Integrating Human Expertise in AI and Robotics Systems

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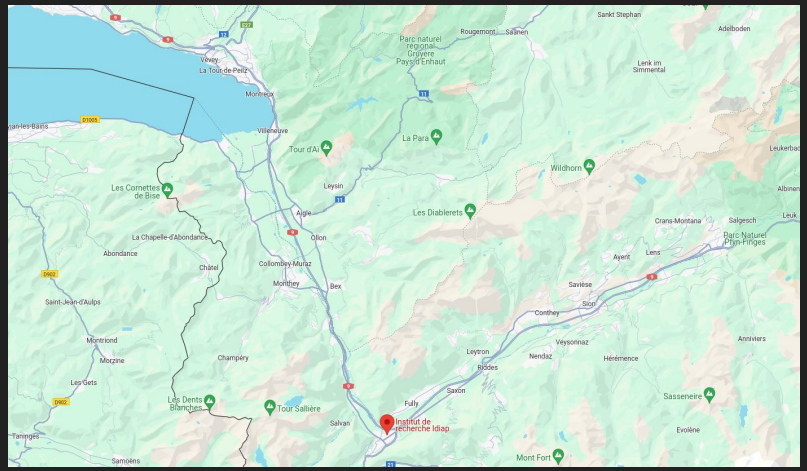


Human-AI Teaming

AI for Sustainable and Resilient Societies

AI for Life

AI for Everyone

Human-Centered Robotics and AI group

Goal of the Talk

Present **methods** for integrating **expert knowledge** throughout a system's **design process**.

Human-Robot Interaction

Challenges

- Cross-disciplinary applications
- Variety of end-users
- Long-term deployment

Insight

- End-users are domain experts
- They know how systems should behave

Research Goals

Creating and **evaluating** technologies that can integrate **domain experts**' knowledge to make robots usable by non-roboticists.

Reuters/Issei Kato
REUTERS/Michaela Rehle
World Economic Forum
https://www.nai-group.com/are-service-robotics-future/
https://hitconsultant.net/2018/08/06/robots-humans-caretaking/
New York Times/Saul Martinez

Collaborative Robotics

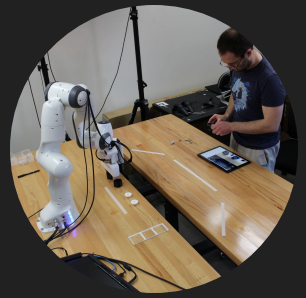
Robotic automation built to work **safely** with **human** workers in a **collaborative workspace**.

Flexible automation

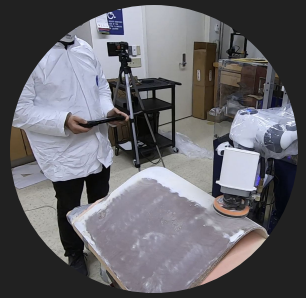
- Higher throughput
- Easier to repurpose

Increase safety

- Access dangerous environments
- Reduce strain on workers



A. In-situ Programming for Collaboration



B. Shared Autonomy for Assisted Sanding

A. In-situ Programming for Collaboration

Context

- Assembly task
- True collaboration
- Easy to repurpose

Challenges

- Formalize an interactive behavior
- Ground robot behavior in changing world
- Program robot in situ

Deployment

- End-user programming

System

Collaborative robot

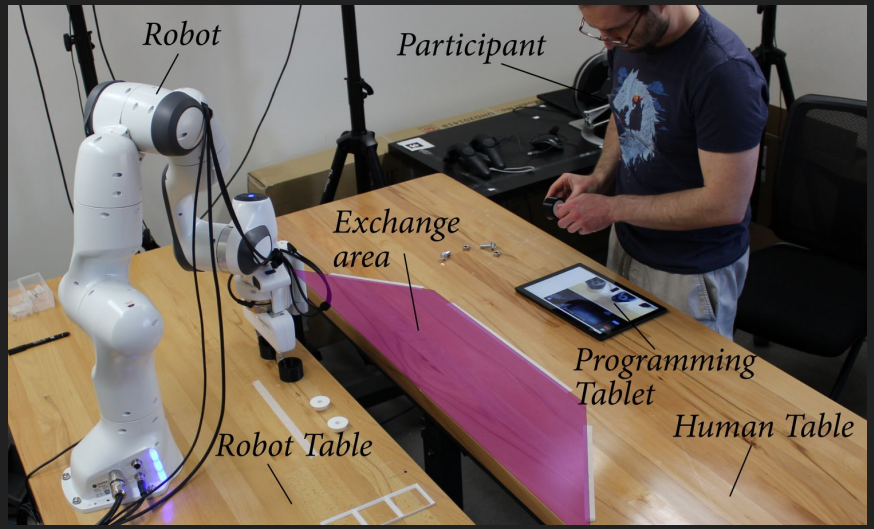
- Gripping capabilities
- End-effector RGB-D Camera

