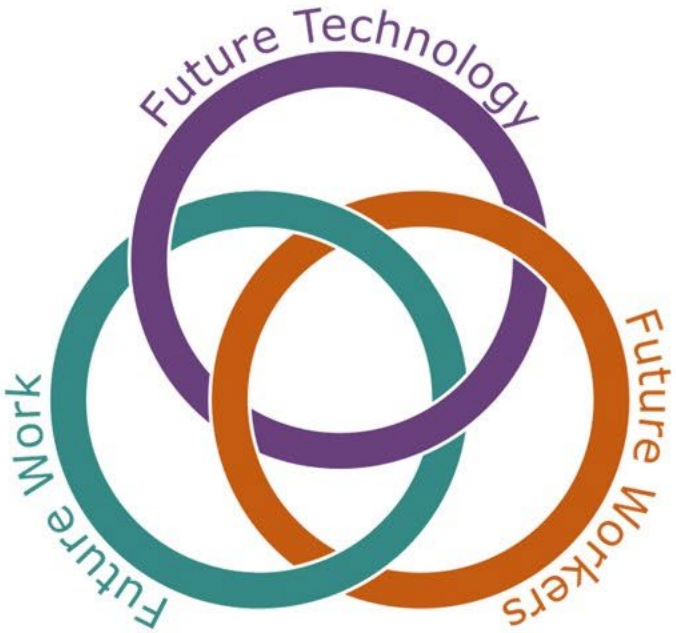
Panel 6:
Manufacturing; Transportation, Logistics, and Emergency Systems



- Augmenting and Advancing Cognitive Performance of Control Room Operators for Power Grid Resiliency
- Augmenting Cyber-Physical-Human Collaborative Cognition and Designing Future Human-Automation Interaction in Complex Manufacturing and Operational Environments
- Future of Firefighting and Career Training - Advancing Cognitive, Communication, and Decision Making Capabilities of Firefighters
- Human-Robot Collaboration in Disassembly for Future Remanufacturing
- Improving Construction Work Performance through Human-Centered Augmented Reality
- Pre-Skilling Workers, Understanding Labor Force Implications and Designing Future Factory Human-Robot Workflows Using a Physical Simulation Platform
- Whole-body Exoskeletons for Advanced Vocational Enhancement (WEAVE)

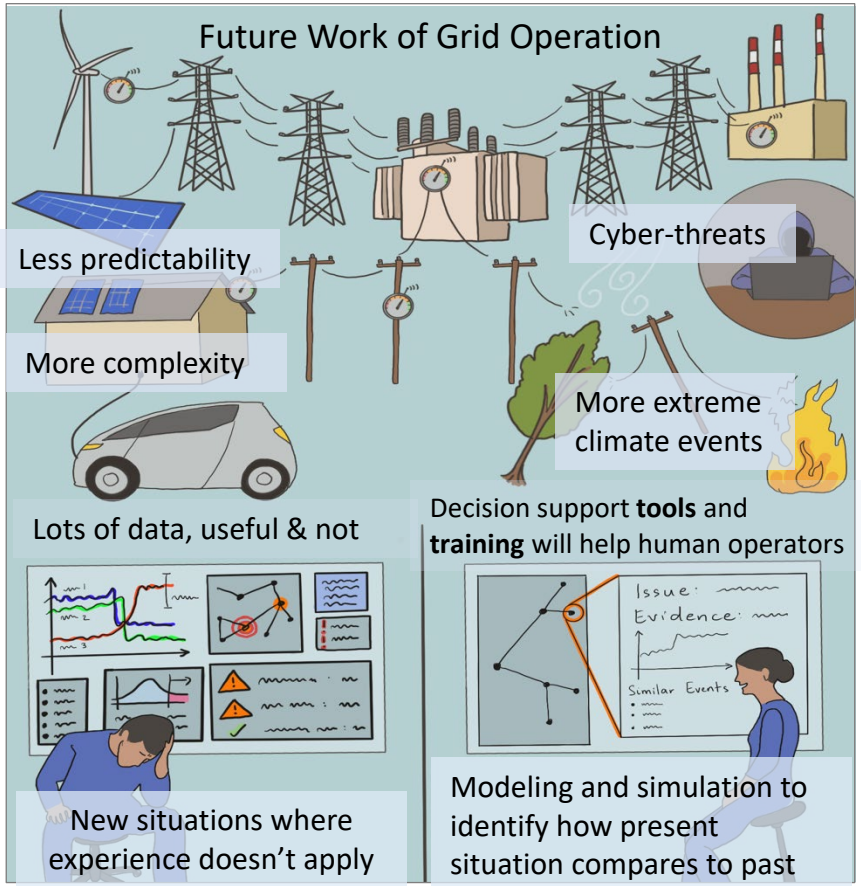
Award #1840192,0052 & 0083 -FW-HTF: Collaborative Research: Augmenting and Advancing Cognitive Performance of Control Room Operators for Power Grid Resiliency

