Introduction to the Special Theme on Human-Robot Interaction

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This special issue addresses the state of the art of human-robot interaction (HRI), discussing the current challenges faced by the research community for integrating both physical and social interaction skills into current and future collaborative robots.

Recent years have seen a proliferation of applications for robots interacting physically with humans in manufacturing and industry [1], from bimanual cooperation in assembly with cobots (i.e., industrial manipulators for collaboration) to physical assistance with exoskeletons. These applications have driven research in many fundamental topics for collaboration, such as shared task allocation, synchronisation and coordination, control of contacts and physical interaction, role estimation and adaptive role allocation during collaboration, learning by demonstrations, safe control, etc [2]. All the developments in these areas contribute to the success of the Industry 4.0, whose elite platforms are essentially cobots and exoskeletons.

At the same time, research in social robotics has made tremendous progress in understanding the behaviour and the intricacy of verbal and non-verbal signals exchanged by robots and humans during interaction, highlighting critical aspects such as trust, mutual awareness and turn-taking [3]. These studies were initially motivated by the increased assistance and service robotics application, ranging from the introduction of robots in malls and shops to hospitals and homes, but are now becoming crucial for the acceptance of new intelligent robotics technologies in other industrial domains, such as manufacturing.

The human-robot-interaction (HRI) research community is thus advancing both physical and social interaction skills for robots. The proof of the convergence of both skills are the new industrial robots such as Baxter and Sawyer, where compliant arms such as in cobots are coupled with a face emulating referential gaze and social behaviour, to facilitate collaboration with humans.

The European Commissions Strategic Research Agenda for Robotics acknowledges the importance of robotics. With their increased awareness and ease of use, robots represent the dawn of a new era as ubiquitous helpers improving competitiveness for business and quality of life for individuals. Their role is expected to continuously expand beyond their traditional role in the man-

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ufacturing industry, providing significant short to medium term opportunities in areas such as agriculture, healthcare, security and transport, while in the longer term robots are expected to enter almost all areas of human activity, including the home. Along this line, the European Commission highlights HRI as one of the key technology areas in robotics with greatest impact guaranteeing project funding of 66 million EUR for 2018-2020. A large number of national and European projects are active in this area and a selection of these can be found referenced in the articles on these issue. Besides some of the current challenges in human-robot interaction and the approaches to tackle these challenges in real applications are presented in this special issue.

Key challenges on human robot collaboration are discussed in several papers. Buoncompagni *et al.* addresses main research questions for HRC in smart factories, advocating an AI-based approach to develop intelligent collaborative robots and Ivaldi is focused on the prediction of the human partner, currently developed within the EU-funded H2020 project AnDy.

Topics related to conversational and dialog systems are addressed in Agirre *et al.* presenting relevant research work in dialog systems for industry aiming to improve the natural language interaction between humans and robots. On the same topic Schindler *et al.* describe a conversational system that faciltates HRI thanks to a context-aware approach based on audio-analysis, which has been successfully exploited in various application areas.

Manufacturing-oriented papers such as those by Kaiser and Horvath aim to support HRC scenarios in their respective areas. Kaiser used simulation tools to design collaborative assembly systems and to support the planning tasks, whereas Horvath describes a context-aware multimodal interface effectively utilised within SYMBIO-TIC H2020 project.

Assistive robots and healthcare applications within the context of HRI are discussed in Cesta *et al.*, Hindriks *et al.* and Efthimiou *et al.*. Cesta *et al.* , present a cognitive architecture combining human perception and AI techniques to infer knowledge about the status of a user and the environment and plan personalised assistive robot actions for elderly people. Hindriks *et al.* reports on their first experiments on a social robot that supports collection of patient data in a hospital, to reduce the workload of nurses. Efthimiou *et al.* are developing a multimodal user-centred HRI solution that encourages trust and acceptance of assistive robots for elderly people.

State-of-the art research in social HRI is presented in Schellen *et al.*, Evers , Mokios *et al.* and Ribino *et al.* . Schellen *et al.* highlights the importance of social attunement in interactions with artificial agents, exploiting methods from experimental psychology and cognitive neuroscience to study social cognitive mechanisms during HRI. The research is partially funded by the starting ERC grant InStance. Evers designs socially intelligent robots for several applications, from service to education. As part of EU-funded FET projects TimeStorm and Entiment, Mokios *et al.* address the open challenge of time perception in HRI to enable fluent HRI. Ribino *et al.* argue that robots acting with humans following social norms may improve their acceptance and the dynamics of HRI by proactively reasoning in dynamic normative situations.

The articles in this special theme not only provide a panorama of the ongoing European research in the field, but highlight the intrinsic multidisciplinarity of the theme. Even in industrial sectors such as manufacturing, it is clear that the problem of introducing collaborative robots cannot be merely reduced to the problem of ensuring safety and controlling their physical interaction with the humans. A multitude of sub-problems must be taken into account for collaborative robots to be accepted and widely adopted: from rethinking the whole system software and hardware architecture to enabling natural communication. The diversity of challenges and topics addressed in the special theme illustrates the several challenges for human-robot interaction and collaboration.

References

[1] A. M. Zanchettin, E. Croft, H. Ding, and M. Li. Collaborative robots in the workplace [from the guest editors]. *IEEE Robotics Automation Magazine*, 25(2):16–17, June 2018.

[2] Arash Ajoudani, Andrea Maria Zanchettin, Serena Ivaldi, Alin Albu-Schäffer, Kazuhiro Kosuge, and Oussama Khatib. Progress and prospects of the human–robot collaboration. *Autonomous Robots*, pages 1–19, 2018.

[3] Andrea Thomaz, Guy Hoffman, and Maya Cakmak. Computational human-robot interaction. *Foundations and Trends in Robotics*, 4(2-3):105–223, 2016. ISSN 1935-8253.