Carnegie Mellon University

Autonomous Water Taxi

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The Robotics Institute

Project Description

The aim of this project is to create a proof of concept that demonstrates a viable water taxi system for the City of Pittsburgh. A fleet of autonomous water taxis would reduce commute time for citizens, boost tourism for the city, and grow businesses located along the rivers.

Hardware

Boat

NREC has recently acquired a 27 ft SeaHawk aluminum welded boat. The boat has been converted to a test bed for maritime autonomy research, with drive by wire controls. The boat also has a cabin and heating to facilitate year-round use for developers onboard.

Sensors

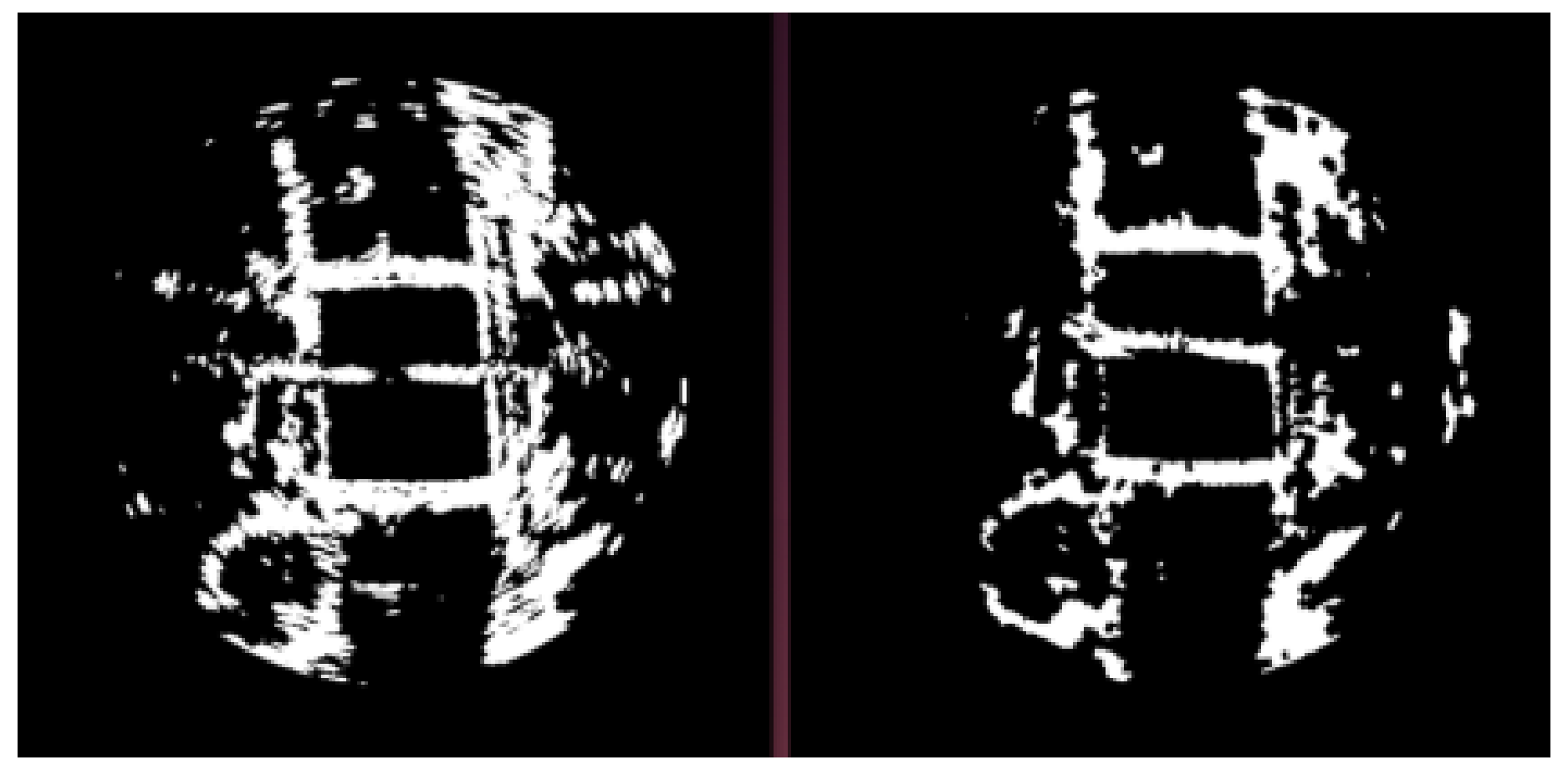
The boat is outfitted with a marine radar (Simrad 4G) and a high accuracy positioning system (Novatel SPAN). In the future, NREC plans to install a LIDAR as well as an array of ultrasonic sensors.

