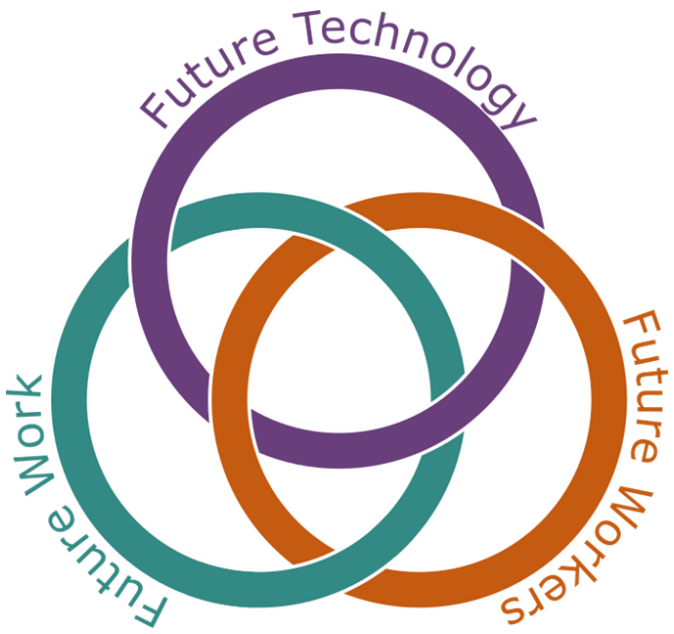
National Science Foundation



Panel 4

Robotics, Wearables, and Future Work

Award Number: 2128907

FW-HTP-P: Firefighter Exoskeleton for Navigation In eXtreme Environments (FENIXE)

PIs: Michael Bazzocchi[1], Sean Banerjee[2], Natasha Banerjee[2], Kevin Fite[1], and Marcias Martinez[1]

[1]*Department of Mechanical & Aerospace Engineering, Clarkson University*

[2]*Department of Computer Science, Clarkson University*

Presenter's Contact Information: mbazzocc@clarkson.edu

Goal: To investigate the challenges faced by career and volunteer firefighters and mitigate challenges by providing FENIXE, a low-cost, automated, adaptive, and integrated intelligent exoskeleton suit

Tasks

- Use markerless motion capture and sEMG to study joint motion and muscle activation for firefighters from various groups completing functional tasks
- Create an integrated exoskeleton design that combines ergonomic and biomechanical considerations with structure, dynamics, and control
- Conduct stress testing of multiple multimodal sensors under high-stress conditions, such as heat and smoke
- Plan meetings and conduct surveys with stakeholders to better understand technological perceptions, safety considerations, injury mitigation, concerns of underrepresented groups, and barriers for adoption

Automated, Adaptive, & Integrated Intelligent Exoskeleton

Robot Dynamics, Controls & Exoskeletons (M. Bazzocchi)

Multi-Modal Sensing & Human-Computer Interaction (S. Banerjee)

Computer Vision & Machine Learning (N. Banerjee)

Materials & Structural Optimization (M. Martinez)

Biomechanics & Ergonomics (K. Fite)

#1928506: Shared Autonomy for the Dull, Dirty, and Dangerous: Exploring Division of Labor for Humans and Robots to Transform the Recycling Sorting Industry

PIs: Berk Calli[1] (bcalli@wpi.edu), Aaron Dollar[2], Kate Saenko[3], Co-PIs: Vitaly Ablavsky[4], Marian Chertow[2], Brian Scassellati[2], Barbara Reck[2], Jacob Whitehill[1], Amy Wrzesniewski[2],

Berk Calli, Worcester Polytechnic Institute

Scope

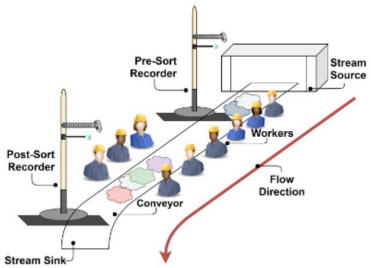
- **Focus:** materials sorting for recycling
- **Recycling:** $117B economy, 530k workers in US
- Tight profit margins, inefficient, high injury rates

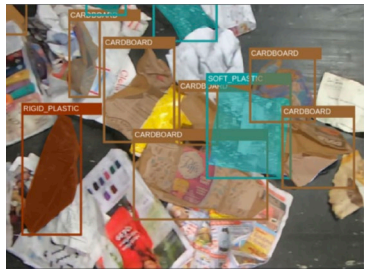
Goal: Best division of labor for humans-robots

