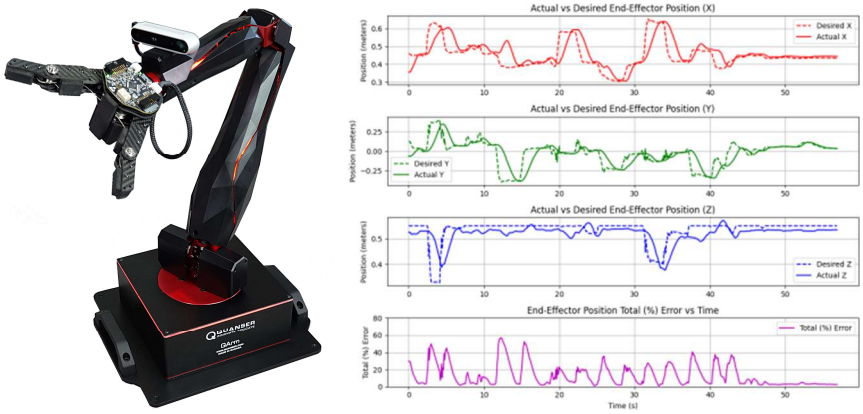
REAL TIME MARKERLESS 3D HAND TRACKING FOR INTUITIVE ROBOTIC ARM CONTROL



Presented By: Dylan Featherson

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Abstract:

This thesis presents a real-time, markerless motion-capture system for intuitive control of a multi-degree-of-freedom robotic arm. Using two synchronized RGB cameras and stereo-vision triangulation, the system reconstructs the three-dimensional position of a user's hand without the need for physical markers or wearable sensors. The reconstructed 3D coordinates are mapped directly to the end-effector position of the Quanser QArm, a four-degree-of-freedom educational manipulator. Developed entirely in Python, the system integrates stereo camera calibration, 3D hand tracking with MediaPipe, coordinate transformation, and inverse kinematics into a unified real-time control pipeline operating at approximately 200 Hz.

Experimental evaluation includes idle-stability tests, controlled path tracking, high-speed motion trials, latency characterization, and gripper-actuation reliability. Performance was compared across two stereo-camera configurations: Logitech C270HD webcams operating at 720p and 30 fps, and OBSBot Tiny 2 cameras operating at 1080p and 60 fps. The system maintained an idle percent error below five percent, achieved reliable gesture-based gripper activation in more than ninety-five percent of trials, and exhibited a step-response time constant of approximately 1.1 ± 0.1 seconds. These results demonstrate that low-cost stereo cameras, combined with open-source software, can deliver responsive and intuitive robotic teleoperation suitable for education, research, and remote applications.