

Cobot Picking & Kitting

Team: Rageb Al-Hazeim, Jesse Basham, Martin Garcia, Chris Jewell, Sophie Kee, Tyler Malik, Fanyang Meng

Mentors: Varshitha Yalamanchili



Polytechnic Institute

Problem Statement

Cummins' current box picking and kitting operations are inefficient, prone to errors, and lead to worker fatigue. Additionally, single parts, which can be oily or entangled, must be picked out, slowing throughput. Furthermore, groups of parts must be carried to a bagging station and routed to the correct workstation. These repetitive manual steps slow production and increase the chance of errors and injury.

Customer Background

Cummins is a leader in global power solutions. It was founded in 1919 in Columbus, Indiana. They are dedicated to leading a future with smarter and cleaner power. They manufacture engines, power systems, and components for these systems. Cummins also manufactures fuel systems, filtration systems, and air handling. They place a large emphasis on sustainable energy solutions and emissions reduction technologies.

Requirements

Main Goal:

- Develop a full mechanical and software solution enabling the ER-Flex robot to perform part picking and kitting

End Effector Design:

- Design a fully functional prototype using CAD software
- Capable of:
 - Picking individual parts from trays
 - Placing parts into kit boxes
 - Delivering completed kit boxes

Computer Vision System:

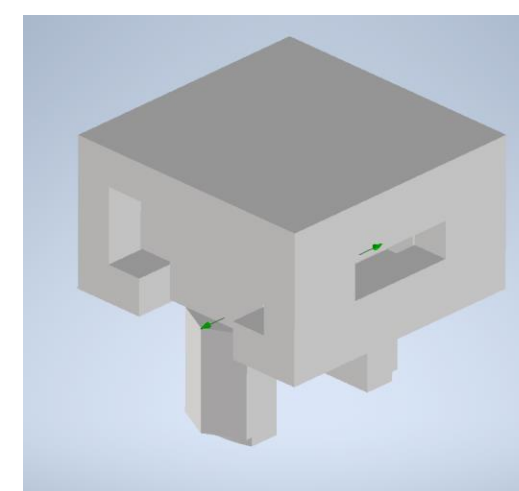
- Detect and classify parts by shape, size, and location
- Guide cobot to accurately select parts for kit assembly
- Ensures safe and efficient coordinate part selection



Experimentation and Concepts

Manual Prototype

Proof of concept for using a parallel style gripper.



Opening Packages

Box cutter scrapped due to safety concerns. Instead, the parts will all be open and dumped into bins by workers.



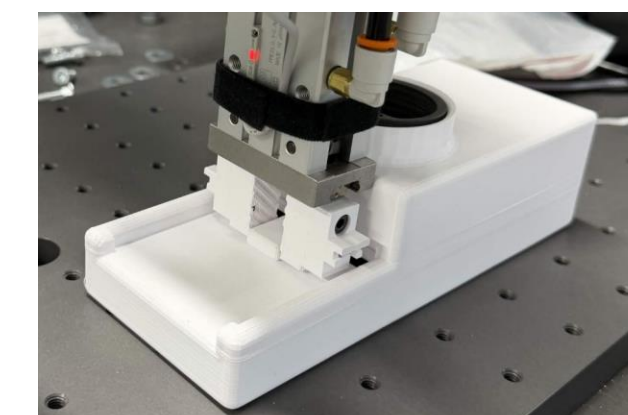
Separating Entangled Parts

If the vision system detects more than one part, the system will execute a shaking motion.

Concept scrapped due to finger design and snap ring magazine.

Snap Ring Magazine

Gravity feed stack of snap rings (original packaging) into a slider actuated by the cobot.



Rubber Fingers

Early concerns of the bolt slipping or damaged threads from the closing action of the gripper was countered by adding rubber pads to the inside of the fingers.

Bin System

Initial couple diamond design to inlock in the opening action. Newer design interlocks with the new fingers.



