Introduction to Journal of Human-Robot Interaction

Special Issue on Haptics in HRI: Cooperation and Communication

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Coming generations of robots will share physical space with humans, engaging in contact interactions (physical Human Robot Interaction, or **pHRI**) as they carry out cooperative tasks. This special issue turns a spotlight on the specific roles that crafted **haptic interaction** can play in *cooperation* and *communication* between a human and a robotic partner, from the viewpoints of human needs, capabilities, and expectations and of engineering implementation.

Physical interaction brings specific challenges to many aspects of robot development and evaluation. These require hardware technologies that can meet high safety requirements, built-in adaptability to comply with unpredictable human behavior, improved control paradigms for physical human-robot interaction and cooperation, embodied intelligence with distributed sensing and active perception capabilities, intuitive programmability of non-repetitive movement that will nevertheless be predictable and unthreatening to the user, and crafting of a physical language for communication.

However, recent developments in sensing, actuation, microprocessors, and robot control platforms and standards render these issues more manageable. As robots appear in health, automation, and home-based assistance, physical contact and interaction with humans will be a relevant and often crucial part of these scenarios. This issue provides a view of where we stand technologically as this movement gains traction and provides a vision for where the touch modality converges with HRI for communication and cooperation.

A recurrent theme in our accepted submissions is the role that touch can provide in *guidance*. Scenarios vary from teleoperated control of mobile robot motion, individually or in swarms, to natural, intuitive guidance of an individual robot. Beyond this, we find insights in *evaluative methods*, *modalities of interaction*, and use of *automated learning techniques* based on sensed forces.

We begin our issue with a perspective on the application of haptic feedback in the teleoperation and supervision of ground-based mobile robots, where standards and metrics are needed to compare approaches and optimize technology. In “*Methods for Evaluating and Comparing the Use of Haptic Feedback in Human-Robot Interaction With Ground-Based Mobile Robots*,” Brooks, Tsui, and Yanco propose to compare the effectiveness of haptic behaviors for controlling ground-based mobile robots with an

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evaluative framework that includes a generalized task, experiment design, and experimental metrics. They illustrate its use on a case study task and suggest it as a standard usable by others.

Proceeding to specific robot-guidance use cases, in “*User-Centered Design of an Attitude Aware Controller for Ground Reconnaissance Robots*,” Walker, Miller, and Ling examined gestural (teleoperation of remote robot movement, implemented on commodity smartphones). In the context of military training, this proprioceptively augmented control modality has cost and training benefits to field users familiar with smartphone interaction, with compromised dexterity (gloves), vision, and attention for screen-based tools. The authors found similar performance and greater preference for untrained users, indicating the potential for using this low-cost approach.

To guide an amalgam of robots with many collective degrees of freedom, in “*Haptic Interactions With Multi-Robot Swarms Using Manipulability*,” authors Setter, Fouraker, Kawashima, Egerstedt, and Kawashima propose to provide a layer of information via haptic cues, while noting the need to identify a comprehensible, operable mapping of swarm state information to an operator’s control task. They propose a mapping in which haptic feedback indicates to the operator what directions the swarm can be easily or naturally turned and examine its effectiveness in a user study.

Our last two papers address direct physical interaction with a robot collaborator. He and Sidobre strive for fluid and natural object handover between humans and robots in “*Synchronization of Grasp-Release by Online Force Classification for Interactive Object Exchange*.” To teach a robot to release an object in the right way and at the right moment as a human partner takes it, they apply realtime machine classification to data streamed from an instrumented handover object. They designed a new device for manipulation learning, and experimentally investigated how force control policies can be learned and then used for interactive object exchange.

We close the issue with “*Tap and Push: Assessing the Value of Direct Physical Control in Human-Robot Collaborative Tasks*.” Here, the operator interacts in a supervisory mode with an automation robot in a collaborative task. The operator indicates commands through direct physical interaction (taps and pushes) on the robot itself. Gleeson, Currie, MacLean, and Croft found this direct interaction outperformed more push-button operator control styles for tasks that were complex and unscripted (i.e., the kind of tasks that are most difficult to automate).

In closing, we thank our authors and submitters for their interest, their ideas, and the findings they have shared with us. This highly multidisciplinary area is evolving rapidly, and we hope this initial glimpse will offer insights into its possibilities.

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