AUTONOMOUS SELF-DRIVING WHEELCHAIR

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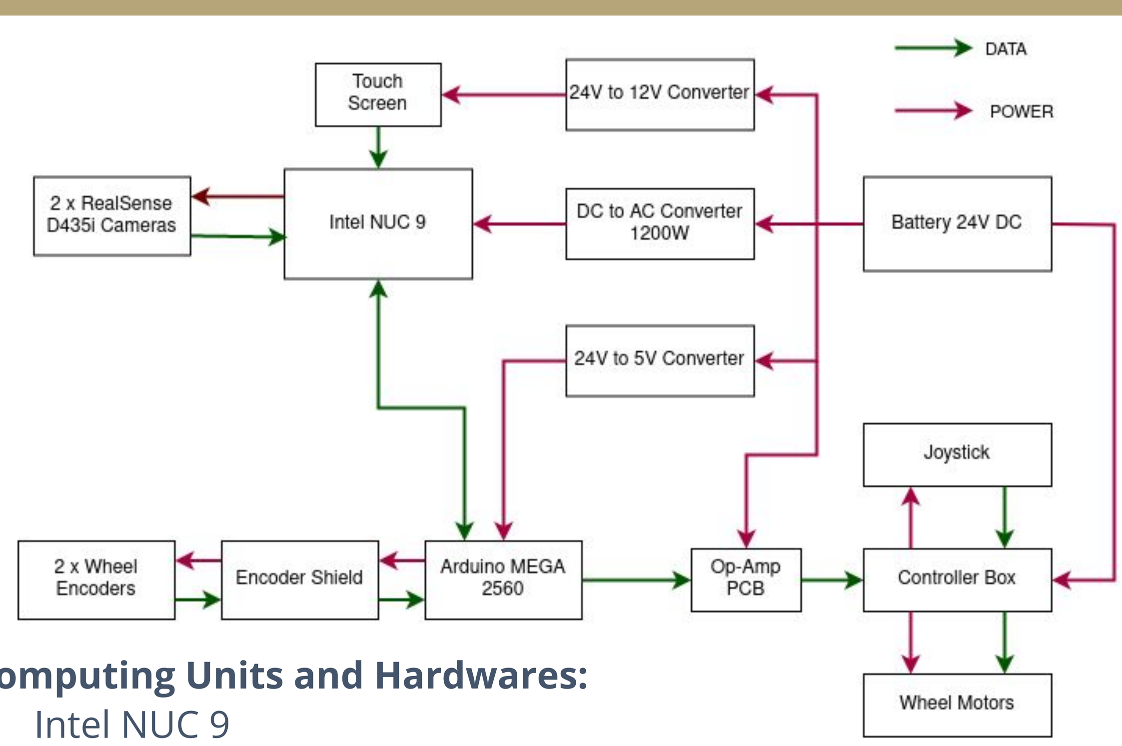
Objectives

The main goal of this project is to integrate both hardware and software for a Self-Driving Autonomous Wheelchair. In addition, we develop software to manage a fleet of robots. The project is divided into 3 sub-groups: Skylane, Fleet and Testing.

The primary goal for each group:

- **Skylane:** Test and integrate ceiling features detectors with SLAM for indoor navigation when SLAM fails
- **Fleet:** Develop a web application for fleet management and remote control feature for the robots
- **Testing:** Perform real world testing using the wheelchair and ensure all hardware on the wheelchair are operational

