

Project Portfolio

Pranay Kabra

BASc Manufacturing Engineering

University of British Columbia

pranaykabra13@gmail.com | +1 236 999 0388 | [LinkedIn](#) | [Website](#)

CONTROLS & INSTRUMENTATION PROJECTS

Teleoperation & Haptic Feedback

- **Situation:**

Controlling a robot arm remotely requires translating human motion into precise robot commands while giving the operator physical feedback of what the robot is experiencing.

- **Task:**

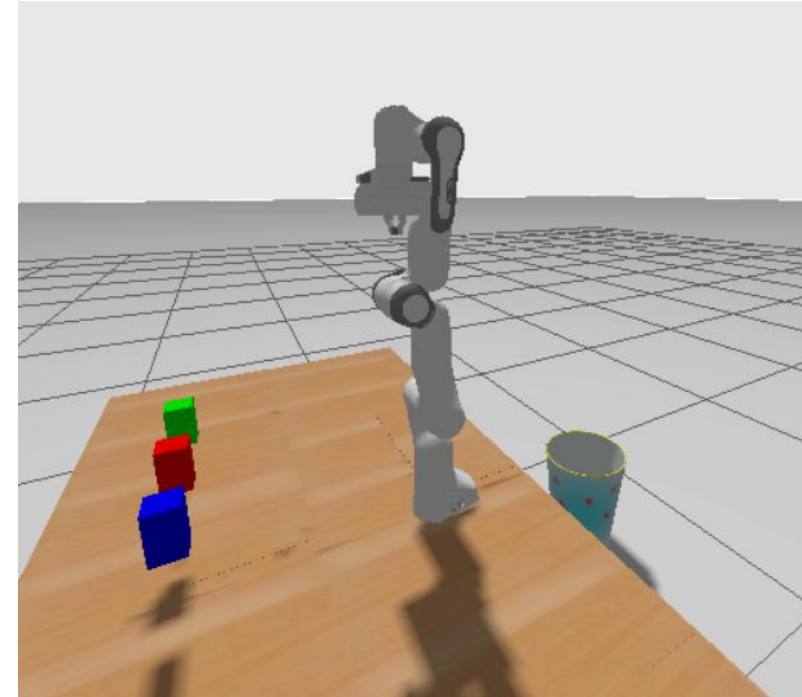
Build a **closed-loop teleoperation** system allowing a human operator to control a simulated **Franka Panda** robot arm using **Novint Falcon haptic devices**, with real-time force feedback reflecting contact events in simulation.

- **Action:**

- Set up the full **ROS2 Humble** environment on Ubuntu 22.04, including Franka URDF, **Gazebo** simulation, and ros2_control hardware interfaces from scratch
- Integrated **Movel2** for IK/FK motion planning, hand-crafting all six config files after the Setup Assistant proved incompatible with WSL2
- Resolved multiple integration issues including Gazebo rendering failures, controller spawning race conditions, and VS Code PATH contamination in WSL2
- Designed and owned the full ROS2 topic/service interface architecture used across all team members' nodes

- **Result:**

Delivered a functional Franka simulation stack with Movel2 planning, Gazebo physics, and a validated node interface pipeline. Successfully achieved real-time control of the Franka arm using the Novint Falcon haptic devices.



Computer Vision and Augmented Reality Pipeline

- **Situation:**

Real-time AR applications require a full pipeline from physical camera calibration through to accurate 3D pose estimation and live object detection, all operating reliably on a single video stream.