PI(s): Anurag Srivastava, Washington State University, anurag.k.srivastava@wsu.edu, Alexandra von Meier, UC Berkeley and Gautam Biswas, Vanderbilt University

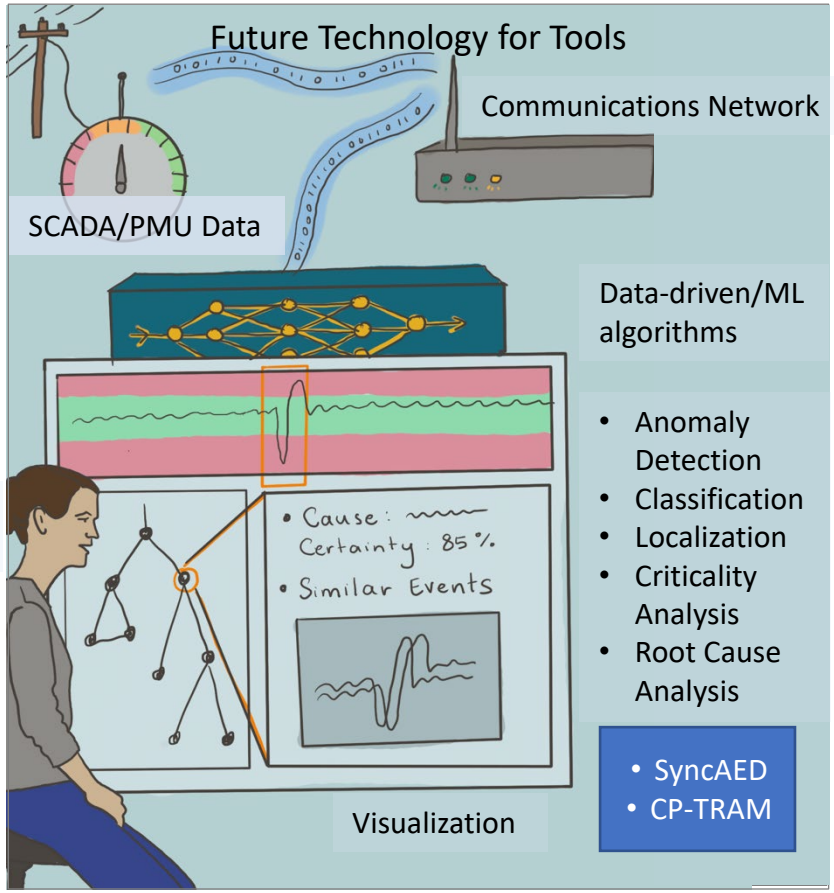
A. Srivastava, P. Whitney, A. Hahn, S. Lotfifard, A. Bose and S. Sadanandan; Washington State University
A. von Meier; University of California, Berkeley
G. Biswas and A. Dubey; Vanderbilt University
R. Podmore and A. Anderson; IncSys
M. Legatt and J. Obradovich; ResilientGrid
S. Murphy; PingThings
E. Andersen and A. Ashok; Pacific Northwest Nat'l Lab
M. Cassiadoro; Total Reliability Solutions
H. Zhang; National Renewable Energy Lab
K. Abdul-Rahman; California ISO
A. Janisko; Snohomish PUD

The key objective of this project is to help power grid operators perform better, especially during extreme adverse events, with advanced monitoring and decision support tools. The project is developing innovative tools by bringing together principles from cognitive neuroscience, data science, machine learning, artificial intelligence, cybersecurity, and power engineering.