Hardware Implementation

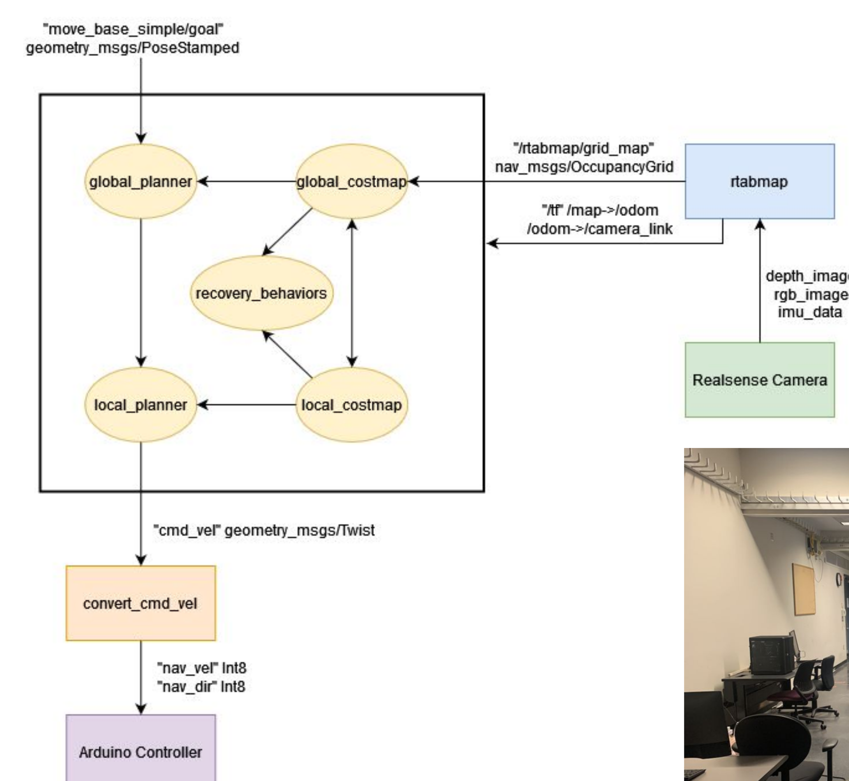


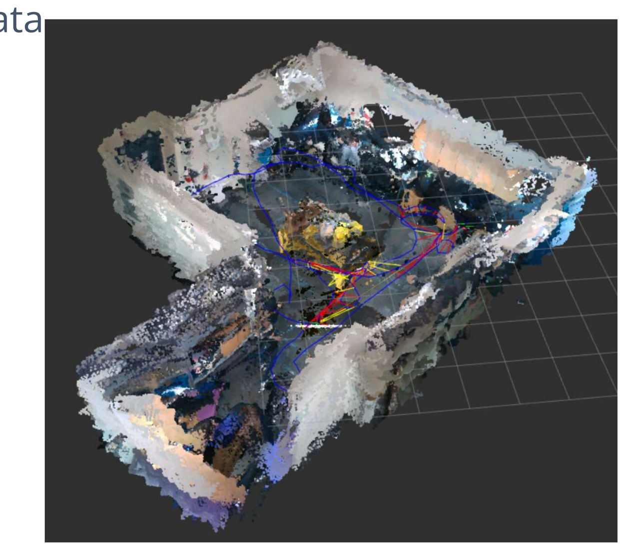
Computing Units and Hardwares:

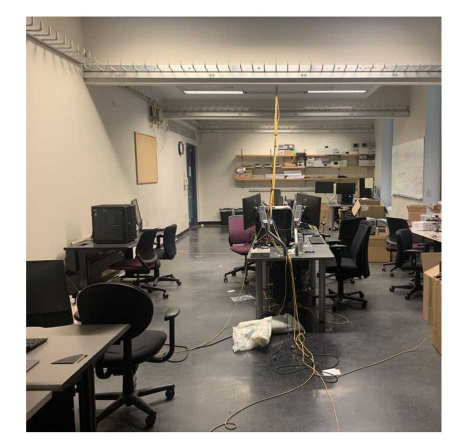
- Intel NUC 9
  - Perform the following tasks: SLAM, Navigation and Ceiling Drift Detector
- Arduino MEGA 2560
  - Convert velocity and direction signals from the NUC into PWM to control wheel motors
  - Process information from encoders and send to the NUC
- Sensors:
  - RealSense D435i Cameras
  - Wheel Encoders

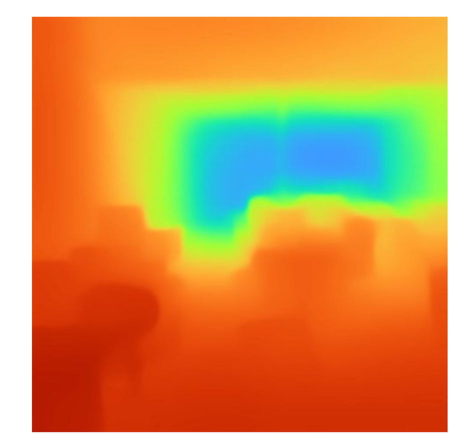
SLAM and Navigation Stack

- Map and localize using RTAB-Map package with one D435i Intel RealSense camera
- The ROS Navigation package was used to plan path from the map generated
- Implemented a node that converts `cmd_vel` twist velocity from move_base node into velocity and direction values for the Arduino controller to steer the wheelchair
- Implemented DistDepth ML method to generate depth data from monocular camera









Lateral Drift Detector

The primary purpose of Lateral Drift Detector is to maintain straight movement for robots in situations where the SLAM system struggles to detect an adequate number of close loop features. This occurs in specific corner cases, including large empty halls.