- **Task:**

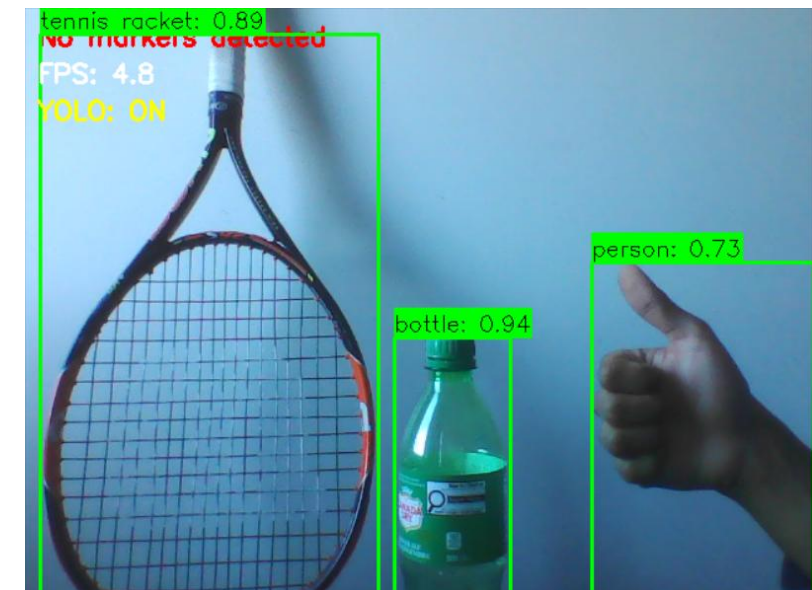
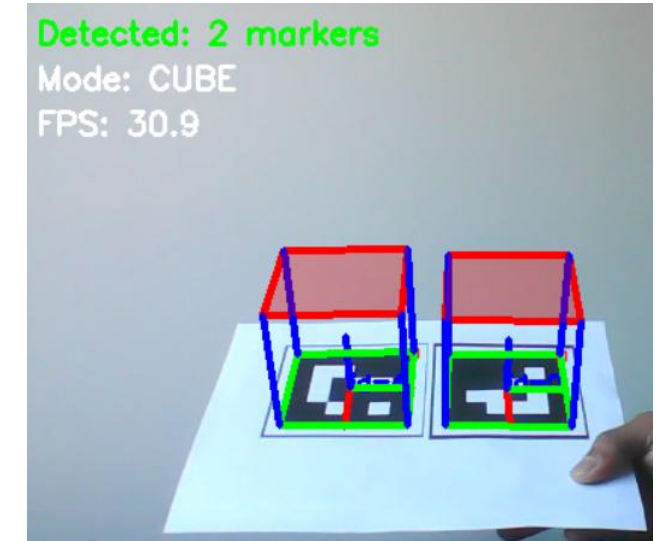
Build a complete computer vision and AR pipeline covering camera calibration, **ArUco marker detection**, 3D pose estimation, **AR overlay rendering**, marker path tracking, and **YOLOv8 object detection**.

- **Action:**

- Calibrated a physical camera using a checkerboard pattern, achieving sub-1px RMS reprojection error
- Implemented real-time ArUco marker detection with **6-DoF pose estimation**, displaying marker ID, distance, and coordinate axes live
- Projected **3D AR cubes** anchored to detected markers, including a smooth Z-axis rotating variant using Rodrigues rotation matrices
- Built a marker **path tracker** with fading trail visualization and integrated **YOLOv8 bounding box** overlays on the same live frame

- **Result:**

Delivered a fully functional multi-stage AR and computer vision pipeline integrating classical calibration, marker-based pose estimation, and deep learning inference in a single real-time system.



PSEN motion sensor radar

- **Situation:**
Needed a safety system to detect personnel within cobot product assembly zones during mechanical testing.
- **Task:**
Implement a reliable motion detection system integrated with the PLC for automated safety control.
- **Action:**
 - Configured and programmed a **PILZ PSEN** motion sensor for personnel detection in cobot assembly zones
 - Implemented a **state machine** in Python for PLC communication and automated safety control
 - Developed an **HMI** page for live safety status monitoring
 - Designed mounting brackets in Creo for sensor installation
- **Result:**
Enhanced operator safety by 100%; improved system responsiveness and reduced downtime from false triggers.



Hot Wire Anemometer Calibration

- **Situation:**
Required accurate airflow velocity measurement for subscale product testing.
- **Task:**
Calibrate a hot-wire anemometer to ensure precise velocity–voltage correlation under different conditions.
- **Action:**
Integrated Omega velocity sensor with existing pitot, APT, and DPT sensors; wrote **Structured Text** in **TwinCAT PLC**; developed **HMI** interface for automated data collection.
- **Result:**
Achieved accurate, real-time calibration with repeatable results, improving confidence in experimental data and system performance.

