ENGINEERING PORTFOLIO

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TURTLE VISION

Objective:

- Develop image recognition functionality for the Amphibious Robotic Turtle (A.R.T.)

Methods:

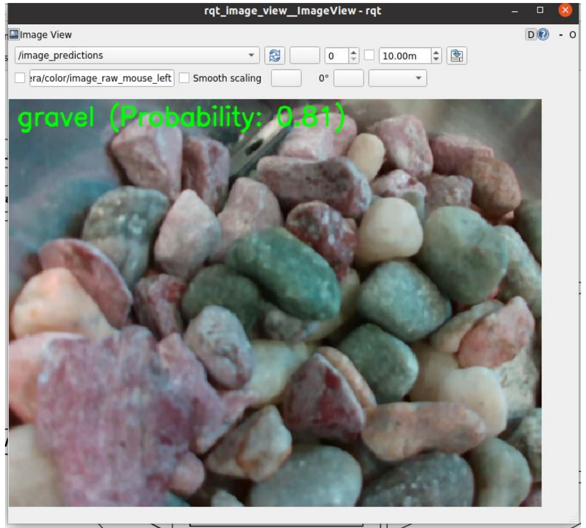
- **Training:** Utilized a pretrained convolution neural network (CNN) in PyTorch, applying transfer learning to fine-tune the model
- **Transfer Learning:** Retrained model using smaller dataset (200 images per class) to identify grass, gravel, concrete, and sand
- **ROS2 Integration:** Developed code in ROS2, leveraging existing nodes and topics from the Isaac ROS Visual SLAM package to classify real-time data from a RealSense camera

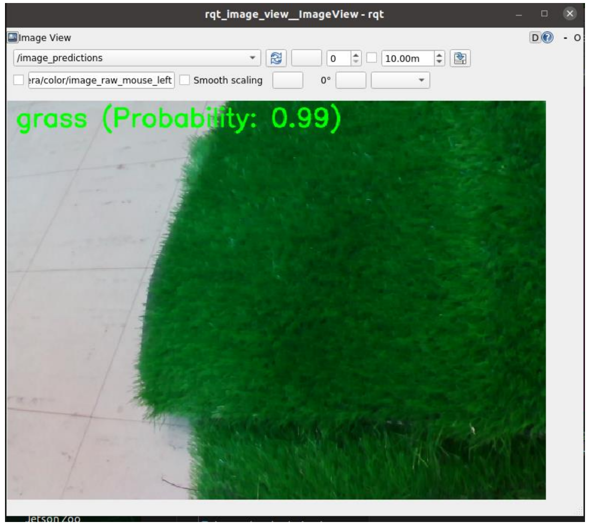
Results:

- **Environment Recognition:** Enabled A.R.T. to identify environmental changes and adjust its movements accordingly
  - E.g., perform walking gait on grass and crawling gait on sand

Turtle vision predictions using validation dataset

Realization of turtle vision using RealSense Camera inputs in ROS2 framework





VOICE ACTIVATED ROBOT NAVIGATION

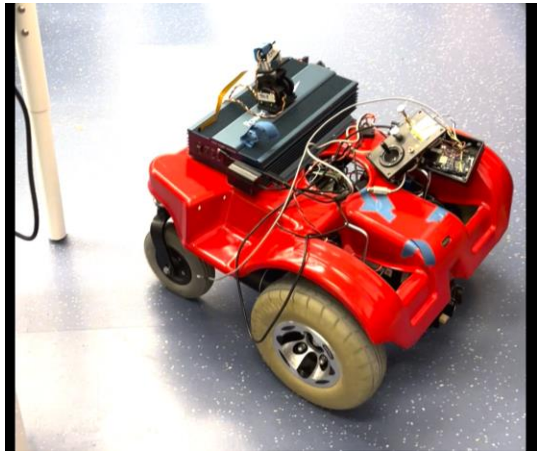
Objective: Maneuver a 4-wheel robot in real-time using voice commands

Methods:

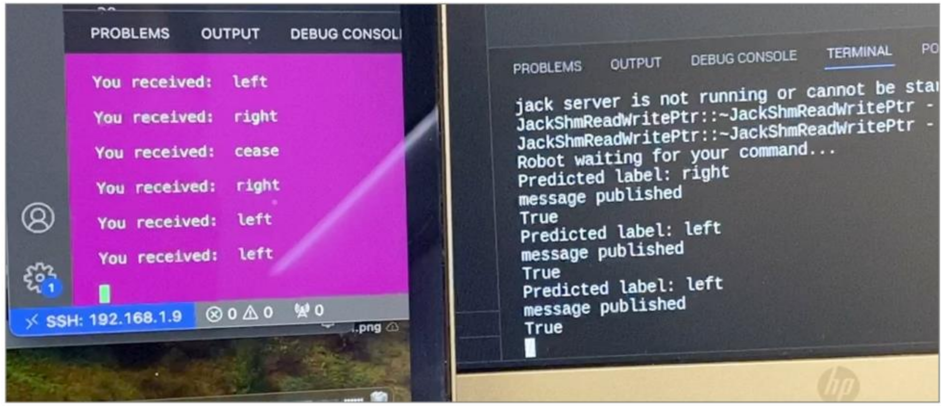
- **Speech Recognition Model:** Developed using Keras and TensorFlow
- **Command Classification:** Trained to recognize 'cease', 'go', 'left', and 'right' using manipulated audio signals from Google's Speech Commands Dataset

