

A Multi-Modal Framework for E-Waste Disassembly: From AI Classification to Optimized Screw Removal

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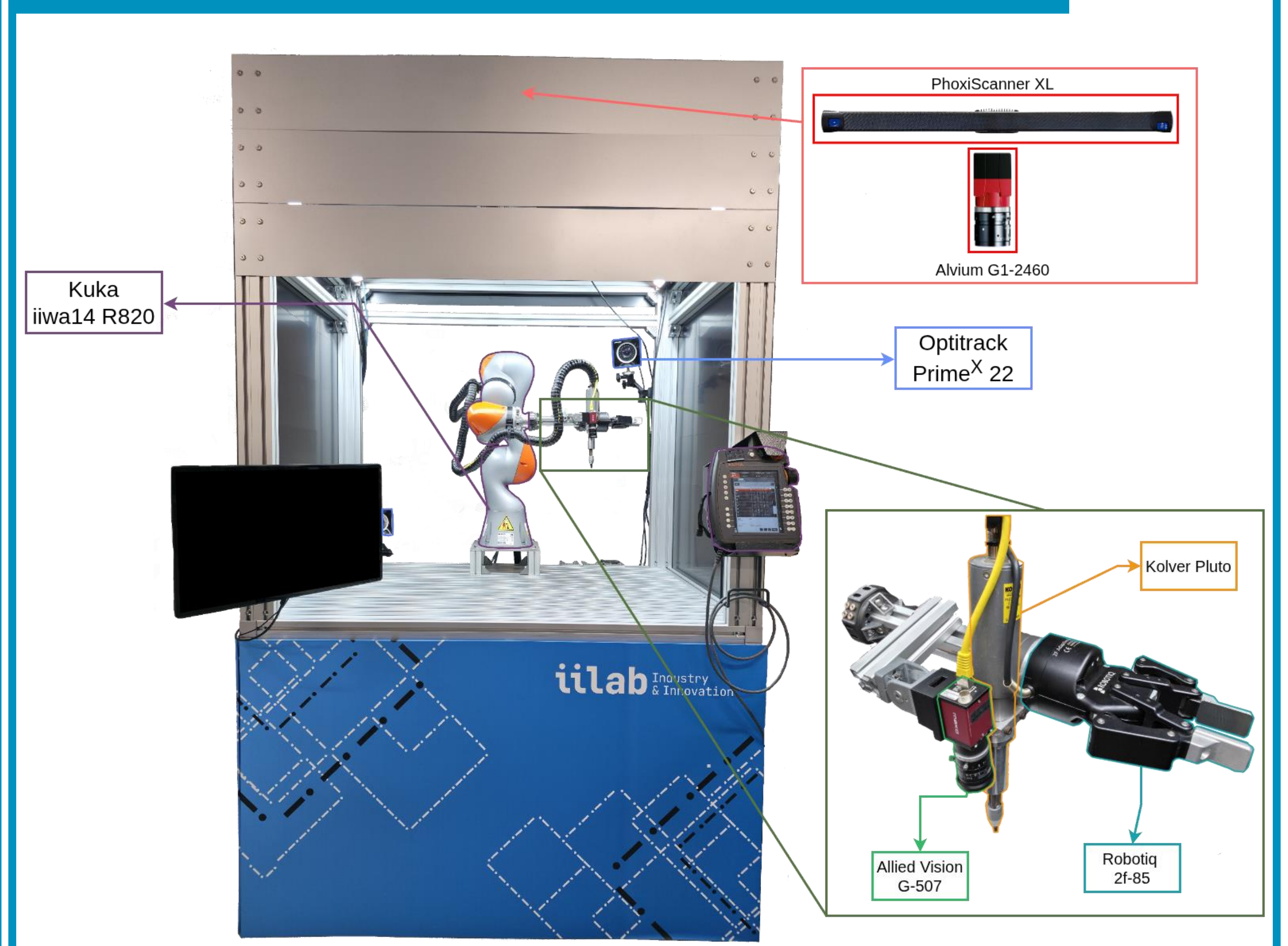
Abstract

Rapidly increasing **E-Waste** poses significant environmental and economic challenges. Manual disassembly is slow, hazardous, and costly. This project presents a fully **autonomous robotic dismantling cell** that bridges the gap between perception and action. The system utilizes AI for real-time classification and object detection, coupled with Image Jacobian visual servoing for precise robotic control. By integrating a novel screw database for tool suggestion and optimized disassembly sequencing, the cell provides an end-to-end solution for efficient end-of-life electronics recycling.

