long and respected tradition in the cognitive sciences, but can they be used to model people so a robot understands what they do and why? If so, can this be used to build robots that predict what people will do in different situations? Trafton et al. extend the ACT-R cognitive architecture, now dubbed ACT-R/E, to deal with embodied interaction. The paper presents four case studies illustrating the value of cognitive architectures to HRI.

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Wrede et al. address the problem of programming kinematically redundant robot arms by non-expert users. As these arms are highly flexible, non-expert users find kinesthetic teaching by of the robot very challenging. Their approach is to separate the training into a task-independent configuration phase and a task-specific programming phase. The model, which relies on a neural network to learn joint control and gravity compensation, controls the joints of the robot, allowing the user to focus on training what the end effector needs to do. The model is implemented on a KUKA Lightweight Robot IV and evaluated in an industrial setting. The study convincingly demonstrates how the model has a positive impact on programming-by-demonstration.

Breazeal et al. take a unique approach to acquiring interaction data from a wide range of users. Using crowdsourcing, they pair internet users to solve a collaborative task in a simulated environment, where one user acts as a robot and the other as a human. An interaction history is built-up and used to train a case-based planning system for a real autonomous robot. The robot is then tested in the Boston Museum of Science, showing how crowdsourced data can indeed be used to generate autonomous robot behavior that is comparable on a number of measures to that of a human operator.

The last three papers in this issue report on real-world human-robot interactions, demonstrating how people use, interact with and accept HRI systems. The study by **Strabala et al.** shows how people hand over objects to others, and successfully replicated such natural hand-over interactions on a robot. The authors specifically reveal how people coordinate hand-over interactions, and identify the way in which people agree on the timing and configuration in which the hand-over occurs.

Kondo et al. report a method to generate natural motion in an android robot. This technique is used in a multi-party dialog setting in which the robot is able to orient its gestures and gaze toward the person addressing the robot. Their field study reveals how appropriate robot behavior results in stronger engagement with the audience.

Finally, **McColl et al.** developed a robot for encouraging elderly people to eat. They integrated sensors in the robot as well as in the meal tray and cutlery, allowing the robot to model and monitor the progress of the meal and to encourage the user based on the model. In a unique field study with eight users over 80 years of age, they not only demonstrate the functionality of the robot but also show how users positively engaged with the robot and were willing to follow its advice.

The papers in this special issue are a showcase of the exciting and wide-ranging progress in HRI systems studies, where the challenges of building actual systems and testing these with naïve users in relatively unconstrained environments are varied and often difficult to overcome. In addition, the papers show that such HRI systems cover a wide range of topics in artificial intelligence, cognitive systems and robotics. Topics such as sensing, motion planning, non-verbal behavior planning, natural language interaction and system architecture are all brought to bear on HRI. The papers shows how progress in all these subfields and the creative integration of them in real HRI systems can lead to breakthroughs and real-world applications of robots.

We would like to thank all authors who submitted a contribution. Even if your paper did not make the final selection, your efforts are tremendously appreciated. We are also grateful for the hard work of all reviewers who kindly provided their time and expertise for this issue. Without their help, this issue would not have the quality and breadth it has now. We hope this issue will encourage other researchers to take up the

challenge of building and evaluating technical HRI systems and report their adventures, systems, and results in future contributions of the HRI journal or conference.

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