Results: Achieved 1.5-second system processing time

- **Audio Processing:** 0.4 seconds to record and recover command
- **Neural Network Processing:** 0.16 seconds to make prediction
- **Command Transmission:** 0.9 seconds to send command to motors
- **Latency Optimization:** Experimented with different messaging protocols including, Arduino Wi-Fi modules, MQTT, and ROS2, decreasing command transmission latency from 1.5 to 0.9 seconds (40% reduction)



4-wheel robot turning a corner in response to left and go commands



Transmission of predicted commands

MAZE MOUSE

Objective:

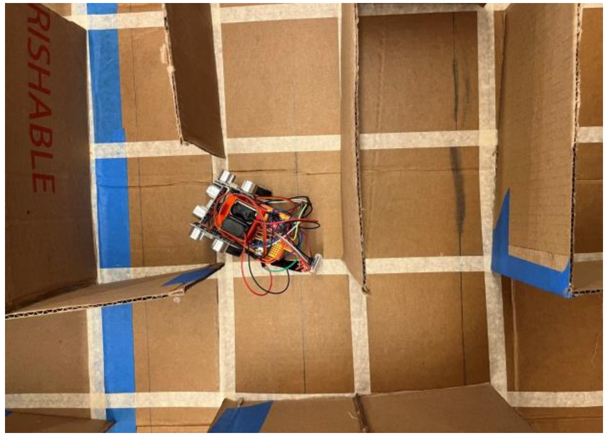
- Design a robot capable of autonomously solving any simply connected maze

Methods:

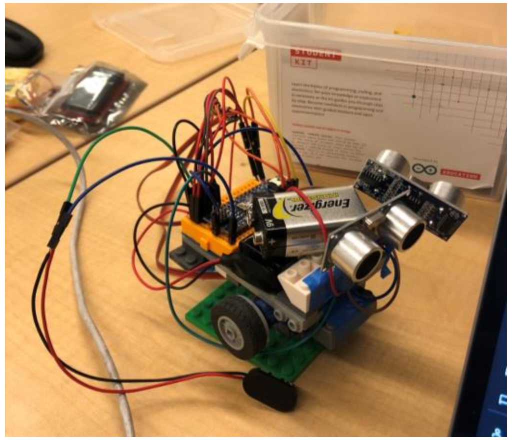
- **Robotic Mouse Design:** 3D printed chassis with onboard power supply and 3 ultrasonic range finders
- **Control Systems:** Used interrupt service routines and a PID controller for collision prevention and trajectory correction

Results:

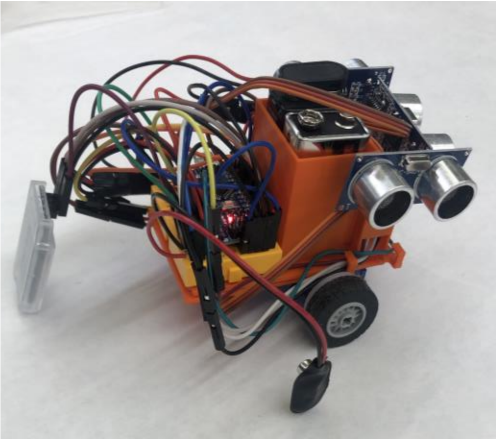
- **Maze-solving Algorithms:** Implemented left/right wall following strategies using sensor data
- **Communication Protocols:** Utilized I2C communication for sensor data collection and Bluetooth to specify maze solving mode (follow right or left wall)



Maze mouse in action! The customizable cardboard maze showcases maze mouse's adaptability and versatility



Initial maze mouse design



Final maze mouse design

CONTACTLESS MICROSCOPE

Objective:

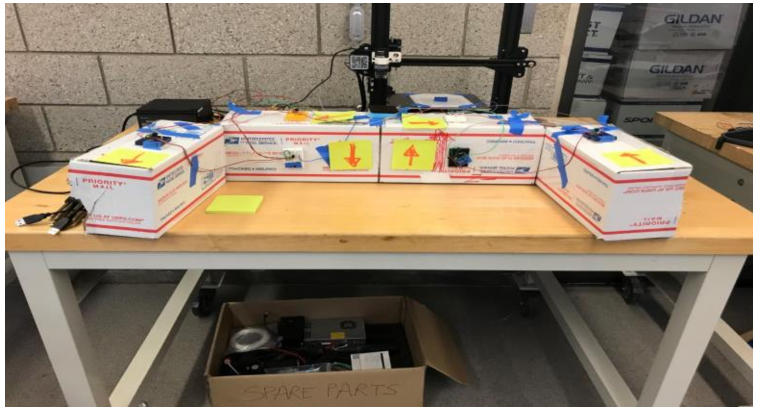
- Create a child-friendly console to control a digital microscope for the Yale Peabody Museum

Methods:

- **Repurposed 3D Printer Frame:** Mounted a digital microscope onto a motorized 3D printer frame
- **IR Sensor Integration:** Controlled by data from multiple IR sensors

Results:

- **Precision Movement:** Hand/object hovering over sensors moves the microscope at variable speeds with high precision and accuracy



Initial console design (UI proof of concept)

Demonstrated use of contactless microscope