Team 5: Autonomous Object Picking Robot

Final Presentation

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Executive Summary

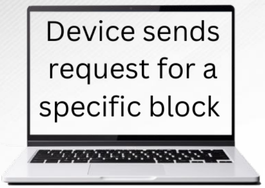
Problem statement:

- With millions of packages processed daily through warehouses, the need for safe and efficient sorting methods is of the utmost importance.
- Workplace injury rates are increasing as the demand grows.

The autonomous object picking robot offers:

- The ability to navigate through indoor environments with no human control
- The ability to differentiate between objects depending on the color
- The ability to grasp and transport designated objects to a given location

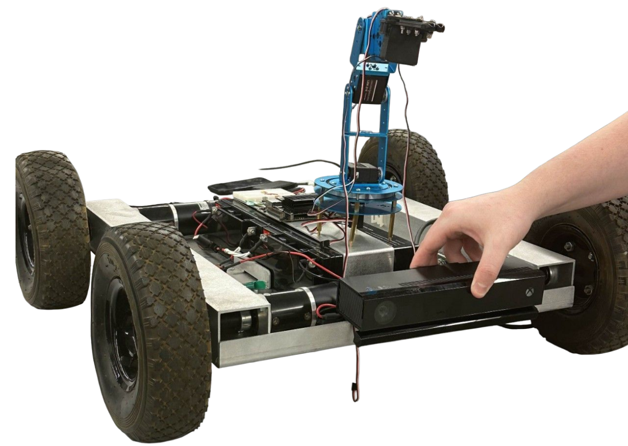
Integrated System Diagram



Onboard microcontroller receives request and begins searching for requested block via object detection code

Robot searches location for designed block

When the designed block is located, the robotic arm will pick up the block and bring it to the designated home location



Navigation System - James Dickson

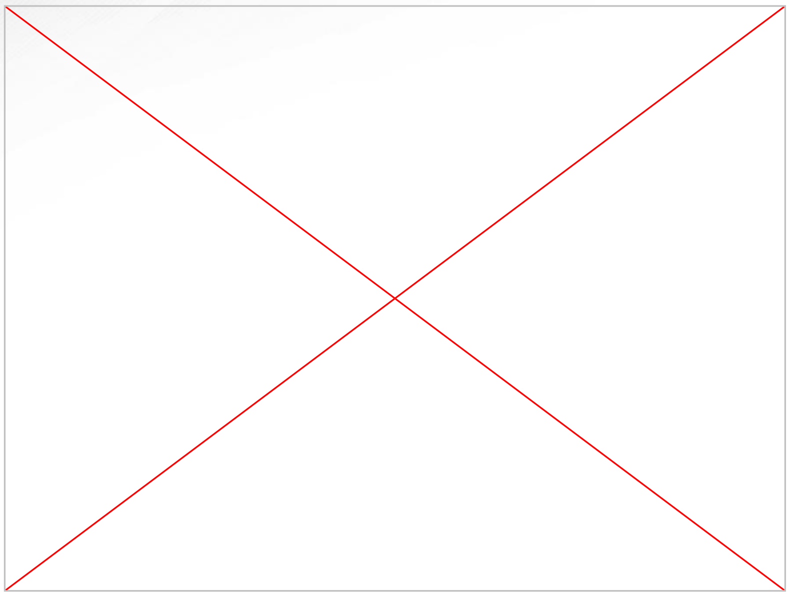
Accomplishments:

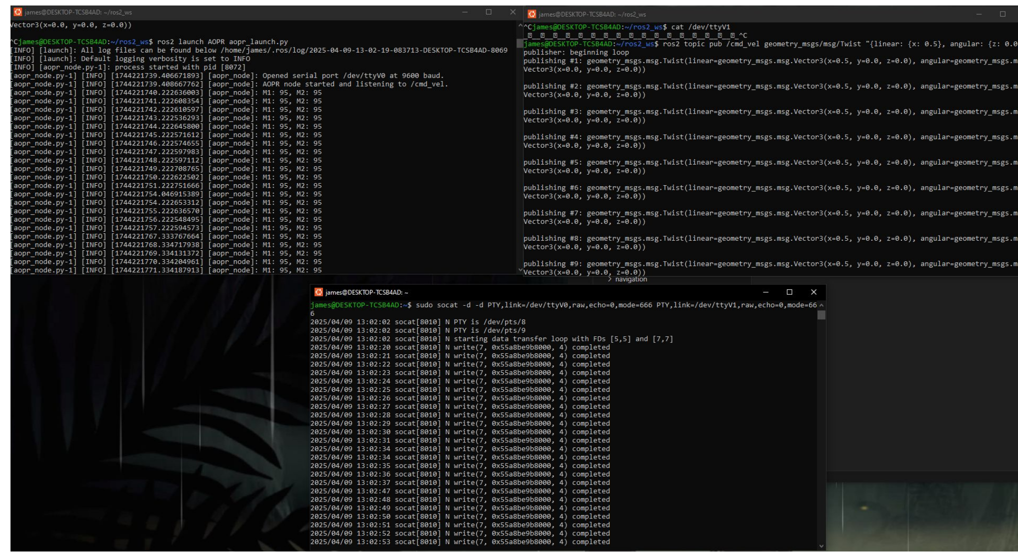
- Developed and implemented a navigation system for the microcontroller unit.
- Coded the robot’s forward and reverse motions using serial communications.
- Implemented left and right turning
- Implemented speed control features precise to a hundredth percent.
- Integrated autonomous movement in virtual Gazebo using the machine learning algorithm.

Challenges

- Our first microcontroller, the jetson nano, proved to have many compatibility issues. This led the navigation system to be unstable.
- All code had to be rewritten within an extremely tight timeframe
- Multiple batteries died through this process.
- With ROS2 jazzy, there is no hardware interface. This meant that I had to code a custom one, along with a node to connect the motor driver to the system. This proved hard as there was a surprising lack of documentation.

Navigation System - James Dickson





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Object Detection System - Chris Cox

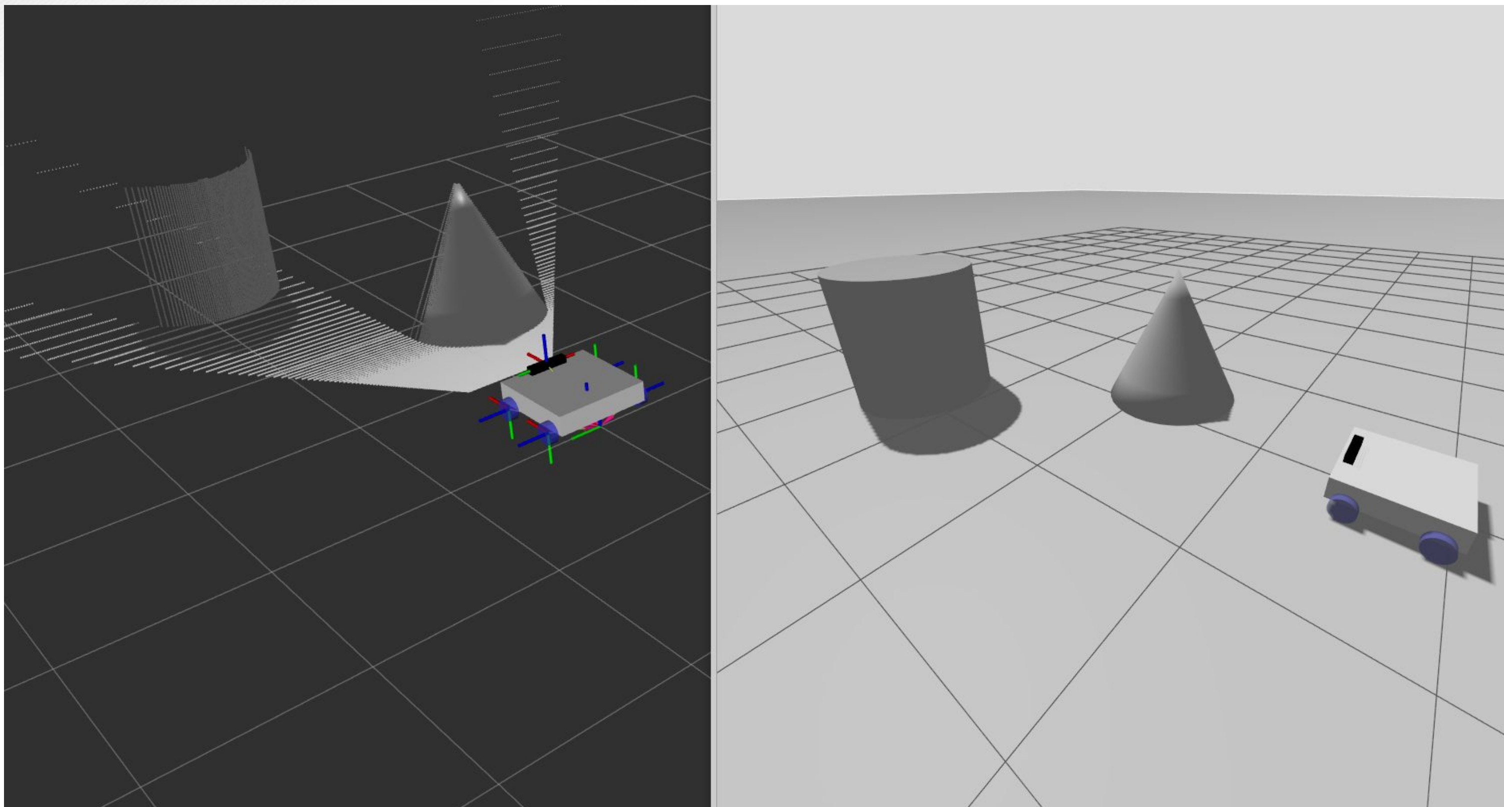
Accomplishments:

- Designed a full ROS2 workspace and product models
- Created an algorithm that detects and differentiates blocks based on color and shape
- Created an algorithm that extracts distance the Robot is from the block based on the size of the block compared to the camera
- Created an algorithm that drives Robot up to the detected block when it detects one
- Created an algorithm that uses RGBD data to map out depth of objects/obstacles from Robot for obstacle avoidance

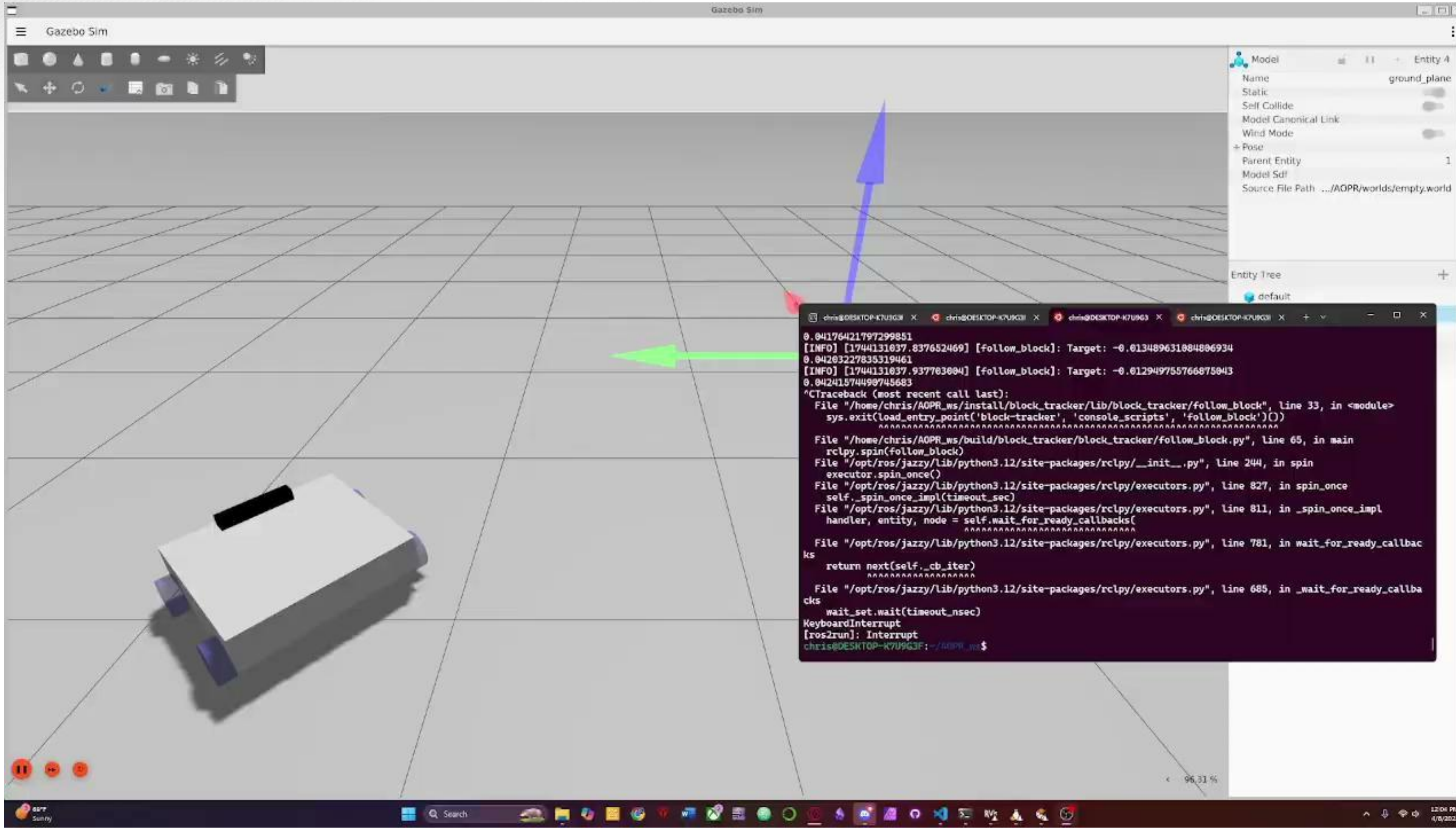
Challenges:

- I had to learn many different programs such as ROS2, YOLO object detection, Gazebo, and more
- With our first microcontroller, there were lots of compatibility issues, especially with other hardware, hindering productivity
- The time commitment learning these programs needed was vast for the timeframe we have, along with the sparse information provided by the developers

Object Detection System - Chris Cox



Object Detection System - Chris Cox



Arm Manipulation System - Kathy Vo

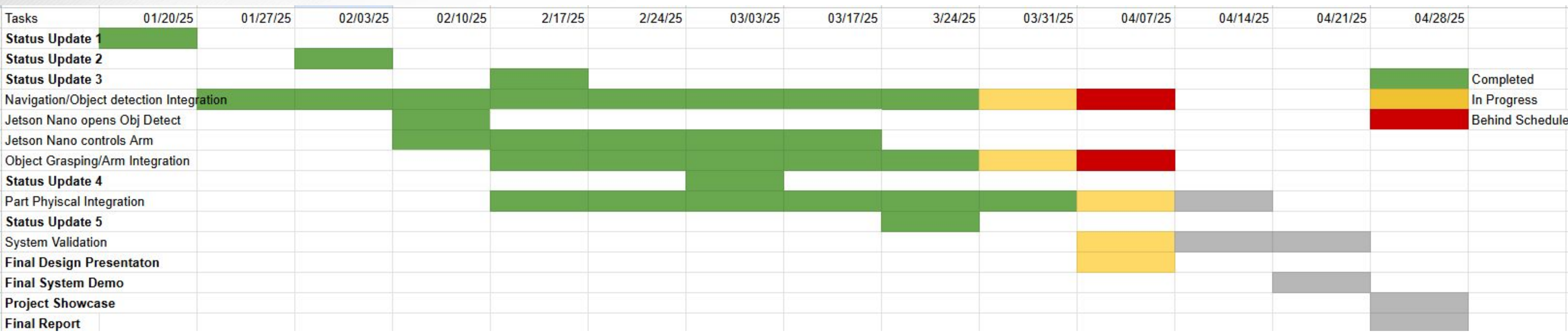
Accomplishments:

- Can control all robotic arm servos with the Raspberry Pi. It can open and close the gripper. The other servos can move up and down.
- Can send servo data (voltage and position) from the microcontroller back to the Raspberry Pi

Challenges:

- Further integration with Object Detection: Gathering object coordinates/data from the raspberry pi once it is connected to the camera.
- Finding alternatives to powering the components without a outlet.

