NRI: Mutually Assistive Robotics

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https://aabl.cs.tufts.edu/NRIMutuallyAssistive/

Motivation

- **Strengths-based approach** to assistive robotics
- User and robot **complement each other**, with assistance freely flowing in both directions
- Users empowered to **understand and control** both high-level task goals and low-level characteristics of robot's movement
- **Joy and self-determination are central** for disabled users, in tasks that make life enjoyable, not just easier for caregivers
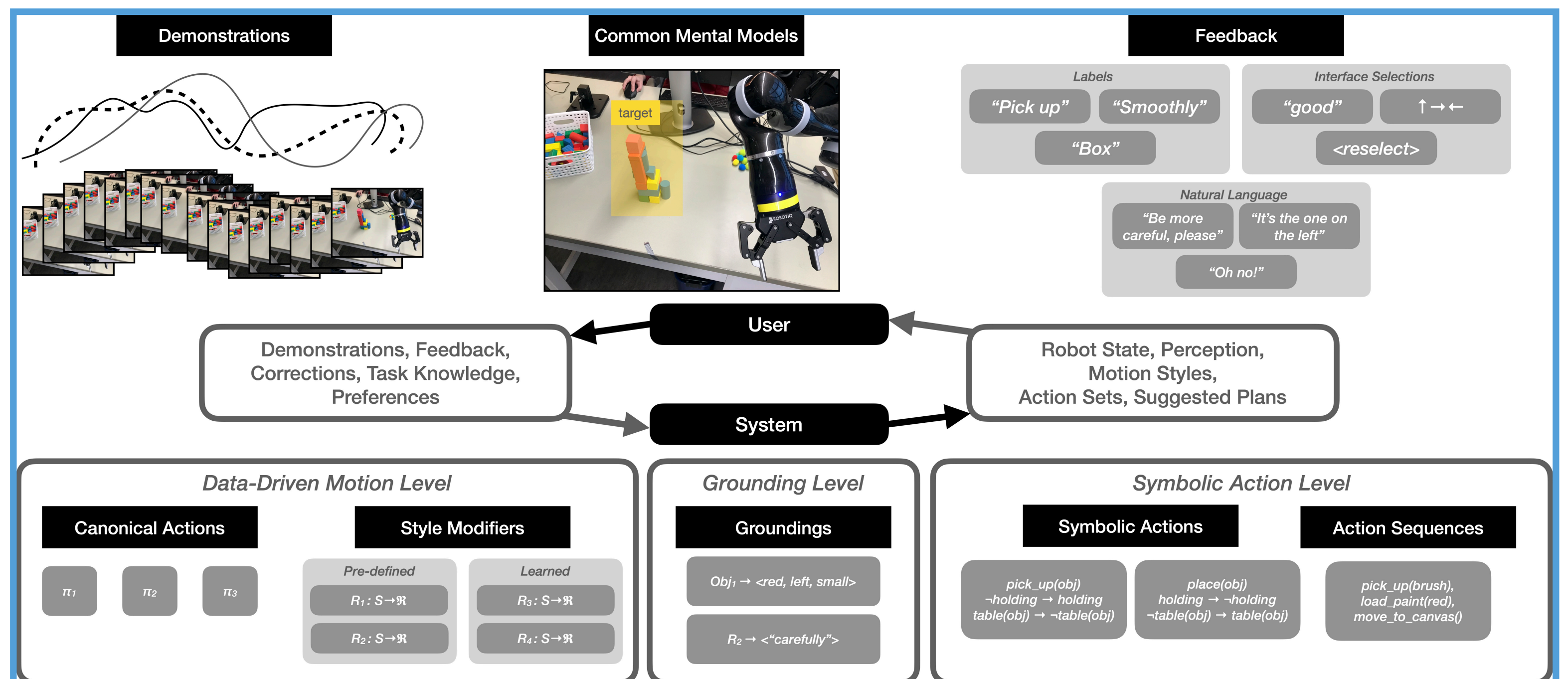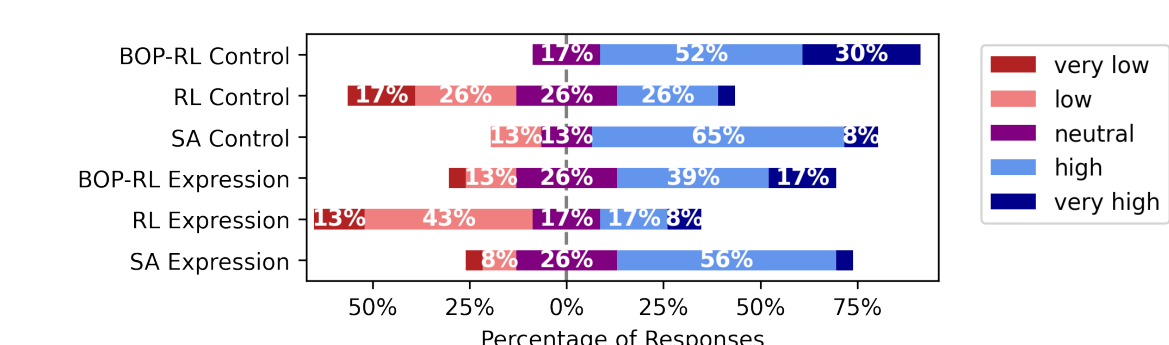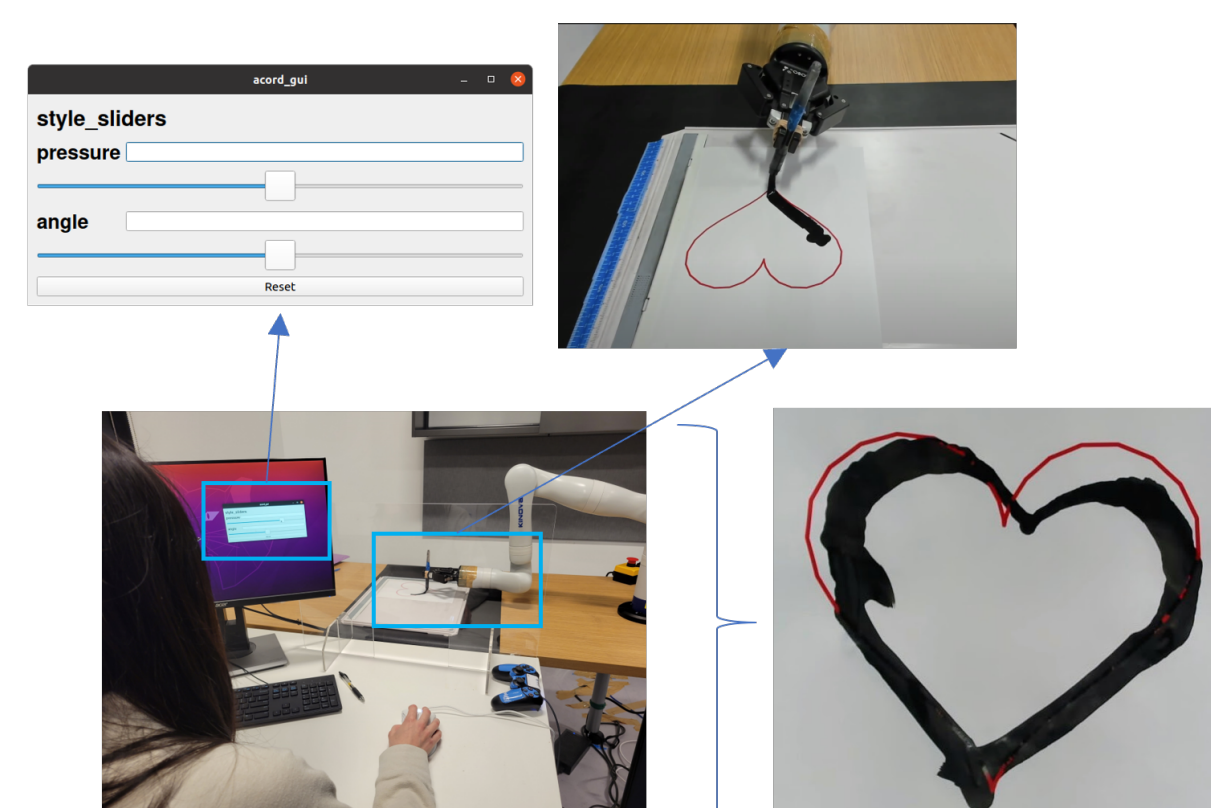