Implementation

Perception Subsystem

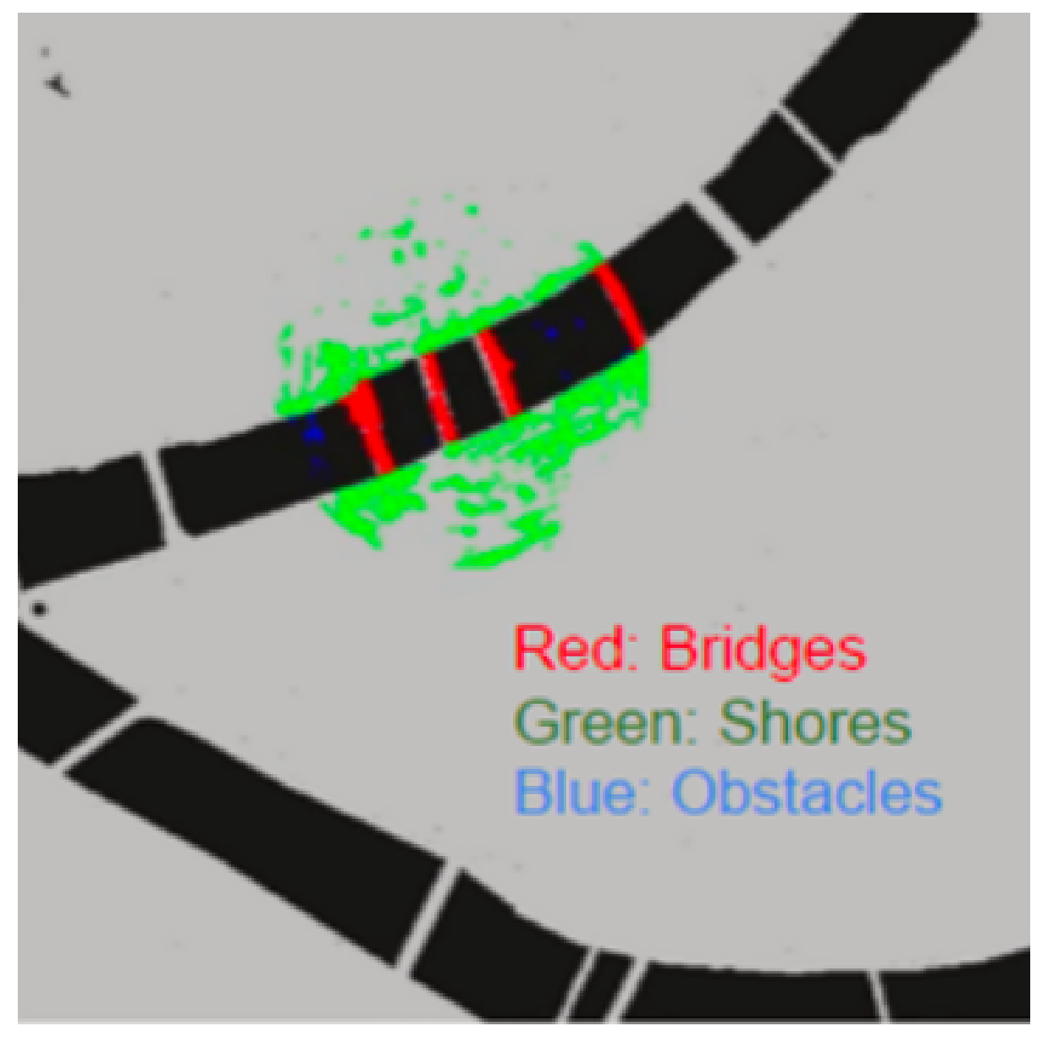
Sensing

We used OpenCPN to acquire data from the radar. After this, we performed contour extraction, identified the bridges, and removed them from our radar image. Next, we sent the data to the OctoMap package in order to filter the radar data. The final output is the obstacles that are sent to the planning subsystem.



