GoWrench Self-Navigation Vehicle

McMaster University

ENGINEERING

W Booth School of Engineering Practice and Technology

GoWrench

Community Partner

Faculty Leads: Dr. Moein Mehrtash

Project Team: Haocun (Matt) Jing M.Eng., Sebastian Rivera Alfonso M.Eng – McMaster University, Hamilton, ON

Introduction to Community Partner

- GoWrench provides mobile auto repair and maintenance services in Ontario. They offer a wide range of services, including tire swaps, brake repairs, oil changes, A/C service, and more, directly at your home, work, or job site. They also provide fleet services for businesses, ensuring convenient and efficient vehicle maintenance.

- The Husky robot platform serves as a testbed to validate self-navigation algorithms in real-world scenarios.
- A Husky robot is a rugged and versatile unmanned ground vehicle (UGV) designed for research and development in various fields, including robotics, autonomous systems, and field operations.

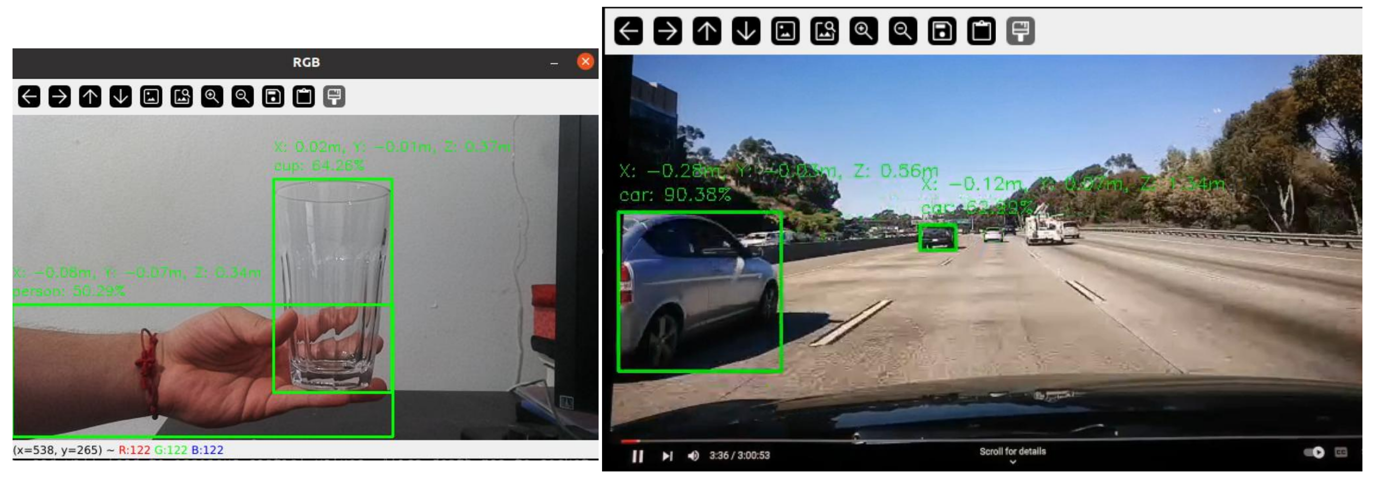
Objectives

- The project aims to develop a Level 4 autonomous off-road service vehicle. The current phase focuses on integrating the SwiftNav Duro GNSS receiver and Oak-D camera into a ROS-based system to enable:
  - **Robust Localization:** Utilizing GNSS and IMU data to accurately determine the vehicle's position.
  - **Obstacle Detection and Avoidance:** Employing the Oak-D camera to identify and navigate around obstacles.
  - **Self-Navigation:** Developing algorithms to plan and execute autonomous routes.
  - **Visual Perception:** Using YOLO models, achieve depth perception, road segmentation and object detection

Modules

SwiftNav Duro GNSS Module and Oak-D Camera Module

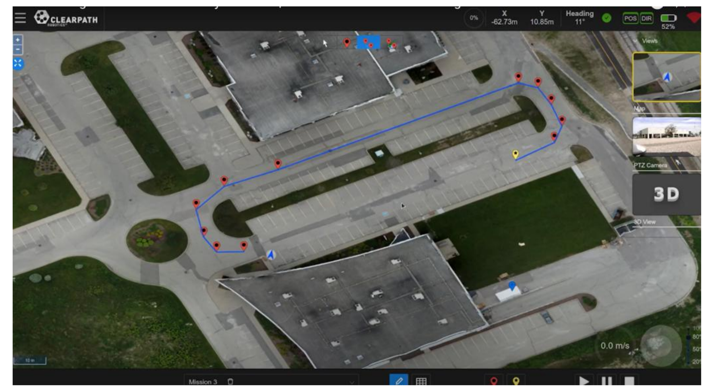
- Global Navigation Satellite Systems (GNSS), such as GPS, GLONASS, Galileo, and BeiDou, provide precise positioning information essential for autonomous navigation. By receiving signals from multiple satellites, GNSS receivers can determine a vehicle's latitude, longitude, and altitude with high accuracy.
- GNSS offers a global reference frame, enabling accurate localization of the vehicle.
- GNSS data can be fused with other sensors like inertial measurement units (IMUs) to improve localization accuracy, especially in challenging environments.
- Waypoint Navigation: GNSS-based positioning allows for precise navigation to predefined waypoints, forming the backbone of autonomous route planning.
- Simulated GNSS signals provide a controlled environment to test and refine navigation algorithms without real-world deployment risks.
- .