Future Work of Grid Operation



Future Technology for Tools



Future Workers Performance

Dynamic attentional control (DAC) framework

- Validation with students trained as operator
- Validation with real grid operators

- Post and pre-training Cognitive Flexibility (CF)
- Post and pre-training working memory (WM)
- Impact on grid resiliency with training

Project Award Number: 1928313

W-HTF-P: Augmenting Cyber-Physical-Human Collaborative Cognition and Designing Future Human-Automation Interaction in Complex Manufacturing and Operational Environments

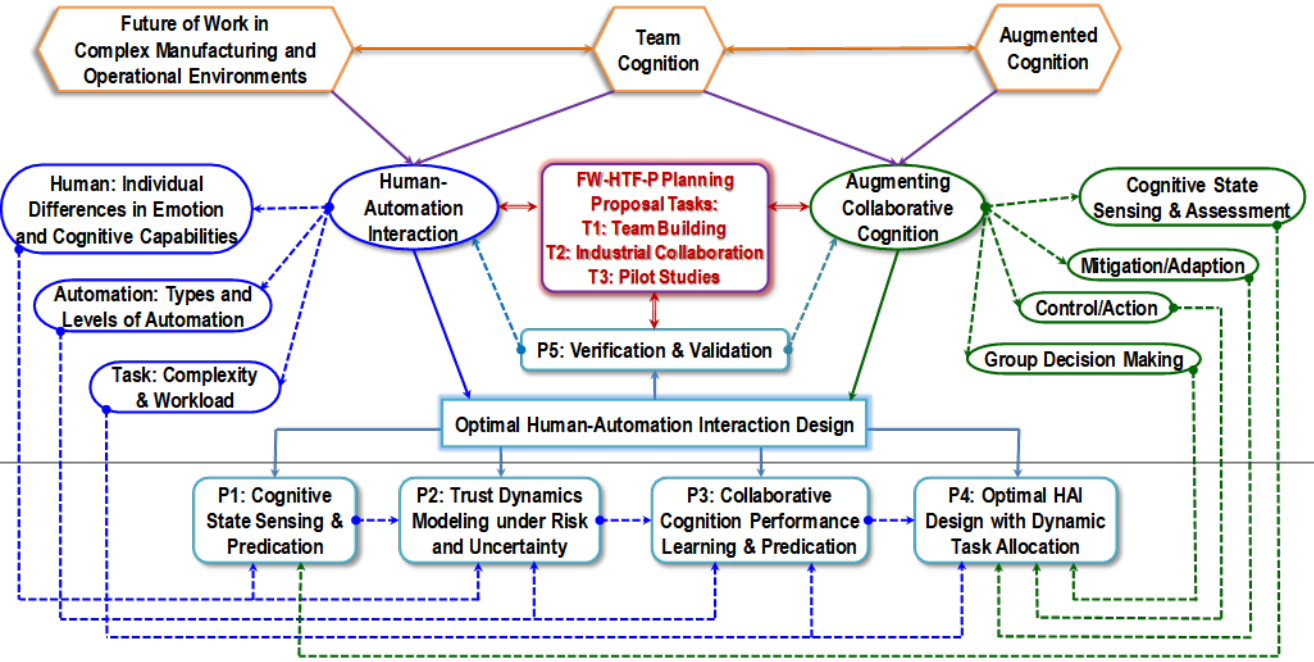
PI(s): Roger Jiao, Georgia Tech, rjiao@gatech.edu
Nagi Gebraeel, Georgia Tech, nagi.gebraeel@isye.gatech.edu

This project investigates the theoretical foundation of augmenting collaborative cognition from the perspectives of cyber-physical-human analysis and model-based decision support.

Augmenting collaborative cognition is envisioned to be important to bolster human cognition with technologies through human-automation interaction in future complex manufacturing and operational environments.

It contributes to a deeper understanding of augmented manufacturing and operational environments of the future by amplifying cognitive capacities and leveraging human cognitive burden with artificial intelligence and smart automation.

This project aims at new insights into cognitive interactions between workers, technologies, robots, and machines in future factories, empowering adaptive task abilities to improve both productivity and worker experience.



1840080 - Future of Firefighting: Augmenting Cognition, Communication, and Decision Making Capabilities of Firefighters

PI(s): Aidong Lu, Weichao Wang, Aixi Zhou, Wei Zhao
UNC Charlotte, NC A&T, UC Riverside, aidong.lu@uncc.edu

Research is motivated by reducing the risks and casualties of firefighters and providing effective decision making tools. We propose new methods of data collection, analysis, modeling, immersive visualization and decision making; as well as social science research on the social transformation of the firefighter's work.

- New methods of using wireless signals to detect major human movement and fire changes
- New augmentation technology to analyze 3D scenes with heterogeneous time-series data with multi-model interaction methods in VR/AR.