Controlling Style with RL

Enable users to control & modify trained RL agents' behavior with respect to specific dimensions of behavior, using quality, diversity + controllability

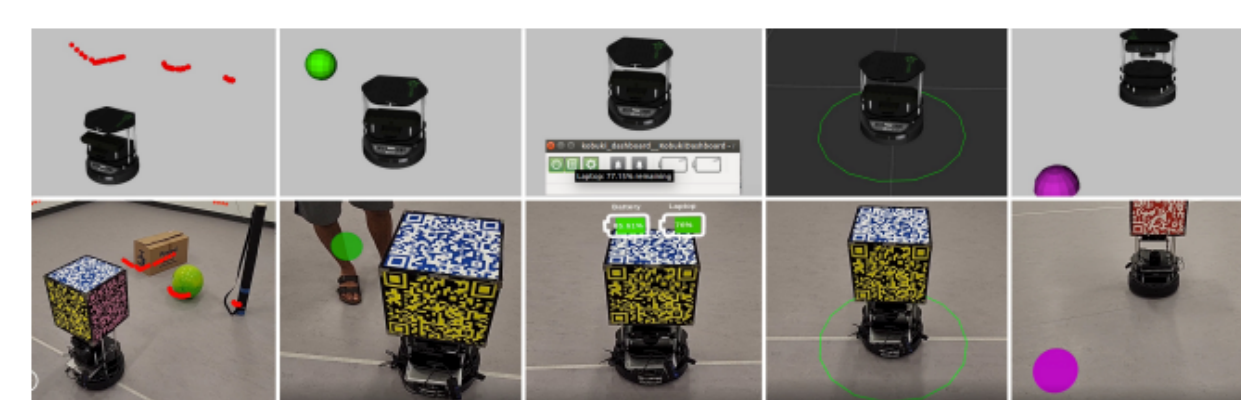**Simulation Results**
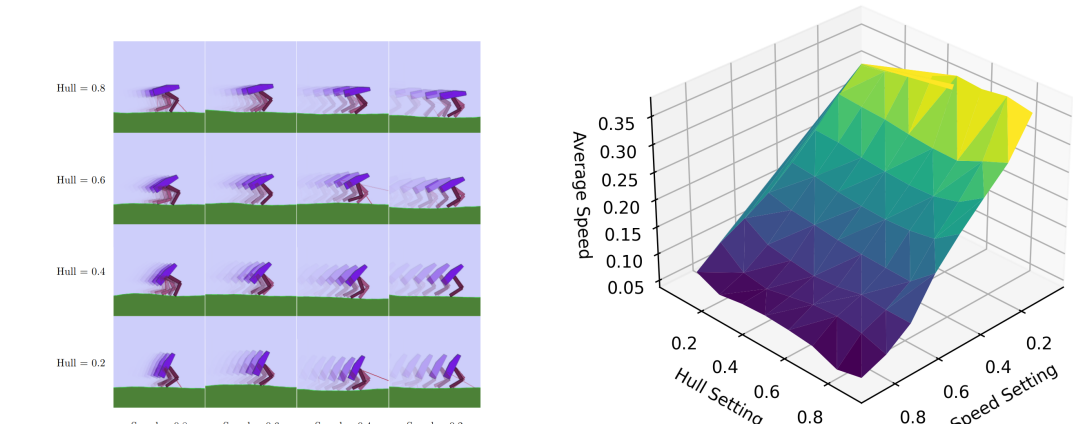
Real-World Study

Achieve control & expressivity of shared-autonomy (SA) with a pre-trained RL agent