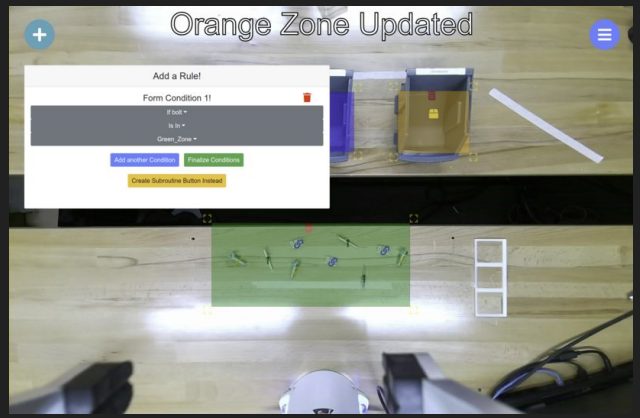
Collaborative task

- Robot reacts to human
- Human reacts to robot

End-User Programming

- Tablet interface with robot view
- Annotations and programming





Method

Trigger action programming

If this ***then*** that

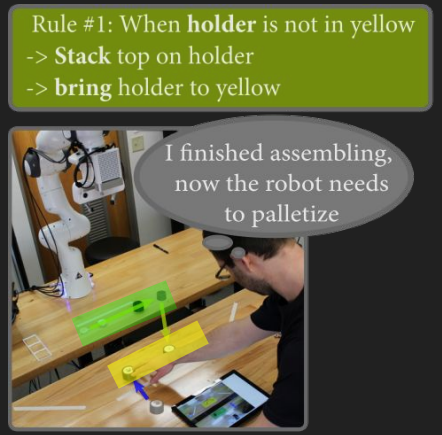
e.g., If a box is in the green zone, *then* move it to the yellow zone

Situated programming

Human labels the workspace

Live programming

Iteratively creates rules



B. Shared Autonomy for Assisted Sanding

Context

- Sanding is ubiquitous in aircraft manufacturing
- Sanding is dangerous
- Offload the physical burden to a robot

Challenges

- Force control
- Complex shapes
- High variability

Deployment

- End-user programming
- Corrections

System

Apparatus

- Franka robot with a sanding tool
- RGB-D camera
- Phone with gamepad
- Boeing test pieces

Two workflows

- Known task
  (registration + template)
- Unknown task
  (end-user programming)

Hagenow, M., **Senft, E.**, Radwin, R., Gleicher, M., Zinn, M., & Mutlu, B. (2024). A System for Human-Robot Teaming through End-User Programming and Shared Autonomy. Accepted at the 2024 ACM/IEEE international conference on human-robot interaction (HRI).

Method

End-user programming

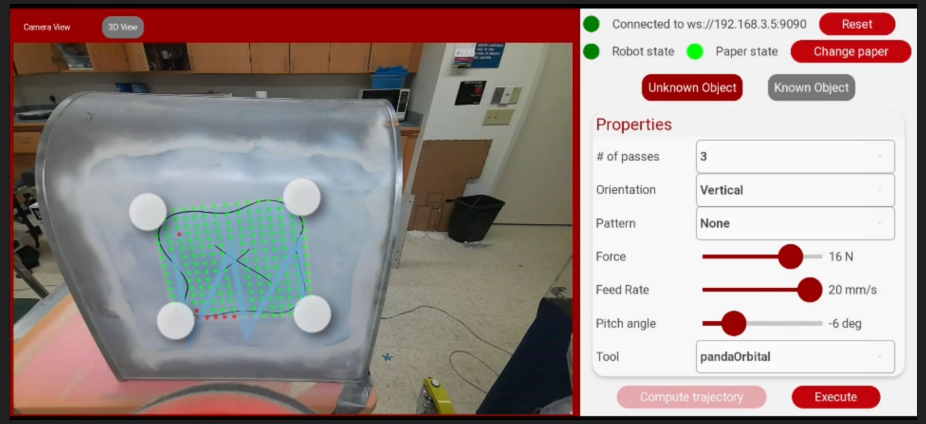
- Smartphone interface
- Task specification