- Real-time fire situational awareness with efficient and accurate AI-based fire modeling
- Information collection, fusion and analysis tools for firefighters on mobile devices
- VR/AR-based tools for a set of firefighting and training tasks

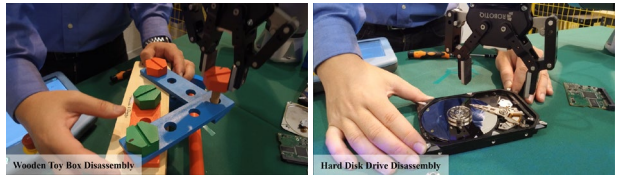
- Improvement of safety and efficiency of firefighters with advanced data fusion technology
- Promotion of new technology to firefighters
- Study of adaptation patterns and factors of various technologies among firefighters

FW-HTF-RL: Collaborative Research: The Future of Remanufacturing: Human-Robot Collaboration for Disassembly of End-of-Use Products (#2026533/2026276)

University at Buffalo: Minghui Zheng (mhzheng@buffalo.edu) and Xiao Liang
University of Florida: Sara Behdad (sarabehdad@ufl.edu), Boyi Hu, and Gulcan Onel

Previous Planning Proposal (#1928595, 2019.09~2021.08)
Year 1 Deliverables (2019~2020): Experimental setup; pilot studies (papers in *ACC* 20, *ISFA* 20); industry collaboration; workshops and symposium being planned; built a multi-disciplinary team.

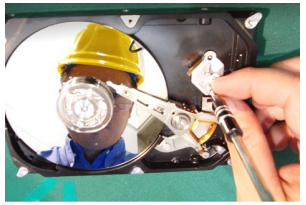
Future Technology



Main Tasks: Work environment monitoring; task distribution and disassembly sequence planning; HRC design guideline; cobot planning and control.

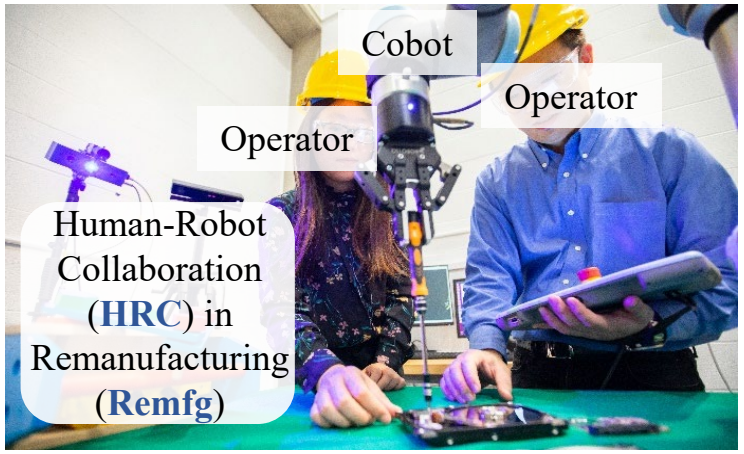
Plan for Year 1: Research - Deep learning for object detection; and optimization for task distribution and disassembly planning. **Education -** Two online workshops for remanufacturing community in Feb. and Apr. 2021.

Future Workers

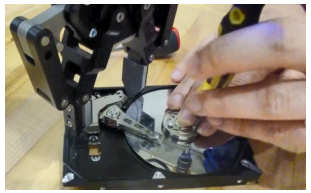


Main Tasks: Human-robotics system integration (physical safety, mental comfortability, and occupational safety).

Plan for Year 1: Research – Evaluate physical and cognitive demands of remfg tasks, and develop design guidelines compatible with workers' safety. **Education -** Undergraduate researchers; training and mentoring students of a multi-disciplinary team; virtual lab tours for outreach activities.



Future Work



Main Tasks: Evaluate economic viability of HRC remanufacturing and labor markets; identify future of work policy for humans within HRC systems.

Plan for Year 1: Research - Explore available dataset on remfg labor market, and predict e-waste market. **Education -** Inviting labor economics and remanufacturing communities to give lectures in planned workshops.