Execution Plan



Validation Plan

Paragraph #	Test Name	Success Criteria	Methodology	Status	Responsible Engineer(s)
3.2.1.1	Object Recognition Time	Detect objects of various colors in a reasonable timeframe	Run multiple tests and see the average time it takes to detect an object	Tested	Chris
3.2.1.2	Object Detection Success Rate	Have a 95% success rate of object detectic	After a series of multiple tests, calculate how often the robot detected an object	Tested	Chris
3.2.1.3	Battery Life	Expected runtime of 2.7 hours with the 36Ah batteries	Allow the robot to run for a certain amount of time then measure the amount of voltage left in the battery	Tested	James
3.2.1.4	Network Requests	Active wifi connection the robot and smartphone	The robot will connecto to the wifi and move	Tested	All
3.2.2.1	Navigation Speed	speed of at least 1.5 meters per second	Use a timer to measure the speed	Tested	James
3.2.2.2	Object Pickup Precision	pick up objects with 90% success rate and error margin of 2 centimeters	Measuring the distance, after a series of tests	Untested	Chris, Kathy
3.2.2.3	Object Placement Accuracy	place objects within a 5 centimeter radius of the designated location	Measuring the distance, after a series of tests	Untested	Chris, Kathy
3.2.3.1.1	Power Consumption	max peak power shall not exceed 432 Watts	Measure the current and voltage of the battery after fully charged	Tested	All
3.2.3.1.2	Input Voltage Level	input voltage level shall be no more than +24V	User multimeter to ensure proper input voltage	Tested	All
3.2.3.1.6	Raw Video Output	create a virtual environment of the robot	Use Gazebo for simulating virtual environment	Tested	James, Kathy

Conclusions

Issues encountered:

- Our microcontroller needed the be replaced after many compatibility issues.We changed from the Jetson Nano to Raspberry Pi 5
- Our first choice of robotic arm was flawed and the model was replaced with one purchased.

Current Status:

- Continue testing the code on the robot
- Continue improvement on arm movement

Thank you for listening. Any Questions

Integrated System Results

- This section shows end-to-end system operation
- Show and provide details on a few important end-to-end use scenarios that you developed and validated. Giving results (be quantitative here – results for key performance indicators … time to complete task, overall accuracy of task, success/fail measures)

About 2 minutes total

Integrated System Results

- We have been able to integrate the object detection and navigation system with great success
- The simulations have been completed and show that the Robot functions in it's desired way, including object recognition, obstacle avoidance, and depth tracking
- The Robot is functionally able to maneuver through a simulated area using depth sensors

Conclusions

- List issues encountered that required changes from system described in Conops, FSR/ICD and resulting system design changes
- Current status (eg. integration/test/validation complete; Integration complete, but BT comm not fully validated; Repeating testing for replacement PCB, integration/validation to be completed in 1 week)

About 1 minute total

Engineering Design Accomplishments

- Each team member should in 2 – 3 slides show what they designed, tested, and validated.
- List challenges / solutions where appropriate.
- Present data (table?) with requirement description (eg rover drill placement accuracy); what spec(s) for that requirement (eg mean error in positioning), measured range of results (min 1.2cm, mean 4 cm, max 11cm);
- Accomplishments should be backed up with quantitative test results and requirements validation

About 60-90 seconds / team member

Guidance on preparing final presentation

- This is not a project update – DO NOT use old templates, do not do the accomplishments/on-going table thing, do not show execution/validation plans.
- Each team will have 10 minutes to do the final presentation. You will be stopped if you go over so practice to make sure you stay within 10 minutes
- You will cover design and validation accomplishments for your project. Each team member should speak on end-to-end use scenarios that relied on their engineering contributions – you will be assessed on the difficulty/complexity of your design work, what you delivered, what engineering skills & reasoning you applied (3pts); progress and completeness of design, test, and validation (2pts); and quality of slides and presentation skill (2pts).
- Results – tables, figures, pictures that reinforce your design/test/validation are encouraged. BUT do not use your very short time to show videos of flights, bench test procedures, walk through code, or talk thru details of a figure. Save Demo content for the demo!
- This presentation will be the culmination of your improved presentation skills. Think of this as a formal presentation to a VP, a VC, or a Client. Avoid informal and slang language; avoid informal, familiar delivery; avoid jokes or humor. Be clear, concise, and don't try to bluff through what is not complete or is problematic.
- Dress should be business casual or business formal.
- Be on time for presentations – with a flash drive. We do not have time for 2 minute transfers between presentations or arrive before class and copy your presentation to the

ECEN 404 Final Presentation
Team # and name
Team Members
TA name
Sponsor

About 30 seconds