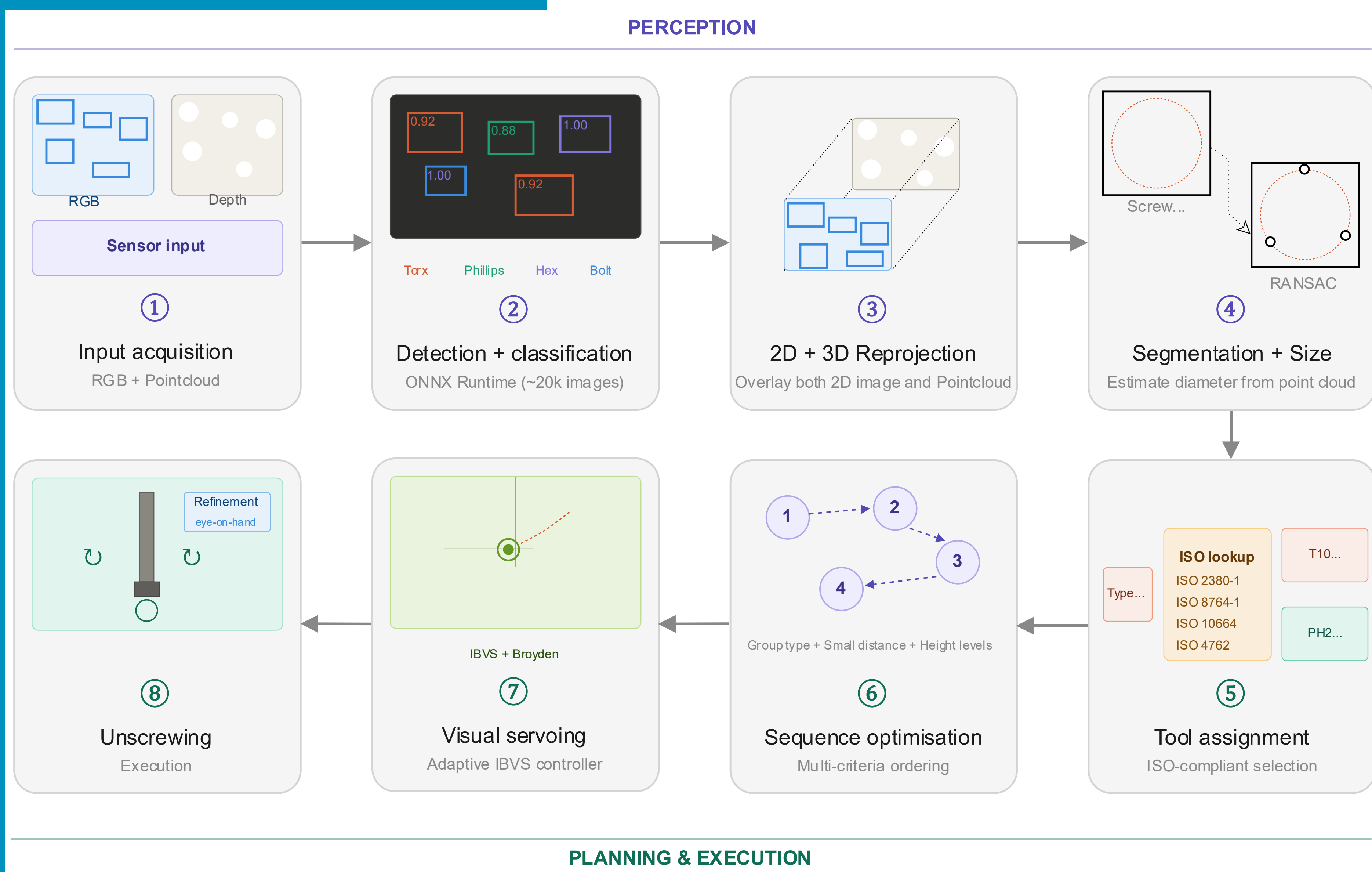
Contributions

- Integrated **Multi-Stage Perception Pipeline**: a four-part interdependent pipeline that combines deep learning fastener detection (ONNX) with point cloud acquisition and 3D reprojection to achieve robust 2D/3D localization.
- Adaptive Control via Visual Servoing: **Image-Based Visual Servoing (IBVS)** strategy implemented using Broyden's method for **online Jacobian** updates, allowing the robot to adapt to