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EATON: Dexterous Robotics for Industrial Solutions

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Problem Statement

The objective is to integrate the Sarcomere Dynamics Artus Lite as the primary tooling for the UR10e robotic arm. The system will be programmed and controlled using HaptX gloves with external Vive motion tracking. This setup will be duplicated to create a mirrored configuration, enabling dual-hand operations with hand tools for the assembly of a breaker box.

Customer Background

Eaton Corporation, a global power management company, is one of the world's leaders in breaker box manufacturing. While Eaton utilizes a range of robotic arms in its current assembly operations, traditional systems lack the fine manipulation required for complex assembly.

This project works toward developing an advanced dual-arm system equipped with dexterous five-finger end-effectors capable of handling difficult-to-manipulate parts, such as small screws and intricate breaker box components. Additionally, the system will utilize teleoperation to accelerate the machine-learning process by mimicking and recording real-time human movements. The primary objective is to deploy a collaborative robotic solution that takes over repetitive or tedious tasks, effectively removing human error while matching or exceeding the efficiency of human labor. In its final form, this project will be designed to be highly modular, allowing it to seamlessly plug into any Eaton factory worldwide to improve production throughput. Ultimately, by addressing challenges related to assembly precision and worker safety, this technology will demonstrate scalable versatility and positions Eaton to capture a lucrative niche within the growing co-bot market.

Requirements

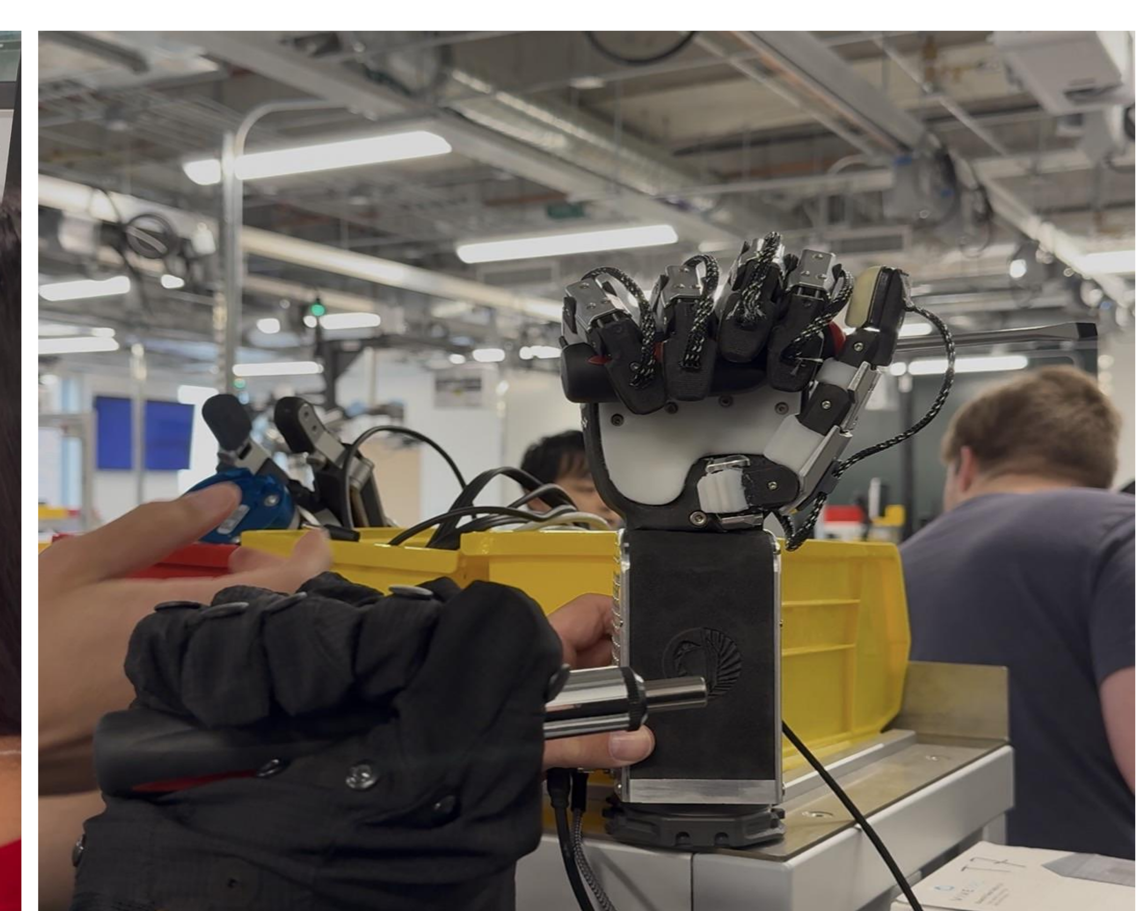
The final design requirement was to develop an end-effector capable of manipulating a variety of objects through a human-in-the-loop control system. The user controls the position and orientation of the robotic hand and robotic arm using motion tracking technology and glove. This system enables accurate replication of human movements while providing real-time tactile feedback to enhance control and interaction fidelity.

Experimentation and Concepts

This project revolves around 3 key aspects: UR10e translational & rotational movement via SteamVR Vive trackers, Sarcomere Dynamics Artus Lite manipulation through HaptX G1 internal sensors, and haptic feedback though TouchPoint sensors on the fingertips of the Artus Lite. All three of these concepts involve navigating proprietary data libraries and programming interstitial solutions. This project involves spatial mathematics & kinematics, Real-Time Data Exchange (RTDE), converting electrical filters to software equivalents, and multi-tiered hardware integration. Experimentation revolved around adjusting Python & C code, physical location of Vive base stations, and HaptX kinematics.

Final Design

The final design integrates the HaptX G1 gloves with the Sarcomere Dynamics ARTUS Lite Mark 9 robotic hand, enabling the use of hand tools commonly found on Eaton's production line. Vive motion trackers attached to the gloves, along with base stations, capture hand movements in three-dimensional space. This positional data is then transmitted to the UR10e collaborative robot (cobot), allowing it to replicate user motions in real time.
To enhance precision, the system incorporates haptic feedback from both the HaptX gloves and TouchLab sensors embedded within the end-effector. A least squares regression model is implemented as an inverse kinematics solver to map the glove measurements to the ARTUS hand. This model computes joint angles that best reproduce the glove's finger poses.
Overall, the design brings together all subsystems into a cohesive teleoperation platform that allows users to control the robotic arm and hand while recording keyframe positions. These recordings can be stored for future use, including playback on the production line or integration with vision-based learning models. This approach ensures consistent, precise execution of assembly tasks aligned with Eaton's operational requirements.



Testing and Results

The spatial tracking system utilizes two Vive base stations strategically placed in the front and back of the workspace to ensure a continuous line-of-sight and capture every movement without obstructions. This configuration allows the sensors to relay precise position and orientation data even during complex, high-dexterity tasks. The resulting stream of information is processed and sent through the UR_RTDE interface, enabling the UR10e to execute smooth, jitter-free movements. Throughout development, the codebase was continuously refined and optimized via GitHub, ensuring that each improvement to tracking synchronization and data transmission is version-controlled and effectively integrated into the dual-hand assembly workflow.