Creative Human-Robot Co-Manipulation

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Abstract

Robotic assistance can help disabled users in many ways. However, current robot tools are limited in their ability to support users in dynamic, creative, physically-embedded tasks. We propose to develop a control algorithm for a 6 or 7 Degree of Freedom (DoF) robot arm to allow people with upper-limb mobility impairments to create works of art or engineering that neither they nor the robot could produce alone.

In order to be successful, we have identified three skills that the robot needs:

- The collaboration must be fluent and pleasant for the user.
- The system must be appropriate for the task and capable of bridging the gaps between the user's capability and the task requirements.
- The system must be effective, supporting the user without limiting their creativity.

These three criteria define three parts of our work. The first part, which comprises our pilot study, is an investigation of collaborative co-manipulation between two humans or a human and a robot, and how the presence or absence of haptic communication influences perceived task fluency and user satisfaction.

The second part of our work involves partnering with collaborators with upper-limb mobility impairments in one or more makerspace environments. Through this collaboration, we will develop a framework for identifying appropriate tasks and designing robotic assistance for creative co-manipulation tasks. We are particularly interested in tasks that are creative, dynamic, and physically embedded, due to the unique constraints and opportunities these tasks provide for robotic assistance.

With this framework, and the guidance from our study of co-manipulation fluency, we will be able to identify one or more candidate tasks for the third part of our work: developing a control system for a 6 or 7 degree of freedom (DoF) robotic arm that supports effective, creative, co-manipulative collaboration with a user who experiences upper-limb mobility limitations. The technical requirements of this system are as-yet unknown, but it will certainly need to be adaptable to different parts of the task and different types of potentially noisy user input (for example: if a system user experiences hand tremors, and the robot needs to filter them out while otherwise following the user's physical guidance for the task).

RESPECT 2025, Newark, NJ, USA

ACM ISBN 979-8-4007-1355-2/2025/07
https://doi.org/10.1145/3704637.3734746

CCS Concepts

• **Human-centered computing** → *User studies*; • **Hardware** → *Emerging interfaces*; • **Applied computing** → **Engineering**.

Keywords

Robotics, Manipulation, Human-robot interaction, Assistive Technology

ACM Reference Format:
Katherine H. Allen. 2025. Creative Human-Robot Co-Manipulation . In *Proceedings of the 2025 Conference for Research on Equitable and Sustained Participation in Engineering, Computing, and Technology (RESPECT 2025), July 14–16, 2025, Newark, NJ, USA.* ACM, New York, NY, USA, 1 page. https://doi.org/10.1145/3704637.3734746

1 Questions and Connections

At the doctoral consortium, I am interested in getting the perspectives of educators, especially those who work in informal STEM environments like makerspaces and/or with disabled students, around educating with/around advanced technical tools like robots. How much would a robot arm in the makerspace be a distraction for the student learning to use it, or other students? How might I turn that "distraction" into a learning opportunity for all the students (and could that be both a learning opportunity about accessibility and assistive technology and about technology more broadly)?

I am interested in making connections with other researchers who are doing technical research that is also about accessibility and/or education. I would like to hear about other researchers' experience keeping their work technically rigorous but still relevant and applicable, and how to balance technical novelty with user-centered design and utility.

I am looking for feedback on the best methods for partnering with disabled collaborators, especially recruitment of members of the target population, and on how to ensure that studies with small groups of participants are still generalizable. What are the key things to keep in mind while recruiting, and what should I consider while analyzing my data to put it in the context of being, or not being, representative of a small subset of a large and diverse population?

I am also interested in advice on the best methods for developing bodystorming exercises and user-led design for robot behaviors, and any lessons learned from working with disabled participants who may or may not have prior experience with the technology you are using to ensure that both everyone is kept safe and the resulting research is high-quality and novel. Advice on how to write procedures to reassure institutional review boards of the safety of our procedures when collaborating with robots is also very welcome, especially when the research is targeting marginalized groups.