Final Design

Hardware

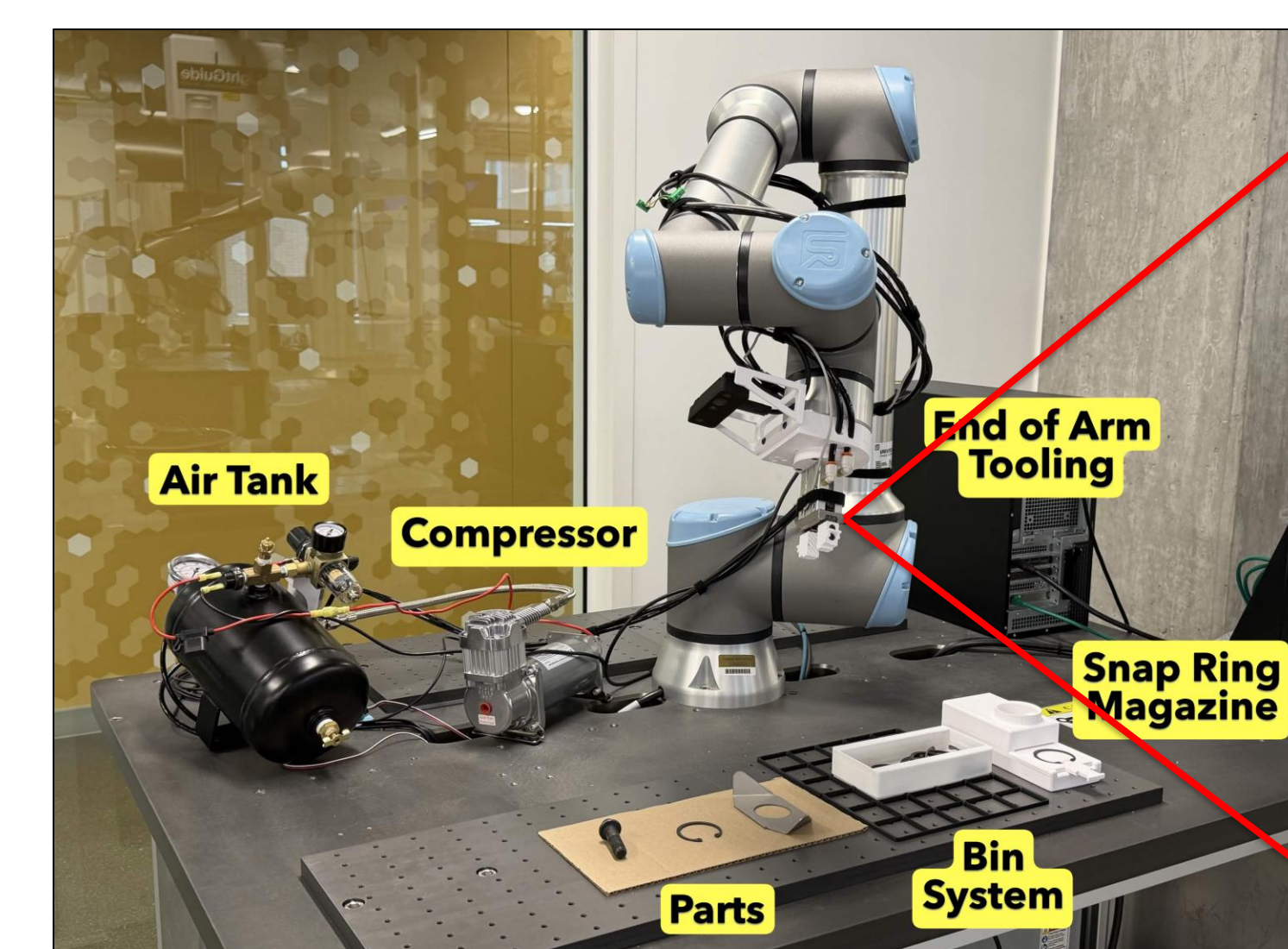
- Gripper successfully picks up all parts: bolts, washer, snap ring.
- The crosshatched fingers clamp the bolt without damaging the threads or dropping it.
- The washers and snap rings are picked up by opening the fingers within the internal hole of parts.
- 24V compressor is powered from the ER-Flex and regulates tank to be between 90 PSI and 120 PSI.
- Stored air travels through the activated solenoid and into the actuator when triggered.
- Picked parts are temporarily stored in 3d printed interlocking bins until the parts go to the packing station.

Software

- Takes user input for number of parts required.
- Takes in model's output for the best part's location.
- Tool tip moves to part and picks it up by executing the appropriate subroutine for the part's type.
- Part is moved to bin location.
- Drops the part into a pre-specified location.