Segmentation

The image below shows the segmented bridges, shores and obstacles on the river. We performed segmentation by comparing our extracted contours with prior map information.



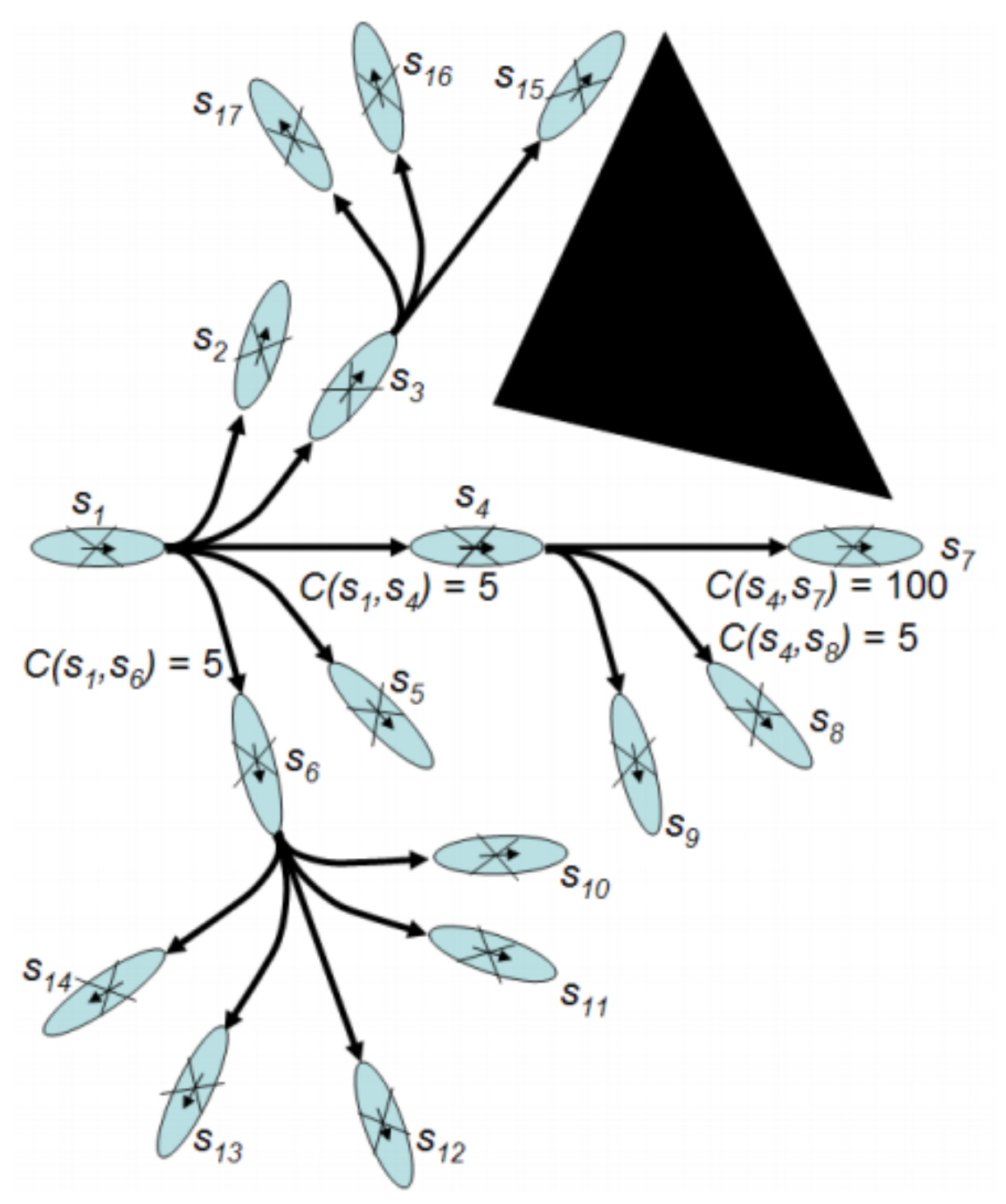
Mapping Subsystem

We generated the maps using QGIS and OpenStreetMap. We pulled data containing the boundary of the rivers, location of bridge supports, and the river channel (middle line). We also applied morphological operations to our costmap in order to inflate the cost around the shores.

