Eaton Dexterous Hand – Group 7

DEXTEROUS ROBOTICS

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OBJECTIVE

Our project aims to demonstrate the viability of integrating a 5-finger robotic end-effector on assembly lines, working harmoniously alongside human operators. While Eaton employs a variety of robotic arms in their current assembly operations, these do not include 5-finger end-effectors collaborating directly with humans. This robotic solution is intended not only to match the efficiency of human labor but also execute these tasks quicker, safer, and for extended durations.

Thank you to all the people at Purdue, Eaton, Sarcomere, HaptX, and Touchlab that helped throughout the course of this project.

CUSTOMER PROBLEM AND BACKGROUND

While Eaton employs a variety of robotic arms in their current assembly operations, these do not include 5-finger end-effectors collaborating directly with humans. Our project aims to demonstrate the viability of integrating a 5-finger robotic end factor on assembly lines, working harmoniously alongside human operators, as well as leveraging a tele-operation system to speed the teaching process of the overall system by leveraging on the job human movements performing the job to tech the robot on replicating precise human being movements

Our main objective was to deploy a 5-finger end-effector capable of taking over tasks that may present safety risks to human workers. This robotic solution is intended not only to match the efficiency of human labor but to potentially execute these tasks even quicker. It is essential that the robotic arm and hand are adept at utilizing hand tools with the same proficiency as a human worker.

In addressing key challenges like human safety and optimizing the speed of the manufacturing line, Eaton envisions extending the application of this technology beyond the current factory. Our future goal is to leverage these advancements to revolutionize other facets of their manufacturing processes, showcasing the broad potential and versatility of 5-finger robotic end-effectors.

CONCEPTS AND EXPERIMENTATION

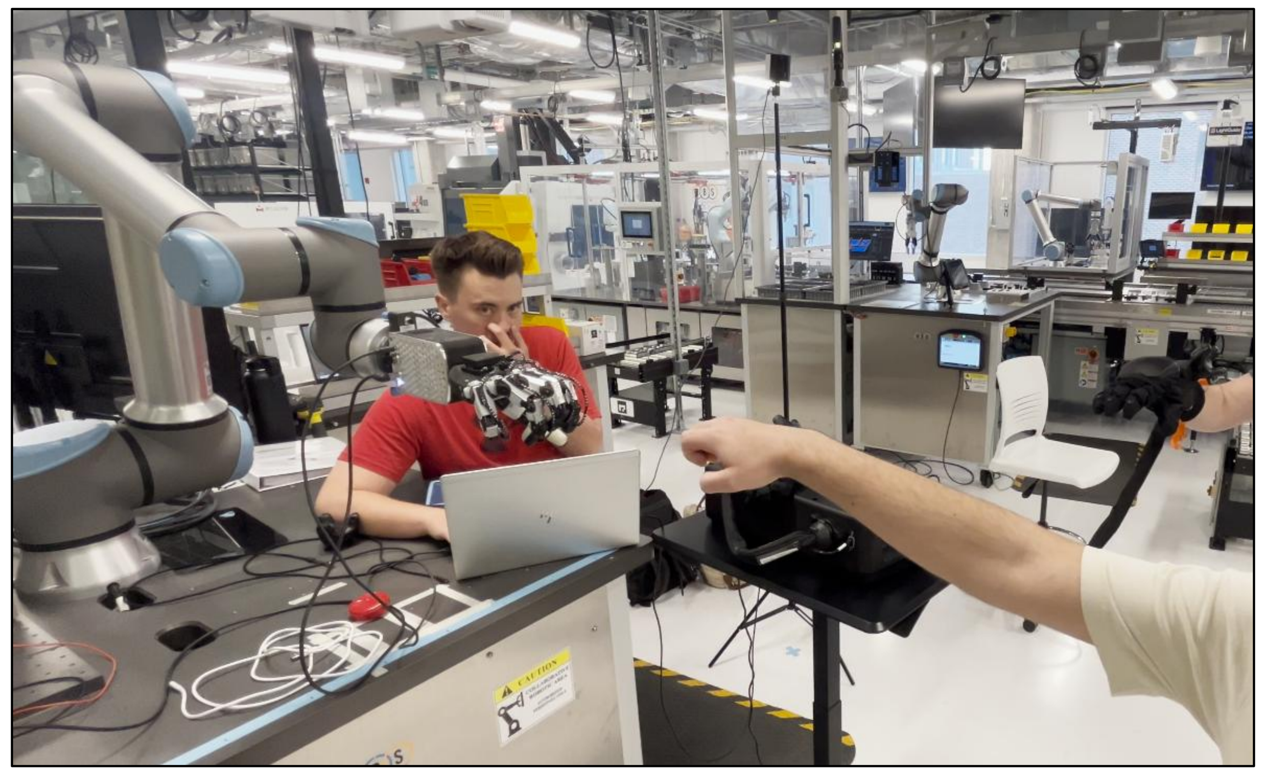
Our effort built three first models: hardcoded automation, computer vision automation, and robot teleoperation. Upon adding haptic feedback gloves, we built a complete teleoperation system. Experimentation included haptic feedback, arm teleoperation, and hand teleoperation.

Haptic feedback conveyed force from Touchlab sensors on the robotic hand to fingertips of the user via HaptX gloves. Arm teleoperation employed positional data from an HTC Vive tracker on the forearm of the user, updating the position of the end-effector of UR10e robotic arm perpetually. Hand teleoperation mimicked movement of user fingertips based on positional data from HaptX gloves, employing similar delta calculations.

Testing confirmed all components function in concert. With further refinement, this integrated system has potential for effective application in precise Eaton product assembly processes.

REQUIREMENTS AND FINAL DESIGN

TESTING RESULTS



CONCLUSION AND RECOMMENDATIONS

Eaton and other stakeholders interested in exploring advanced robotic assembly technology are encouraged to build upon the foundational systems developed through this capstone project. The technology created provides a robust starting framework, though it requires further refinement and optimization to achieve deployment in an assembly-line setting.

Although our current implementation did not achieve full synchronization and operational integration of robotic arms and hands necessary for assembling Eaton electrical panels, significant progress was made in validating the fundamental feasibility of the approach. This successful proof-of-concept clearly indicates that full realization of the desired system is achievable with additional development time and resources dedicated to enhancing integration, precision, and overall system performance.