This system containing following two parts:

Drift Detector

- IMU reading will drift with time
- Implement the feature tracking
- Predict the lateral drift
- Publish correction command

Localization Switch System

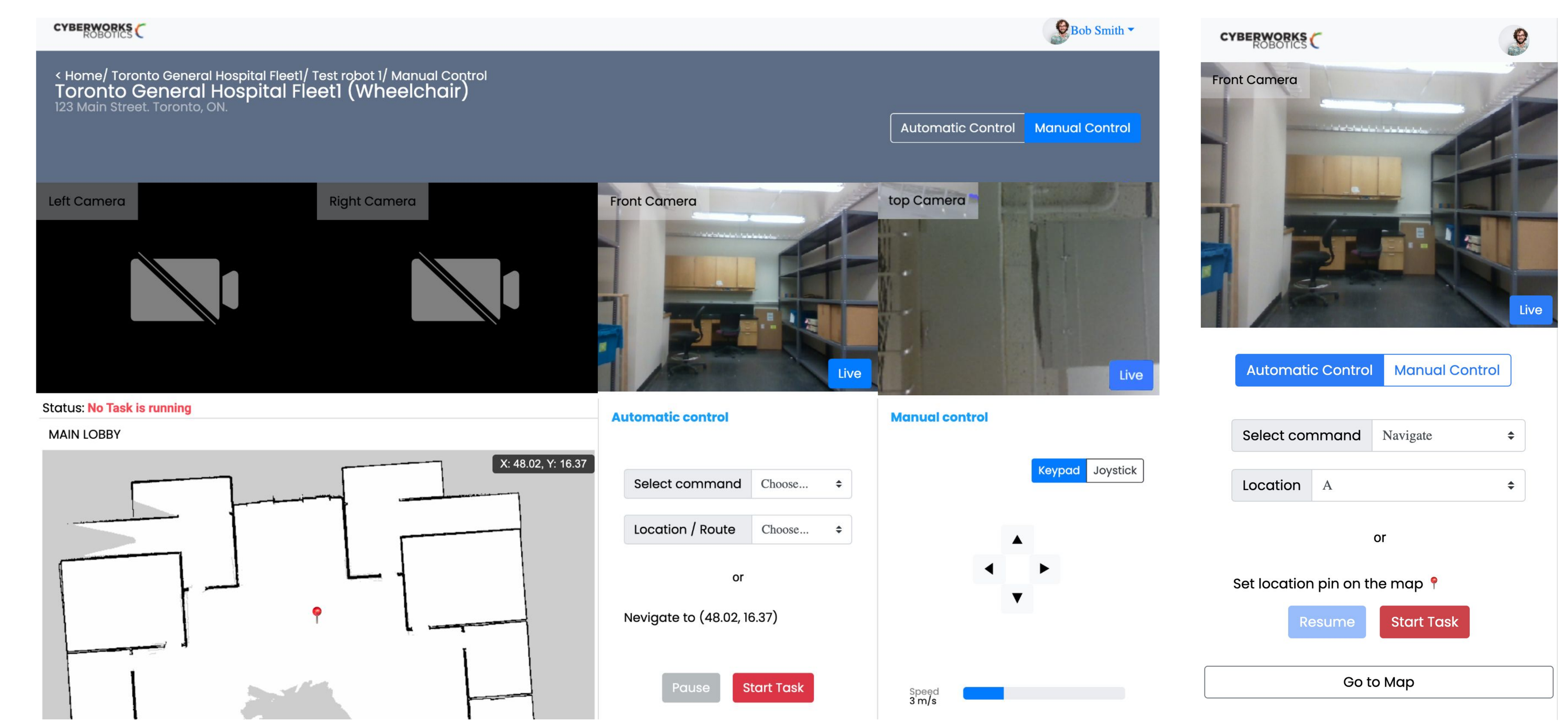
- Use sensor fusion to compare the error from SLAM odometry
- System will switch to use drift detector for navigation when the SLAM result is not reliable
- Revert to SLAM when SLAM gets enough features to localize itself

Fleet Management System

The Fleet Management System is a comprehensive solution for real-time monitoring and control of robotic fleets. Consisting of the Fleet UI, Fleet Server, and Fleet Client, it offers a range of features to streamline fleet operations.

Fleet UI

- User's main interface
- Revamp with bootstrap framework
- Mobile responsive design
- Automatic robot dispatch
  - Selecting a task from pull-down menus
  - Dragging a pin to specify the destination
- Manual robot control



Fleet Server

- Streaming video to Fleet UI
  - Uses the ROS web_video_server package for streaming video
  - Package takes images published on ROS image topics and strings them together to publish as video
  - Supports four video streams simultaneously
- Robot Registration Process
  - Ensures up-to-date information on each robot's state
  - Synchronizes the fleet's status for real-time monitoring and control.

Fleet Client

- The Fleet Client is implemented in ROS1 (melodic) on each robot.
- It enables seamless integration with the Fleet Server, ensuring communication, data transmission, and command execution.

Future Work, References, and Acknowledgments

- Implement automatic switching between SLAM and Ceiling Drift Detector given a location
- Further fine tune SLAM/Navigation parameters
- Enclose all electronics and do cables management for outdoor operation

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