Implementation

Planning Subsystem

In planning, we used the SBPL package to plan the path from the source to the destination. We developed custom motion primitives for the path planner in order to better model the physical constraints of the boat.

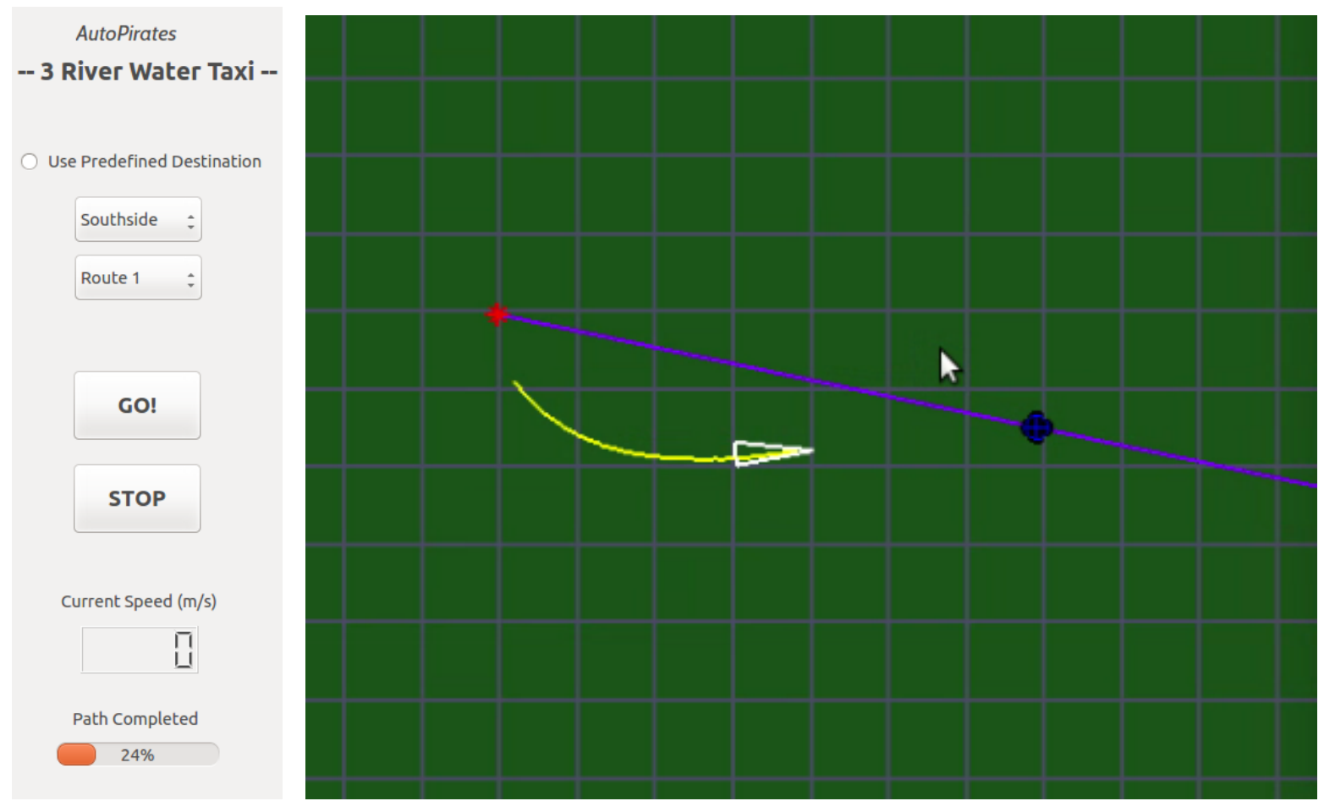


Simulation Subsystem

We developed a simulation program in which we can test path planning and introduce fake obstacles that are static or dynamic. The size of the obstacles can be adjusted. The dynamic behavior of the obstacles are either random or teleoperated with an XBOX controller.

