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EDITORIAL

Guest editorial: focused section on human-centered robotics

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Human-centered robotics requires a fundamental shift from the traditional robot-in-a-cage model to robots interacting with people in an open environment with applications that include wearable robotics, social robots for home and entertainment, and collaborative manufacturing. Many efforts are underway to guarantee safety and improve performance when such robots operate in human environments, such as improved sensors and actuators and data-based methods for enhanced cognition. This generates numerous opportunities for innovation. At the same time there are substantial challenges before such robots become ubiquitous.

To disseminate current advances and identify challenges and opportunities, this "Focused Section on Human-Centered Robotics" of the International Journal of Intelligent Robotics and Applications (IJIRA) highlights several important research and technology achievements in: human–robot interface; action and trajectory planning; sensors; safety; and humans teaming with multiple robots. The Focused Section includes nine papers that represent a sample of current developments in human-centered robotics.

Intent and interface Human-centered robotics should have appropriate interfaces to assess human intent and facilitate human use of robotic systems. The first paper "Gaze and motion information fusion for human intention inference" by Ravichandar et al. presents an algorithm to estimate human intent (target location) based on human reaching actions. Additionally human gaze is used to improve the estimated intent and quantitative evaluations using multiple subjects are presented. The second article "Sequence-based manipulation of robotic arm control in brain machine interface" by Kilmarx et al. uses a new robotic Brain-Machine-Interface (BMI) platform using Electroencephalography (EEG) technology to control a six degree of freedom robotic arm, which can impact the use of such interfaces to control prosthesis. A key result is that the new approach provided good results with about ten minutes of training, which is substantially smaller than the typical days to weeks of training needed with standard BMI approaches that use sensorimotor rhythm to control robotic systems.

Motion planning The article "Robot action planning by online optimization in human–robot collaborative tasks" by Wang et al. addresses the issue of task cost evaluation along with online optimization, which can be used for planning of human–robot collaborative tasks such as manufacturing. Their experimental results indicate that the proposed algorithms can enable efficient human-robot collaborative assembly. The rich set of issues in motion planning even for a specific task is highlighted in the article "Momentum-based trajectory planning for lower-limb exoskeletons supporting sit-to-stand (STS) transitions" by Patil et al. The paper analyses factors that affect human center of mass trajectory and shows that different human movement velocity profiles during STS transitions require different control strategies of the center of mass. The researchers propose a model based on horizontal and vertical momentums that enables efficient planning of the center of mass trajectory for any STS transition velocity. Such efforts to improve STS can enhance independent living for seniors.

Sensing and safety Assessing the human mental and physical state, which in turn can be important for safety in human-centered robotics. The article "Development of a combined time-grequency technique for accurate extraction

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of pNN50 metric from noisy heart rate measurements" by Vaqueiro et al. addresses the measurement of a key metric associated with human mental workload. Such measurements could inform the robot about the degree to which "a human is overwhelmed and error-prone in decision making". The article "Automatic analysis of ultrasound shear-wave elastography in skeletal muscle without non-contractile tissue contamination" by Brown et al. develops a new ultrasound image processing methods to assess muscle activities. Such assessment could be used in clinical settings as a diagnostic tool for monitoring rehabilitation from neuromuscular disease and injury such as stroke and spinal cord injury. The safety of human–robot interaction can also be highly dependent on which part of the body the robot is interacting with and the pose of the body. The work "A design metric for safety assessment of industrial robot design suitable for power and force limited collaborative operation" by Vemula et al. aims to develop simulation tools to assess the safety of transient contact during human–robot collaboration.

Managing multiple robots The article "Motion synchronization for semi-autonomous robotic swarm with a passivity-short human operator" by Atman et al. investigates coordination between a human operator and a robotic swarm where the goal is to guarantee human-enabled motion synchronization to desired position/velocity references. The proposed architecture is demonstrated through simulation studies and with an experimental test-bed. As mentioned in the article, such swarm control can be important for "environmental monitoring, infrastructure support or exploration due to its scalability and robustness against robot failures". The article "Collaborative manipulation with multiple dual-arm robots under human guidance" by Peng et al. develops a method for using multiple robots to collaboratively manipulate an object when the load and size cannot be managed by a single robot. The article uses contact force sensing and infers the human intent to enable collaborative manipulation of the object without loss of contact. Inertial forces are estimated and compensated using feedforward and experimental results are provided to illustrate the efficacy and limitations of the proposed scheme.

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