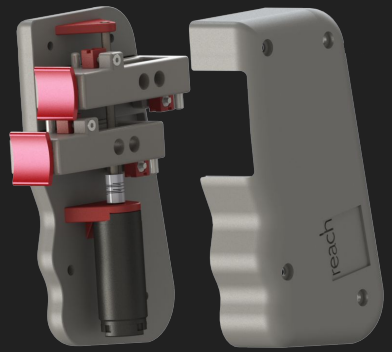
Motion generation

- Motion encoding with DMPs
- Reachability based on 3D view

Corrective shared autonomy

- Layering of correction on behavior
- Variation in DoF provided
- Custom haptics





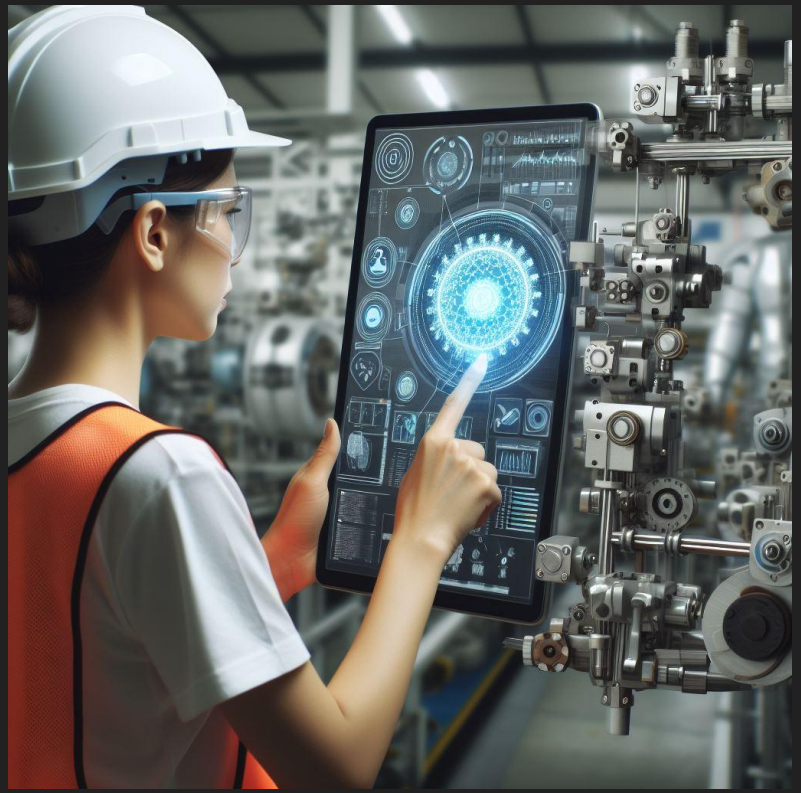
Interactive Learning for Manufacturing and Maintenance

Participatory Design

- Working with operators to understand tacit knowledge
- Designing interfaces for AI interaction

Human-AI Dialogue

- Iterative learning of manufacturing parameters
- Interactive learning with data visualization for maintenance



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Conclusion

Takeaways

AI and robotics can benefit from increased **input from domain experts** and **end users**.

It is important to include **end-users early** in the design process.

After deployments, **users** should be able to **shape the robot behavior** to their specific needs.

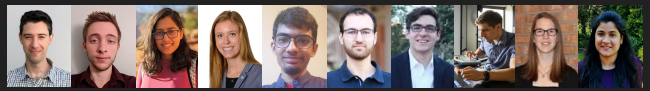
Human-AI interaction should be a **dialogue** to ensure that people can benefit from AI.

Thank you for listening. Questions?

Team

Current and past Collaborators

Previous Graduate students



Current and past funders

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