AUTONOMOUS SELF-DRIVING WHEELCHAIR

CYBERWORKS ROBOTICS

Objective

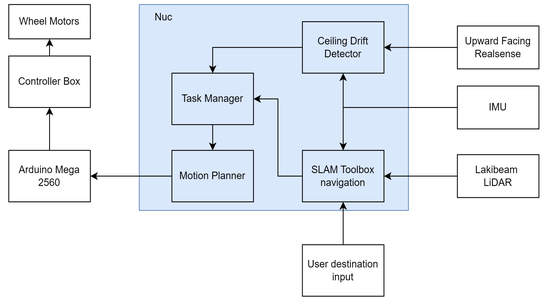
The aim of our capstone project is to seamlessly integrate new hardware and software into the existing autonomous self-driving wheelchair to enhancing the previous generation. Additionally, we seek to enhance the current SkyLane system and implement new and improved mapping methods. This year, our team has been divided into three sub teams to efficiently tackle these tasks: Hardware Integration, Abnormal Map Detection, and SkyLane and SLAM Toolbox Mapping.

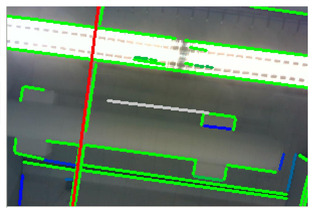
Sub Teams:

- **Hardware Integrations**: As a team integrate new hardware/softaware into curcurrent wheelchair configuartion.
- **SkyLane**: Test and improve current SkyLane navigation with further testing and improvement on ceiling-drift detection.
- **Abnormal Map Detection**: Developed and trained a model in order to detect if a given map is "abnormal".
- **Slam toolbox Mapping**: Improved mapping by switching the current mapping system to a more modern package.

SkyLane

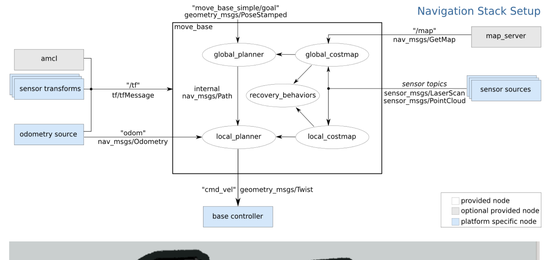
- **Ceiling Drift Detector:** Secondary method of navigation that utilizes a line detection algorithm on the ceiling to calculate a line to follow.
- **Task Manag**er: System for switching between methods of navigation between SLAM and the Ceiling Drift Detector. Triggers a switch when the abnormal map detection detects an unsuitable map for SLAM to the Ceiling Drift Detector and back to SLAM once it detects a suitable map.
- **PID:** PID controller to stabilize the movement of the wheelchair based on the Ceiling Drift Detector.

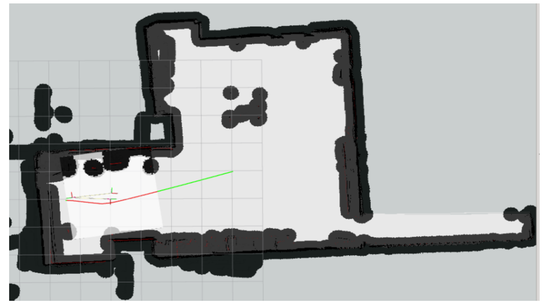




SLAM Toolbox Mapping and Navigation

- **SLAM Toolbox:** Mapping and localization via SLAM toolbox utilizing the Lakibeam LiDAR over older YdLiDAR X4.
- SLAM toolbox allows for higher resolution and accurate maps with more modern LiDAR's such as the Lakibeam.
- **rf2o package**: Utilized this package to improve odometry, leads to more precise localization and mapping.
- Eliminating overlap and offset issues that commonly happened while building a large open area map, thus leading to better mapping within open spaces.
- **Laserscan package:** Sensor fusion, able to fuse imu, scan and odometry data to calculate post 2D messages.

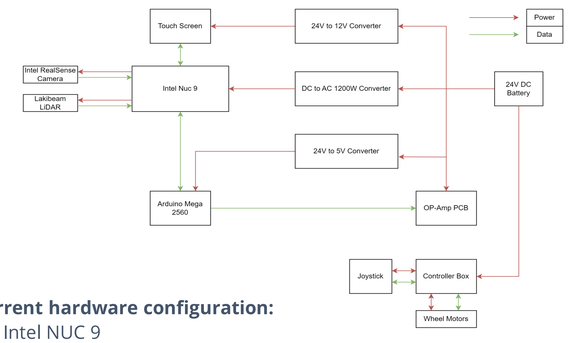




Navigation in the Engine lab using Lakibeam LiDAR

Map of ECE first floor

Hardware Integration

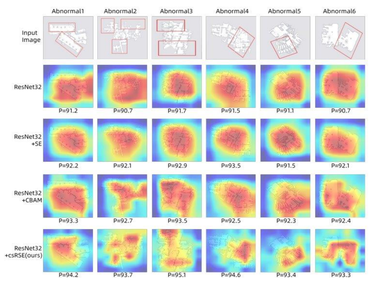


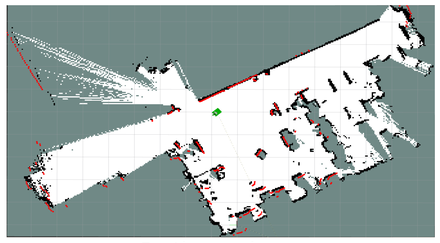
Current hardware configuration:

- Intel NUC 9
  - SLAM, toolbox mapping Navigation and Ceiling Drift Detection
- 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
  - Lakibeam 1L dToF LiDAR

Abnormal Map Detection

- Trained and tuned attention network to detect abnormal occupancy maps
- Abnormal occupancy grid map recognition(OGMD) algorithm uses channel squeeze-excitation(cSE) module to emphasize channels with meaningful information, and spatial squeeze-excitation(sSE) module to determine the importance of specific locations across the feature map.





Ex. Abnormal map

Ex. Normal Map

Future Work, References, and Acknowledgments

- Adding potentially more sensor data to increase map accuracy for large environments.
- Enclose electronics on back side of wheelchair
- Improve on obstacle detection navigation and response.

Faculty: Prof. Kim Ingraham, Prof. Payman Arabshahi
Graduate Students: Amisha Somaiya
Industry Mentors: Vivek Burhanpurkar, Nick Kourtzanidis, Hamed Bozorgi

ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY of WASHINGTON

ADVISERS: Vivek Burhanpurkar, Nick Kourtzanidis, Hamed Bozorgi, Kim Ingraham, Amisha Somaiya

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