Profitable Industry	Safe and Meaningful work	Environmentally Sustainable Economy

Future of Waste Sorting Technology

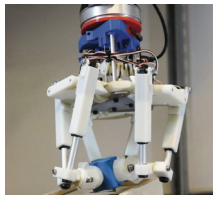
Waste Type Recognition

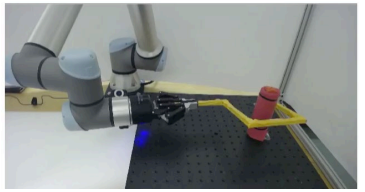




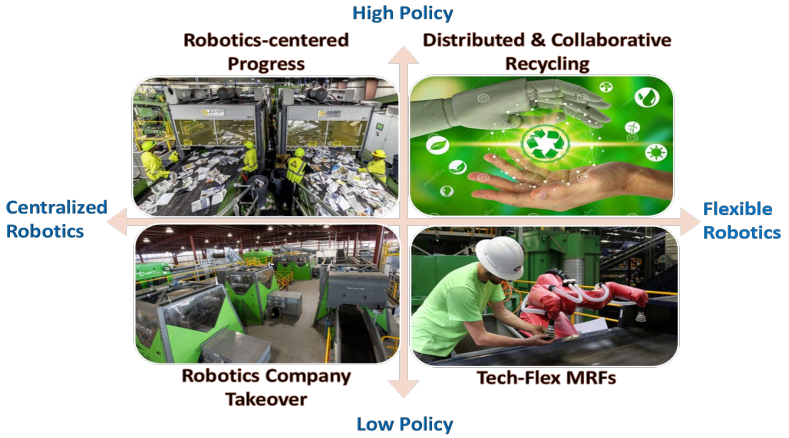
Waste Sorting Setups

Robotic Picking in Clutter



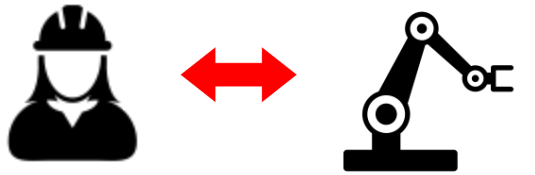


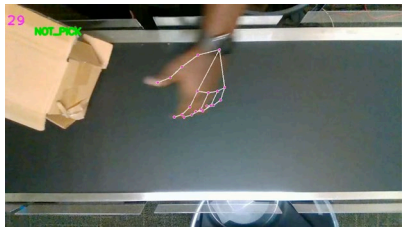
Scenario Analysis Framework



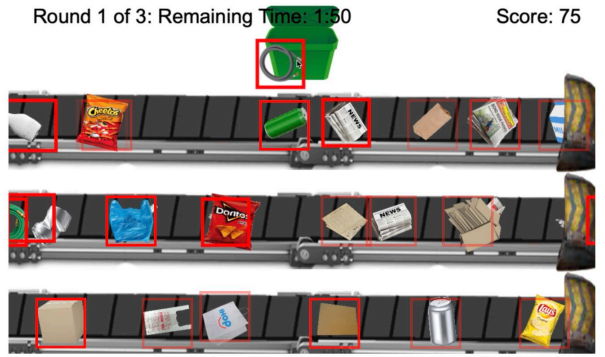
Human Machine Interface

Two-way Learning





AI Assistant with Soft Predictions



[1] Worcester Polytechnic Institute, [2] Yale University, [3] Boston University, [4] University of Washington

2026478 FW-HTF-RM: Human-Robot Collaboration for Enhancing Manual Work

Robert Radwin, Bilge Mutlu, Shiyu Zhou, Lindsay Jacobs, & Timothy Smeeding, University of Wisconsin-Madison, rradwin@wisc.edu

Objectives

- Create a "matchmaking" process for human-robot collaboration to optimally match:
  - Work activities
  - Human capabilities
  - Robot augmentations
  - Economic models
- Improve productivity, health and safety, while maximizing human labor resources
- Transform employment across industries through human-robot collaboration
- Gain insight into how the next generation of robot systems should be designed

Approach

- Study existing manufacturing jobs that show potential to benefit from the integration of collaborative robots
- Hierarchical task analysis
  - Identify the job work activities
  - Quantify human tolerances for strain
  - Optimally assign tasks to the human and robot
- Optimization
  - Physical workload
  - Mental workload
  - Human tolerances
  - Human and robot abilities
  - Cycle time and productivity
  - Human labor and automation costs

Auto Assembly Example

- High levels of physical stress
  - Shoulder elevation
  - Carrying and supporting tool
  - Tool reaction forces
- Robot-human collaboration
  - Robot carries and reacts against tool forces
  - Maintains human dexterity for aligning tool
  - Eliminates physical stress and strain
  - Less tasks reduces cycle time/ increases productivity

Courtesy Ford Motor Company