VR to Improve Understanding

Enable users to use VR to understand key robot capabilities, limitations, and safety considerations
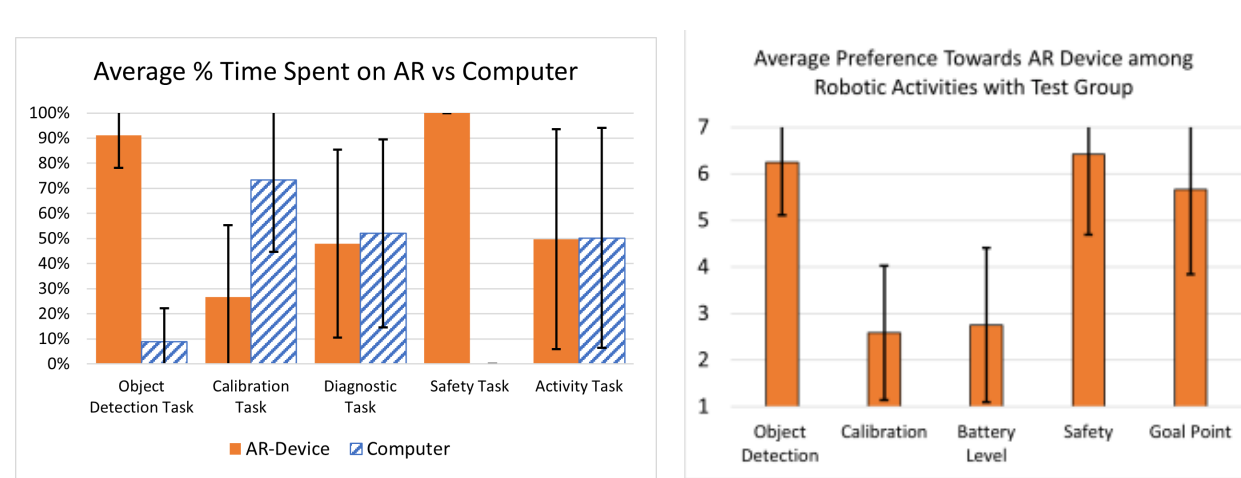
VR Interface
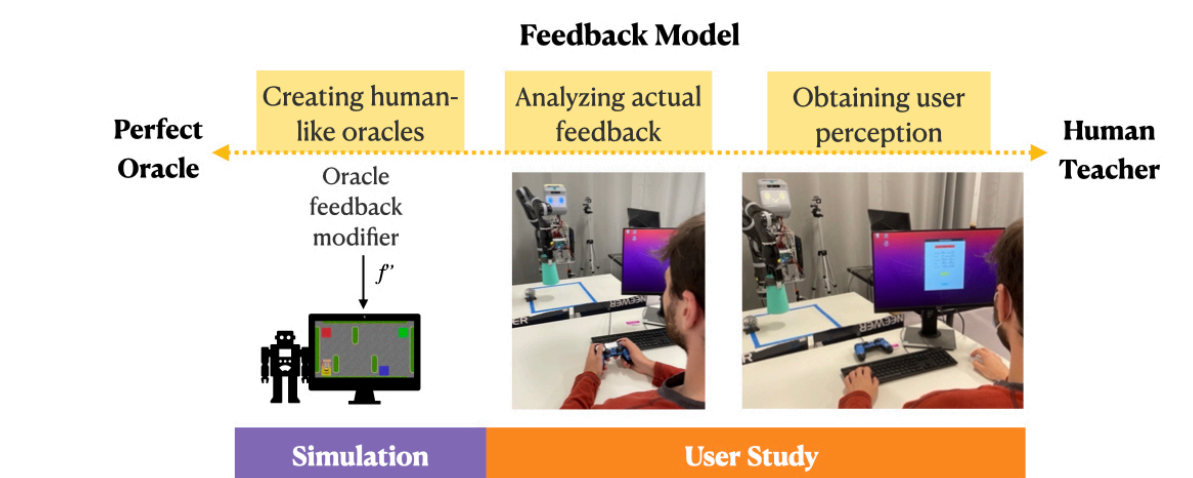

Real-World Study

Use AR to "debug" robot issues; compare to computer interface

Users prefer AR and find it more effective for many tasks

Interactive Design of Oracles

*Enable users to influence early-stage algorithm development by co-designing more human-like oracles*

