Special Issue on Behavior Adaptation, Interaction, and Artificial Perception for Assistive Robotics

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Special Issue on Behavior Adaptation, Interaction, and Artificial Perception for Assistive Robotics

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This Special Issue aims at examining and promoting recent developments in the Assistive/Social robotics field and future directions including the related challenges and how these can be overcome with particular focus on computational intelligence methodologies. With robots getting out of the cages, Human-Robot Interaction (HRI) applications' effectiveness has not only to rely on the skills of trained users, but also on robots' ability to adapt on-the-fly to the users' behavior, needs and motivations. In particular, the development of personal robots, as assistive technological tools, challenges researchers to develop socially intelligent and adaptive robots that can collaborate with people.

Personal robots are expected to incrementally learn user preferences, to learn categories of user preferences experienced during past interactions (so that they do not start each new interaction from scratch), and to modify and adapt their behaviors accordingly. This adaptation requires learning a model of human behavior and integrating this model into the decision-making algorithm of the robot. Efficient on-the-fly adaptation also requires model-free learning abilities to cope with local uncertainties of the environment, variations of the human's desires and motivations, and volatilities of the interaction itself. Thus creating robotic systems capable of correctly modelling and recognizing the human behavior and of adapting their behavior to the user is a very critical task, especially in the domain of assistive and social robotics and when working with vulnerable user populations. Robots should also be able to consider psychological aspects to better adapt the robot behavior to the person mental status. This is particularly relevant for assisting the elderly and children with developmental disabilities.

This special issue is comprised of 14 papers, fostering discussions and investigations in social assistive robotics with the main aim of providing successful interactions. Several aspects and perspectives are taken into consideration by the authors covering various social assistive robotics topics of interest, including research in elderly assistive robotics; robot social skills for enhancing engagement, inducing distraction and reduce anxiety; child-robot teaching through reinforcement learning and learning by teaching; and social robot responses, perception and semantic modalities, ...

- **MC:** In "Emotional and Behavioral Distraction by a Social Robot for Children Anxiety Reduction During Vaccination" (by S. Rossi, M. Larafa and M. Ruocco) a social robot is used to interact with children during the vaccination process with the aim to reduce stress and anxiety through distraction techniques that integrate different emotional states very similar to those used by health professionals.
- **MC:** The article "On-the-fly Detection of User Engagement Decrease in Spontaneous Human-Robot Interaction using Recurrent and Deep Neural Net-

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works" (by A. Ben Youssef, G. Varni, S. Essid and Ch. Clavel) presents a Recurrent and Deep Neural Networks to detect engagement decrease of users spontaneously interacting with a socially assistive robot in a public space.

- **MC:** "A Novel Reinforcement-Based Paradigm for Children to Teach the Humanoid Kaspar Robot" (by A. Zaraki, M. Khamassi, L. J. Wood, G. Lakatos, C. Tzafestas, F. Amirabdollahian, B. Robins, K. Dautenhahn) presents a novel child-robot learning by teaching scheme tested with a group of typically developing children and a small group of children with autism. The objective is to stimulate interaction and collaboration between a group of children while teaching the robot simple object-name associations. The robot makes mistakes and verbally expresses its uncertainty so as to provide the children with tangible examples to understand that sometimes learning requires several repetitions. This kind of novel child-robot learning by teaching scheme could be used in future studies to support the development of social and collaborative skills of children with Autism Spectrum Disorders (ASD).
- **MC:** On the same topic of learning in child-robot interaction the article "Children Teach Handwriting to a Social Robot with Different Learning Competencies" (by S. Chandra, P. Dillenbourg and A. Paiva) presents an autonomous educational system incorporating a social robot to enhance children's handwriting skills. The system provides a one-tone learning scenario based on the learning-by-teaching approach where a tutor-child assess the handwriting skills of a learner-robot. This research supports that the contrasting learning competencies of social robots can impact children's learning differently in peer-learning scenarios.
- **MC:** The paper "ENRICHME: Perception and Interaction of an Assistive Robot for the Elderly at Home" (by S. Cosar, M. Fernandez-Carmona, R. Agrigoroaie, J. Pages, F. Ferland, F. Zhao, S. Yue, N. Bellotto, A. Tapus) introduces the robotic platform developed in the ENRICHME project, with particular focus on its innovative perception and interaction capabilities. The project's main goal is to enrich the day-to-day experience of elderly people at home with technologies that enable health monitoring, complementary care, and social support.
- **MC:** The article "Multimodal object-based environment representation for assistive robotics" (by Y. Breux, S. Druon and J. Triboulet) proposes a global architecture bridging the gap between perception and semantic modalities allowing the automatic generation of object-related ontology for a practical formalization of the ill-defined notion of context.
- **MK:** "A hybrid Joint/Cartesian DMP-based approach for obstacle avoidance of anthropomorphic assistive robots" (by C. Lauretti, F. Cordella, L. Zollo) proposes an approach based on joint-space dynamic movement primitives (DMP) to perform goal reaching with a robotic arm, while performing human-like obstacle avoidance. The approach integrates two DMPs in the task and joint space that are merged together using a scheme that gives priority to the task space position. The approach is compared with a more conventional cartesian-space-based DMP with inverse kinematics approach on performance and user perception. The results suggest that the authors' approach is notably more human-like while maintaining equivalent performance. These results are of importance to contribute in further developing socially interactive robots with anthropomorphic gestures, which can improve human capability to interpret and predict robot motion, with an impact on robot acceptability and human-robot interaction safety.
- **MK:** "TROS: Protecting Humanoids ROS from Attackers with Physical Access" (by G. Mazzeo, M. Staffa) constitutes a novel solution to deal with cybersecurity issues during robot deployment within human societies, and especially during human-robot social interaction. Indeed, humanoids typically reside in untrusted environments where physical access to the robot is allowed and expected, thus permitting anyone, including hackers, to exploit the Linux kernel vulnerability (e.g., through the insertion of a USB pen drive) with the objective of tampering sensitive data. This opens the risk of violating the privacy of people's data, or – even worse – threaten human integrity from physical and emotional/social point of views. Since many current humanoids are programmed with the Robot Operating System (ROS), the authors first study the most-recent security solutions introduced in ROS2, SROS, and H-ROS, and find that they are not sufficient for facing powerful adversaries. They then present a patched ROS solution called TROS (Trusted-ROS) leveraging hardware-assisted trusted computing to shield data managed by ROS, which otherwise would reside in robot's memory unencrypted. Simulation and evaluation with the NAO humanoid secured through an Intel SGX hardware demonstrate the practicability of the approach.
- **MK:** Conceiving robot control architectures enabling their application to a variety of experimental situations is the central issue addressed in "THE RHI-

