Natural User Interfaces for Adjustable Autonomy in Robot Control

Joseph J. LaViola Jr. ▪ *University of Central Florida*

Odest Chadwicke Jenkins ▪ *Brown University*

The increasing popularity of robotics in modern society makes interacting and communicating with them of critical importance. Although one of the main goals in robotics research is to develop fully autonomous systems, the ability to control robots in teleoperation applications and provide guidance to them for semiautonomous tasks in a natural and intuitive way is still an important research goal. To this end, adjustable autonomy focuses on exploring the space between fully autonomous and fully telerobotic interfaces and how humans can naturally and easily communicate with robots to support human-robot interaction (HRI) within this spectrum. As such, natural interfaces that utilize 3D gestures, speech, touch, eye gaze, and other modalities are becoming increasing cost effective and have the potential to create powerful human-robot interfaces that support adjustable autonomy.

This special issue presents some of the latest research results in the exploration of natural user interfaces for robotic control and teleoperation. In particular, this issue presents two articles that investigate several natural user interface strategies for engaging with robots, including eye gaze and touchscreens as well as taking concepts from tangible user interfaces and augmented reality (AR) to develop new HRI metaphors.

In This Issue

In "Visual and Manual Control for Human-Robot Teleoperation," Andreas Dünser, Martin Lochner, Ulrich Engelke, and David Rozado Fernández investigate the use of eye tracking for a pick-and-place task by comparing it against a touchscreen and traditional computer mouse. For the eye-tracking interface, users selected items via either a mouse click or dwell time. The authors based their experiment on Multiple Resource Theory (MRT), a concept from cognitive psychology that predicts performance on tasks that require disparate cognitive resources. Thus, their experiments had users perform a secondary task, manual operation of a joystick, in parallel with object and location selection. They hypothesized that using eye gaze could help to reduce the cognitive burden of performing motor and visual tasks together. In other words, eye gaze would help preserve performance in the dual-task condition, whereas the mouse and touchscreen would not. The results of their experiments showed that users performed faster with the manual interfaces (touchscreen yielding the best performance) than with the eye-tracking interfaces but eye tracking with dwell time activation does show promise. Additionally, with eye tracking, the distance between targets is not as important, but manual interaction time increases with longer distances.

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Takeo Igarashi and Masahiko Inami's article "Exploration of Alternative Interaction Techniques for Robotic Systems" presents a series of alternative interaction methods for working with robotic systems in the home based on their work with the Japan Science and Technology Agency's ERATO Igarashi Design Interface Project. They observe that typical user interfaces for robots are either overly abstract or excessively detailed for everyday use. They propose applying techniques from human-computer interaction, such as AR and tangible user interfaces, to HRI. For example, in terms of GUIs, they discuss prototypes for teaching robots to fold garments and cook meals. In terms of AR, they present tools for managing multiple home consumer devices, controlling a cleaning robot, and giving instructions to computer-controlled lighting. Finally, in terms of tangible user interfaces, they discuss controlling robots with paper tags and using physically active markers to support robot navigation. Additionally, they also present some novel I/O devices that bring computational and robotic elements together unobtrusively and discuss the overall implications of how the developed prototypes may affect the future of HRI.

Future Directions

As HRI continues to evolve with less effort focused on pure telerobotic interaction and more research focusing on guided autonomy, where users provide simple commands and the robot has enough autonomous power to independently perform complex actions, there will be excellent opportunities for future research that will significantly impact the field. One critical area is in the robot's understanding of the physical world. The more the robot understands its surrounding world, the more it will be able to act autonomously based in the user's commands. Thus, developing new algorithms and methods for improving a robot's understanding of the world will go a long way to pushing the state of the art forward. These approaches need to develop better ways for robots to understand object geometry as well as the higher-level semantics of the affordances that accompany any object in its world model. User interfaces that can support this process of world acquisition and understanding represent another interesting research direction. Interesting questions for human-in-the-loop, robot-world modeling include identifying the best interaction metaphors and strategies to support this task as well as how to best enable humans to visualize and understand what the robot sees and already knows.

Joseph J. LaViola Jr. *is the CAE Link Professor and an associate professor in the Department of Electrical Engineering and Computer Science and director of the Interactive Systems and User Experience Research Cluster of Excellence at the University of Central Florida. He is also an adjunct associate research professor in the Computer Science Department at Brown University. His research interests include pen-based interactive computing, 3D spatial interfaces for videogames, human-robot interaction, multimodal interaction in virtual environments, and user interface evaluation. LaViola has a PhD in computer science from Brown University. Contact him at jjl@eecs.ucf.edu.*

Odest Chadwicke Jenkins *is an associate professor of computer science at Brown University. His research addresses problems in robot learning and human-robot interaction, primarily focusing on robot learning from demonstration, as well as topics in computer vision, machine learning, and computer animation. Odest has a PhD in computer science from the University of Southern California. Contact him at cjenkins@cs.brown.edu.*