Computer Vision

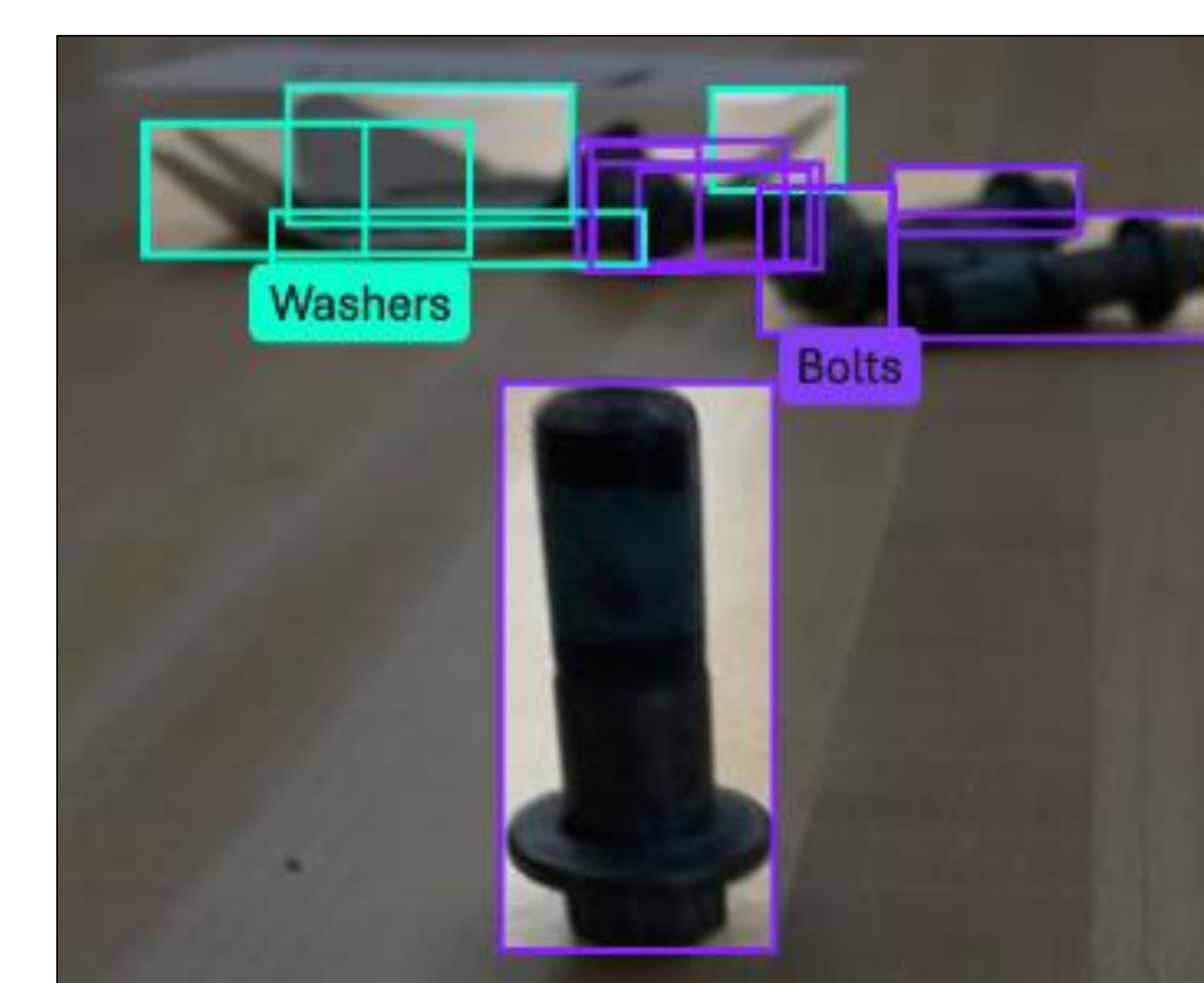
- Model successfully reads constant camera feed and outputs the coordinates.
- Bounding boxes of all detected parts are in frame.
- Selects highest confidence part and sends coordinates to cobot.