unmodeled dynamics and depth variations without an explicit system model.

System Hardware



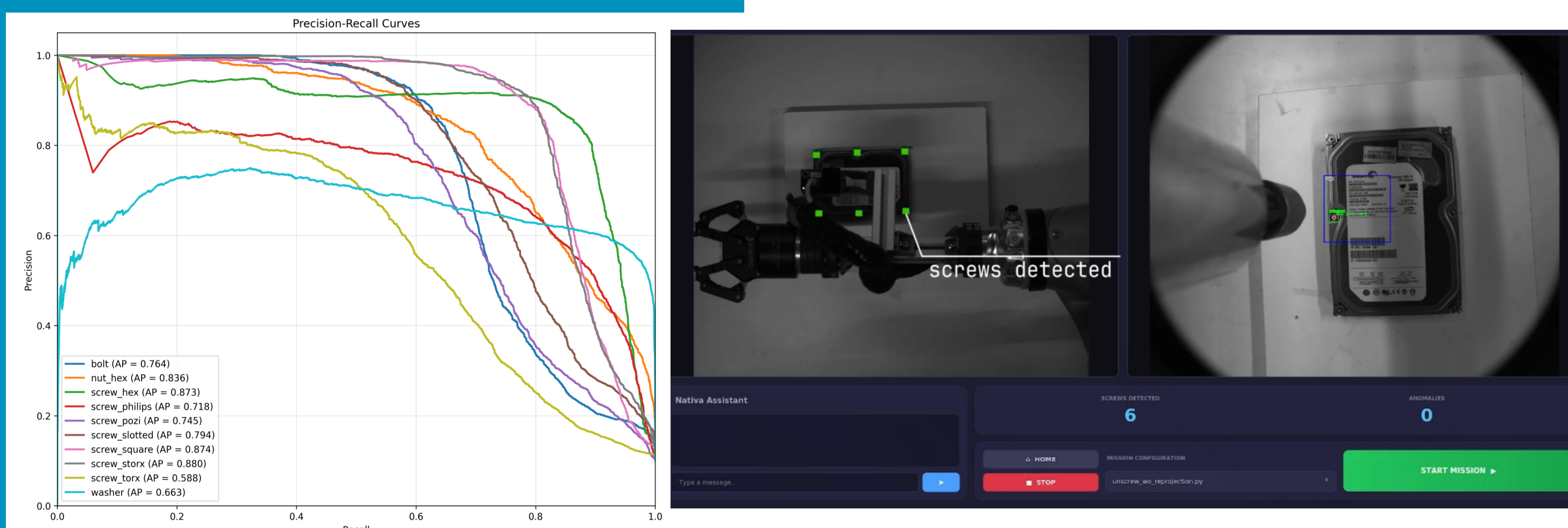
System Architecture



YOLO Models



Results



Future Work

- Evaluate system with other End-of-Life devices.
- Include orchestrator for task assignment.
- Improve models for detection/classification
- Integration of real-time force-torque feedback
- Design of adaptive grippers for internal components
- Detection of damaged fasteners