ZOME ARCHITECTURE: An Adaptive Neurobehavioral Control Architecture for Cognitive Robots Application in a Vision-Based Indoor Robot Navigation Context" (D. M. Rojas Castro, A. Revel, M. Ménard). The authors propose a control architecture called RHIZOME (Robotic Hybrid Indoor-Zone Operational ModulE) as a new control paradigm capable of easy adaptation to different scenarios where a robot is able to interact with its environment and other cognitive agents while coping with possible unexpected situations. The architecture is based on the synergy of different state-of-the-art control paradigms by merging them into a neural structure, which follows a perception-action mechanism that constantly evolves because of the dynamic interaction of the robot with its environment. The RHIZOME architecture was tested on the NAO robot humanoid in an indoor vision-based navigation context. The presented experimental results show the feasibility, genericity and adaptability of the architecture. Moreover, the generic composition of the architecture make it is possible to develop it further with respect to robustness and completeness by simply adding new modules without modifying the already in-built components. This opens the perspective of further testing the RHIZOME architecture in a variety of other cognitive tasks.

- **Silvia:** Dealing with machine learning for artificial perception is the contribution "A WiSARD Network approach for a BCI-based Robotic Prosthetic Control" (by Mariacarla Staffa, Maurizio Giordano, and Fanny Ficuciello). The manuscript presents a method relying on the use of a WiSARD weightless neural network-based classifier, a robotic hand and a BCI controller interface to realize a portable and easy of use solution in the area of automatic robotic-prosthesis control.
- **Silvia:** Adaptation to the specific needs of patients was considered in "A Holistic Approach to Behavior Adaptation for Socially Assistive Robots" (by Alessandro Umbrico, Amedeo Cesta, Gabriella Cortellessa, and Andrea Orlandini). This work introduces the design of a semantic-based cognitive architecture allowing to automatically generate robotic assistive objectives. The proposed approach is based on ontologies for characterizing the internal knowledge and the self-awareness of a Social Robot and specifying its capabilities to support users during its assistive services in adaptive and personalized scenarios.
- **Silvia:** Also dealing with ontologies, "Culture as a Sensor? A Novel Perspective on Human Activity Recognition" (by Ting-Chia Chiang, Barbara Bruno, Roberto Menicatti, Carmine Tommaso Recchiuto, and Antonio Sgorbissa) presents a culture-aware Human Activity Recognition system which aims to include culture-specific information about where and when activities are most likely performed in different cultures. This contribution, that belongs to the special issue, was already published in a regular issue by mistake and can be found here (https://link.springer.com/a 019-00590-3).
- **Silvia:** Adaptation to the user is also considered in "Short-Term Human–Robot Interaction Adaptability in Real-World Environments" (by Antonio Andriella, Carme Torras, and Guillem Alenya), where an assistive robotic platform that can be used for short-term human-robot interactions. A cognitive system that relies on planning is extended with adaptive capabilities is used to assist people while they are playing a puzzle game. The robot adapts itself according to the stage of the game and provide assistance to the user.
- **Silvia:** On the same line, the development of a strategy for robot-assisted navigation is investigated in "Reinforcement Learning Aided Robot-Assisted Navigation: A Utility and RRT Two-Stage Approach" (by Luís Garrote, João Paulo, and Urbano Nunes) that is based on user intent adjustment. Such adjustments are learned by reinforcement learning (RL) and supported on a rapidly exploring random tree (RRT) inspired algorithm. The proposed framework relies on local environment perception, based on a kinect sensor, and several layers for computing corrections to avoid collisions and follow social norms, so to effectively guiding the user through the environment while enforcing safer routes.

THE FOLLOWING SENTENCE MUST BE CHANGED. IT IS COPY-PASTED FROM ANOTHER EDITORIAL: We greatly appreciate the encouragement, support, and efforts of the Editors-in-Chief (Professor Shuzhi S. Ge and Agnieszka Wykowska), the Co-Editor-in-Chief (Professor Oussama Khatib), the Springer Senior Editor for Engineering (Nathalie Jacobs), staff at Springer, and numerous reviewers in producing this special issue. It is our hope that this special issue will generate more interest and research endeavors, resulting in better understanding of assisitive social robots and their many potential applications for improving human lives.

Guest Editors

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