Allow users to modify feedback model; model user feedback to robot; interview users about choices

Model Components

- **Delay** — how long the teacher needs to react to the learner's action
- **Frequency** — how often the teacher provides feedback
- **Strictness** — how willing the teacher is to accept multiple solutions
- **Bias** — how positive or negative the teacher's feedback is in general
- **Accuracy** — how well the feedback reflects the actual performance

Results
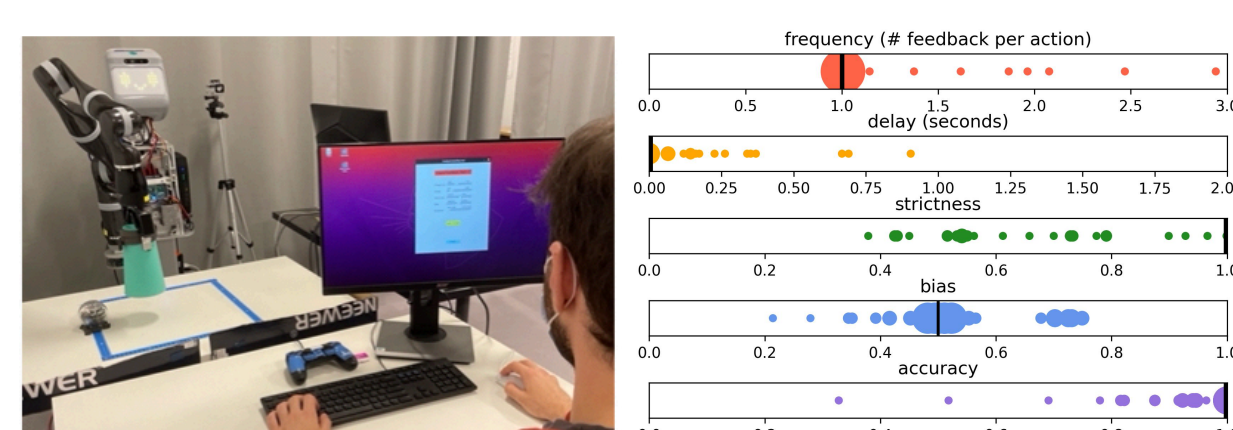
Feedback model captures key variability; enables self-reflection on teaching style and expression of self-perception

Accessible Hackathons

Interview makerspace admins and disabled makers to understand the experience of disabled makers and accessibility considerations in hackathons and makerspaces

Results

Makerspaces and disability should go hand-in-hand…

Makerspace culture is great for this because the attitude is "I don't know, let's make this work" — but you have to get inside before you can makerspace the makerspace.

> *…my father, like he was very adamant that if we had a thing we needed to know how to take care of it […] as soon as I got a wheelchair I was like, this is like, why aren't you teaching me how to take care of it? I should know that! So I began to ask questions and develop those skills as soon as I basically got one.*

… but inaccessibility is a persistent problem for disabled makers

Everything's so expensive. Hobbies have become luxuries. So we don't have the time that we can go to these spaces. And so, because of that maker spaces, I think, are being forced into inaccessibility just to keep the lights on.

> *[…] a standing, disabled person that I know […] quickly discouraged me from trying to get in touch with the Maker space downtown because there's an elevator to get into the building but it breaks down all the time. And then once you're in the building, there's not an elevator into the actual makerspace, and it's pretty similar across the city…"*

Scientific Contributions

- Algorithms for learning new manipulation skills with mutual assistance at multiple levels of abstraction
- Methods for giving users usable mental models of robots, such as using AR to empower users to understand robot perception and decision-making
- Algorithms for mutual assistance after initial models are learned that enable users to provide feedback on and influence all aspects of learned robot behavior

Impact on Education & Outreach

- Developing hybrid virtual/in-person makerspace/hackathons to support access to maker communities
- Direct dissemination to disability community through PI connections (AccessComputing BPC Alliance; self-advocacy groups)

Impact on Society

- Improved performance and customizability of co-robots through human assistance
- More disability-friendly intelligent assistive robotics
- Assistive robot behavior designed for joy and creativity, not just chores