Project Award 1928398: Improving Construction Work Performance through Human-Centered Augmented Reality

PI: Matthew Hallowell (matthew.hallowell@colorado.edu)
Co-PIs: Paul Goodrum, Tom Yeh, and Matt Jones
University of Colorado Boulder

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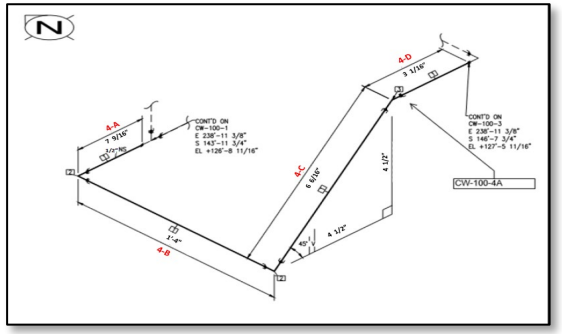
The primary goal of this research is to improve the future of construction work by gaining a deeper understanding of how the level of detail and origin of design information impacts the work performance of construction workers.

Future Workers

- Construction Craft Professionals
  - Type of information being used today to complete assembly tasks
  - Input on how the format of information could be provided in the future

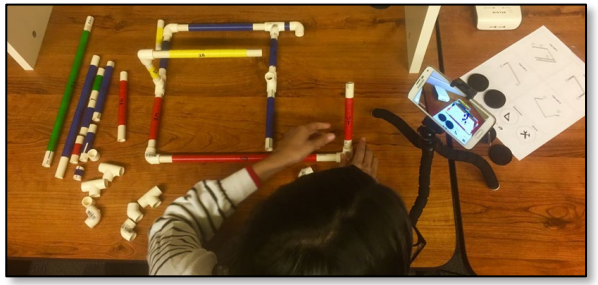


Future Technology

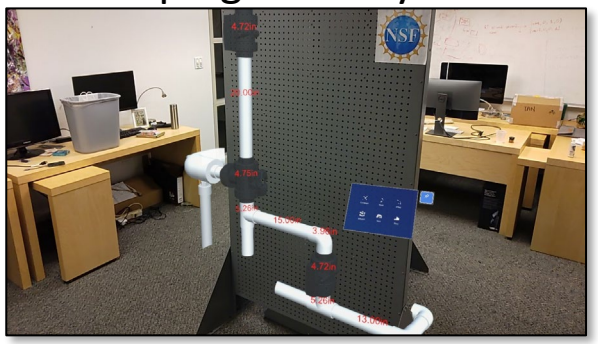
- Design and develop a functional AR application to provide a step-by-step pipe assembly instructions.
- Exploring trust in origin of design information

Future Construction

- Initial Desktop Trial



- Developing Industry Testbed



1839971: Collaborative Research: Pre-Skilling Workers, Understanding Labor Force Implications and Designing Future Factory Human-Robot Workflows Using a Physical Simulation Platform

PI: Karthik Ramani, Distinguished Prof. Purdue University, ramani@purdue.edu

Co-PIs: Alex Quinn (aq@purdue.edu), Kylie Peppler (kpeppler@uci.edu), Shimon Nof (nof@purdue.edu), Tom Redick (tredick@purdue.edu), Daron Acemoglu (daron@mit.edu)

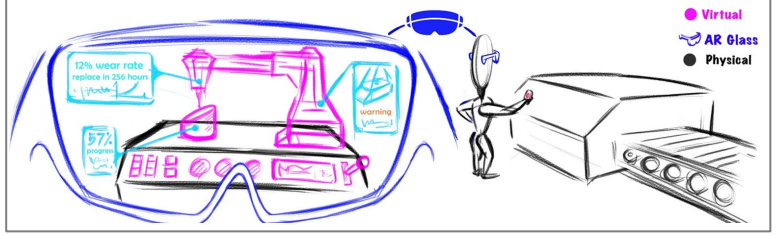
Goals: 1. Developing physical-reality simulation platform (PRSP), 2. pre-skilling the manufacturing workforce, and 3. understanding and evaluating the labor market implications of augmented Humans (H)-Robots (R) -Machines (M) and AI technologies.