YOLOP and YOLOv8 with xyz depth preception

Methods of Approach

- Global Localization: Utilizes the SwiftNav Duro GNSS module for precise outdoor localization, integrated with IMU data using an Extended Kalman Filter (EKF) to provide reliable positional estimates.
- Local Localization: Combines lidar or high-resolution camera data with IMU for short-range navigation and obstacle avoidance
- Implemented via ROS, using the move_base node for path computation and execution.
- Static Transforms: Used to simulate a stationary robot for initial localization and navigation validations.
- Testing conducted in RViz with visual overlays, validating the integration of navigation algorithms.
- Google Maps API Integration: Generates realistic navigation routes using geographic data. Outputs include latitude and longitude waypoints for dynamic visualization in RViz or Google Earth.
- Visualized static and dynamic paths via simulated data overlay on satellite imagery and exported in formats like KML for detailed analysis.
- Combines all necessary nodes (e.g., localization, planners, fake GNSS data) into a centralized file for efficient system testing and deployment.
- YOLOP and YOLOv8 can run on the docker
- YOLOv8 has integrated depth perception
- Linux on laptop with Oak-d cameras was the first testing apparatus for X,Y,Z coordinate script testing
- Jetson Orin was then used with the Oak-d camera for testing and software integrations
- Modifying existing work on these model in a manner to not disrupt the dependencies was critical
- Testing of both models was done on a computer display to simulate road conditions



Project Achievements

Development of Waypoint Self-Navigation System

Successfully implemented a robust waypoint navigation system using the ROS framework.

Integrated global and local path planning through navfn and dwa_local_planner, ensuring efficient and accurate navigation.

obstacle avoidance.

Simulation Validation

Created a comprehensive simulation environment for pre-deployment testing using:

Fake GNSS and IMU data.

Static transforms for stationary robot simulation.

RViz visualization to debug and validate navigation algorithms in controlled settings.

Successfully simulated navigation routes between predefined waypoints and validated them in RViz and Google Earth.

Google Maps API Integration

Integrated Google Maps API to generate real-world navigation routes.

Enabled seamless visualization of routes, connecting simulated environments with real-world geographic data.

Foundation for Real-World Deployment

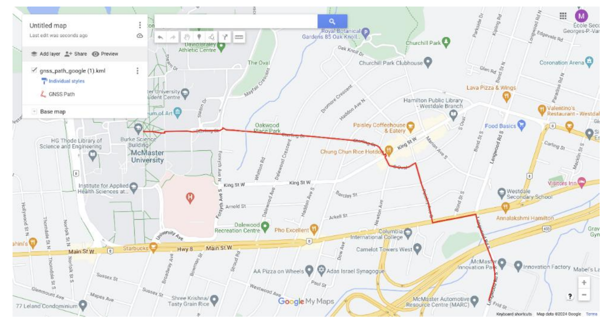
Established a pre-validated navigation system, minimizing risks associated with real-world deployment.

Positioned the project for future enhancements, such as real-time sensor integration and improved obstacle detection.

Development of Road and Pedestrian segmentation and depth

Successfully implemented YOLOv8 and YOLOP in the same docker file

X,Y,Z coordinates are output on the YOLOv8 model



Recommendations for Future Research

- Optimize the self-navigation algorithm and self-navigation function activation process
- Merge the Google Maps API with the move base system to achieve fully functioning self-navigation
- Integrate both YOLO (v8 and Panoptic)models into one script with XYZ using all three cameras simultaneously

References

- A. Chatterjee, “GPS-waypoint-based autonomous navigation in ROS,” GitHub Repository, https://github.com/ArghyaChatterjee/gps-waypoint-based-autonomous-navigation-in-ros.
- “Sensor fusion of GNSS and IMU data for robust localization via Extended Kalman Filter,” MDPI Sensors, vol. 23, no. 7, p. 3676, 2023. https://www.mdpi.com/1424-8220/23/7/3676.
- “GPS/GNSS for robotic and autonomous devices,” Septentrio https://www.septentrio.com/en/learn-more/gps/gnss-robotic-and-autonomous-devices.
- R. Sasaki, “Kalman filter localization,” GitHub Repository, https://github.com/rsasaki0109/kalman_filter_localization.
- MacMetroMate. *Presentation*. GitHub, https://github.com/macmetromate/Presentation
- Sep783Lab. "lab7.md." *macbot-labs-*, GitHub, https://github.com/Sep783Lab/macbot-labs-/blob/main/lab7.md

The Project Team

- Faculty Lead: Dr. Moein Mehrtash
- Community Partner: GoWrench – Josh
- Team Member: Haocun (Matt) Jing, M.Eng. In Systems and Technology
- Team Member: Sebastian Rivera Alfonso, M.Eng. In Systems and Technology

BRIGHTER WORLD