Final Solution



End of Arm Tooling



Vision System

Testing and Results

Testing Phase

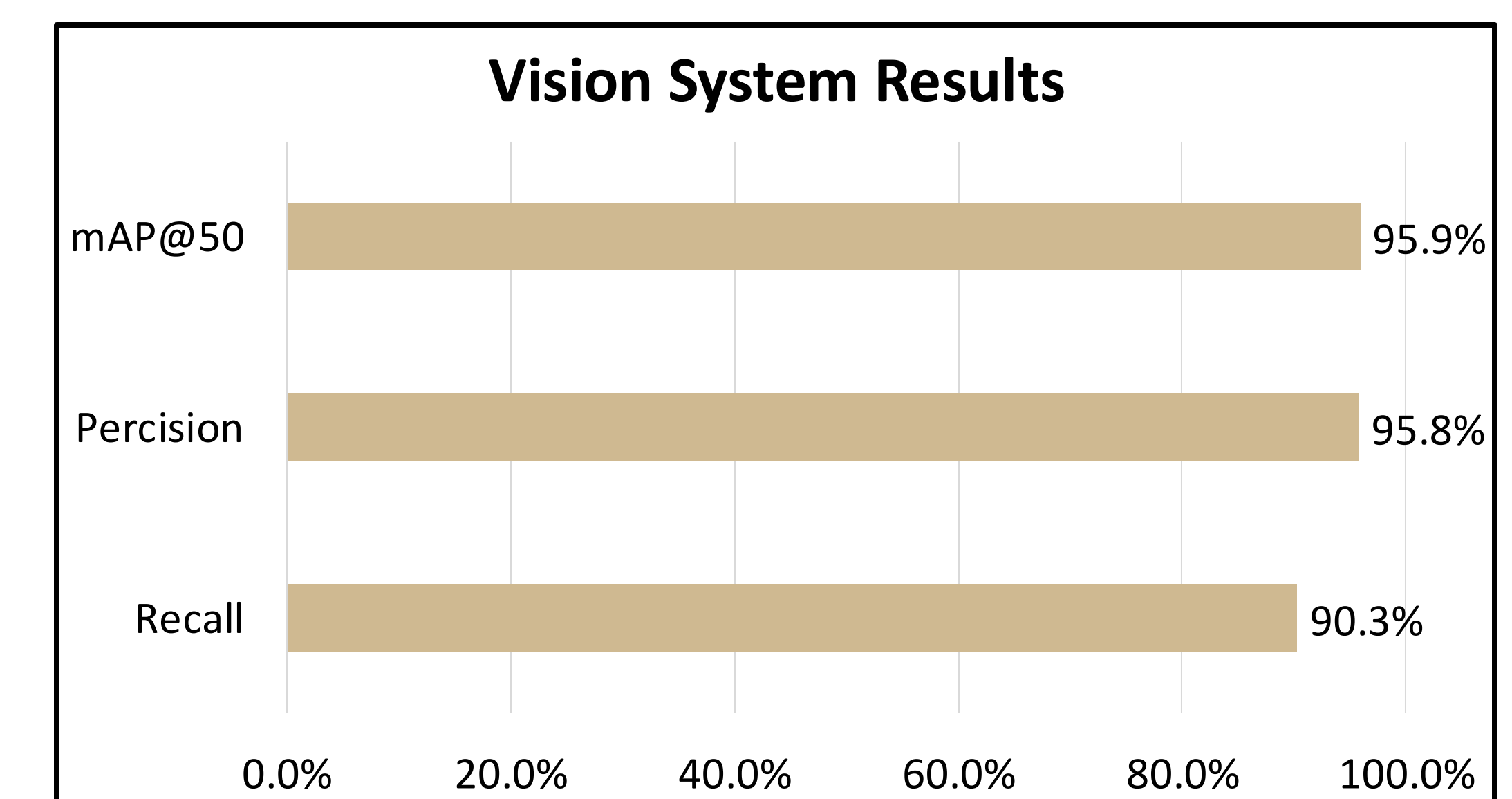
Phase One:

- Computer vision system: Test to accurately detect, identify, and determine the position of each part.
- End effector: Evaluated to ensure it could consistently and securely grasp each component without slippage.
- The test data collected: Total number of pick attempts, successful picks, failed grasps, and correct part identifications for each component.

Phase Two:

- Vision part identification and position data used to guide the cobot arm motion and gripping actions.
- Integrated testing was performed over repeated cycles to confirm consistent performance, proper error handling, and ensure the combined system functions as intended.

Results



Results indicate reliable part detection, while maintaining a high detection rate for the washers, bolts, and snap rings.