Future Technology

> Mixed reality (MR) to capture interactions + workflows for H+R+M

> In-situ Authoring for IoT-based Machines

> Humans + MR + AI for easy accessibility

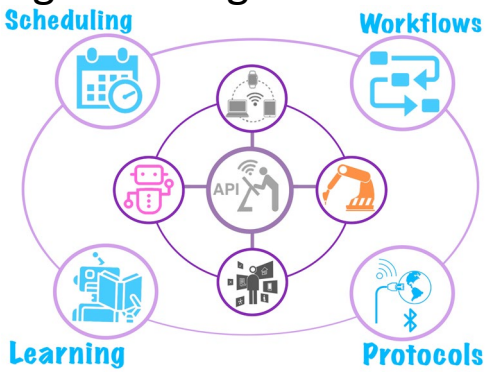


Future Work

> Assessment and metrics in MR: cognitive and learning

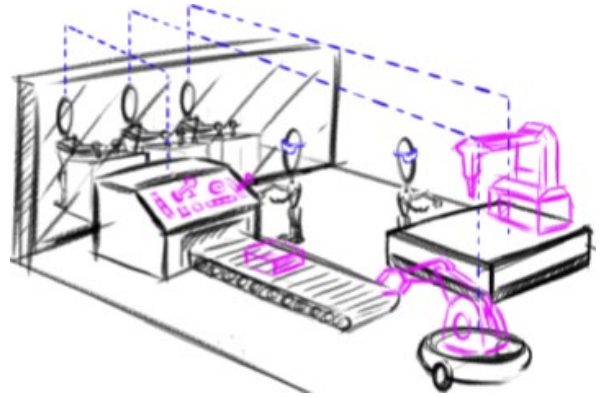
> MR based local-spatial-body coordinated tasks

> Leverage learning theories



Future Workers

> Design and Prototyping Smart Things & Augmenting Human Cognition (Purdue), IoT Course (UCI) 140 + 120 students annually



Publications are available at the CONVERGENCE DESIGN LAB website: https://engineering.purdue.edu/cdesign

FW-HTF 1839946:
Whole-body Exoskeletons for Advanced Vocational Enhancement

PIs: Divya Srinivasan sdivya1@vt.edu, Maury Nussbaum nussbaum@vt.edu, Alexander Leonessa aleoness@vt.edu, Nathan Lau nkclau@vt.edu, Suqin Ge ges@vt.edu

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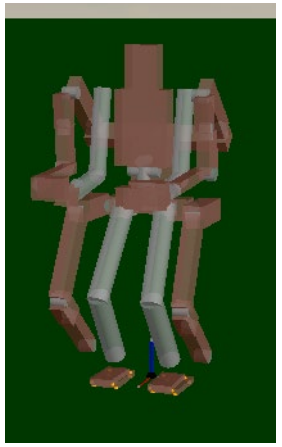
Advance the state-of-the-art in Whole Body Powered Exoskeleton technology and augmented reality, for holistic augmentation of a worker's physical and cognitive capacity. Understand the technology's potential impact on individual workers' ability and safety, and model the broader sociotechnical landscape of industrial jobs.

Future Technology

Identified through a user study key areas of improvement in the effectiveness of current exoskeletons at increasing workers' ability decreasing risk of injury.

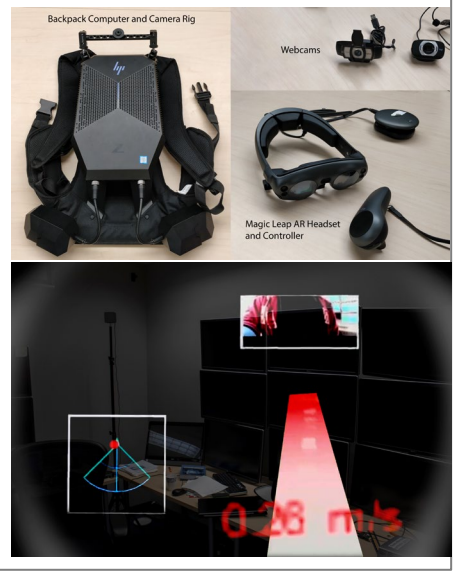
Created a simulation of an exoskeleton and a human operator, to develop a partner-aware robot controller that can balance human intention and safety with task objectives, as well as adapt to individual users.



Future Work

Developed an interchangeable Augmented and Virtual Reality visualization platform for augmenting human spatial perception in an industrial environment.

This can be leveraged to improve worker awareness of their surroundings, provide task specific aid and information, and assist in achieving seamless human-exoskeleton interaction



Future Workers

Assessed the large inter-individual differences in effectiveness at using exoskeletons to perform simulated industrial tasks, as well as development of skills-training protocols necessary for a user to adopt augmentation technologies.

Modeled how the effects of exoskeleton (safety and productivity) vary by gender and age, as well as the economic impact that the introduction of automation technologies has had in the past, specifically its effect on the wage gap between male and female workers.