Low Level Controller & GUI

In our GUI, we can choose predefined destinations. Then the path planner will generate a path and compute several waypoints. The low level controller uses pure pursuit path tracking algorithm to follow the waypoints.


AutoPirates

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○ Use Predefined Destination

Southside

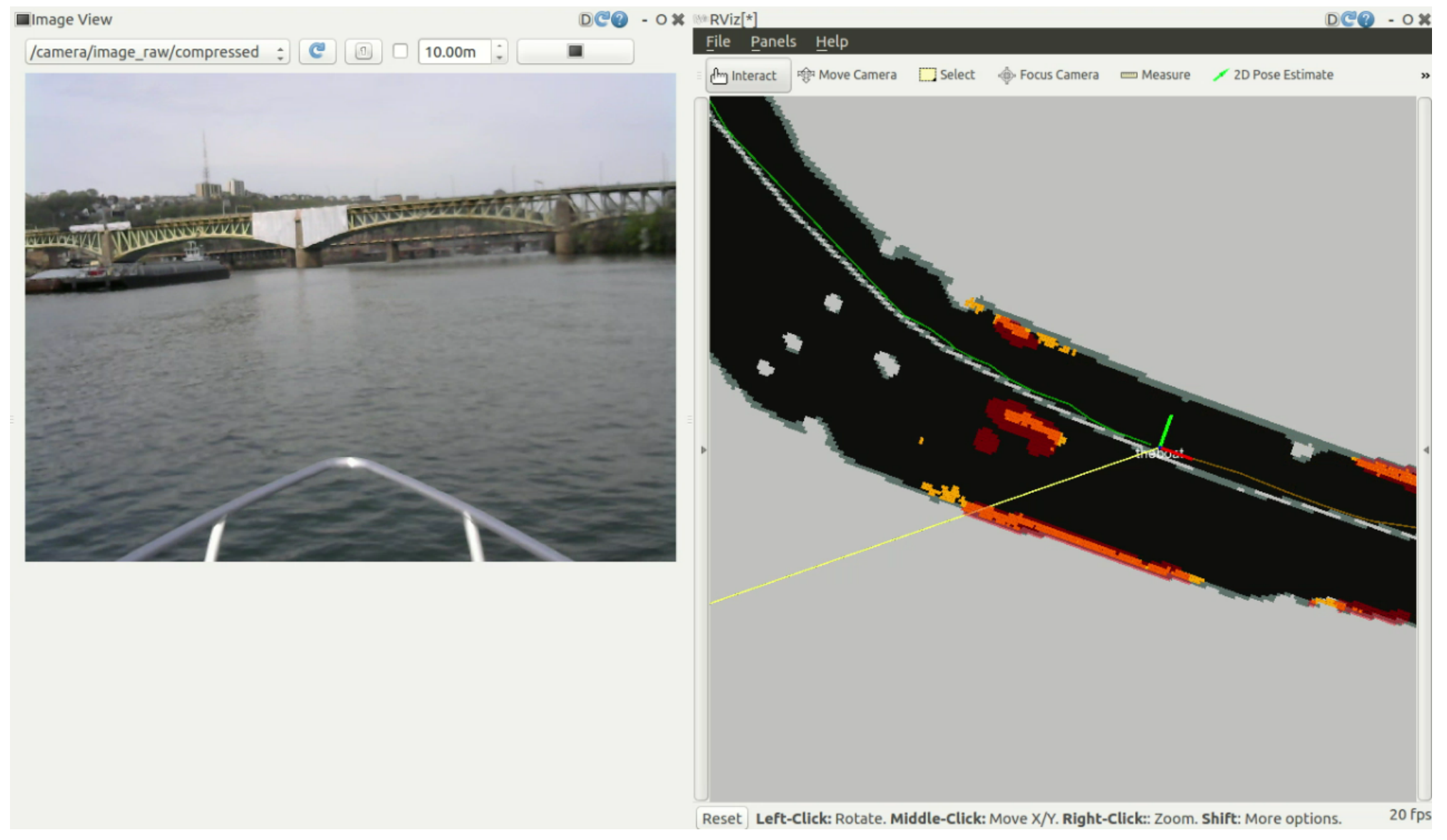
Route 1

Current Speed (m/s): 0

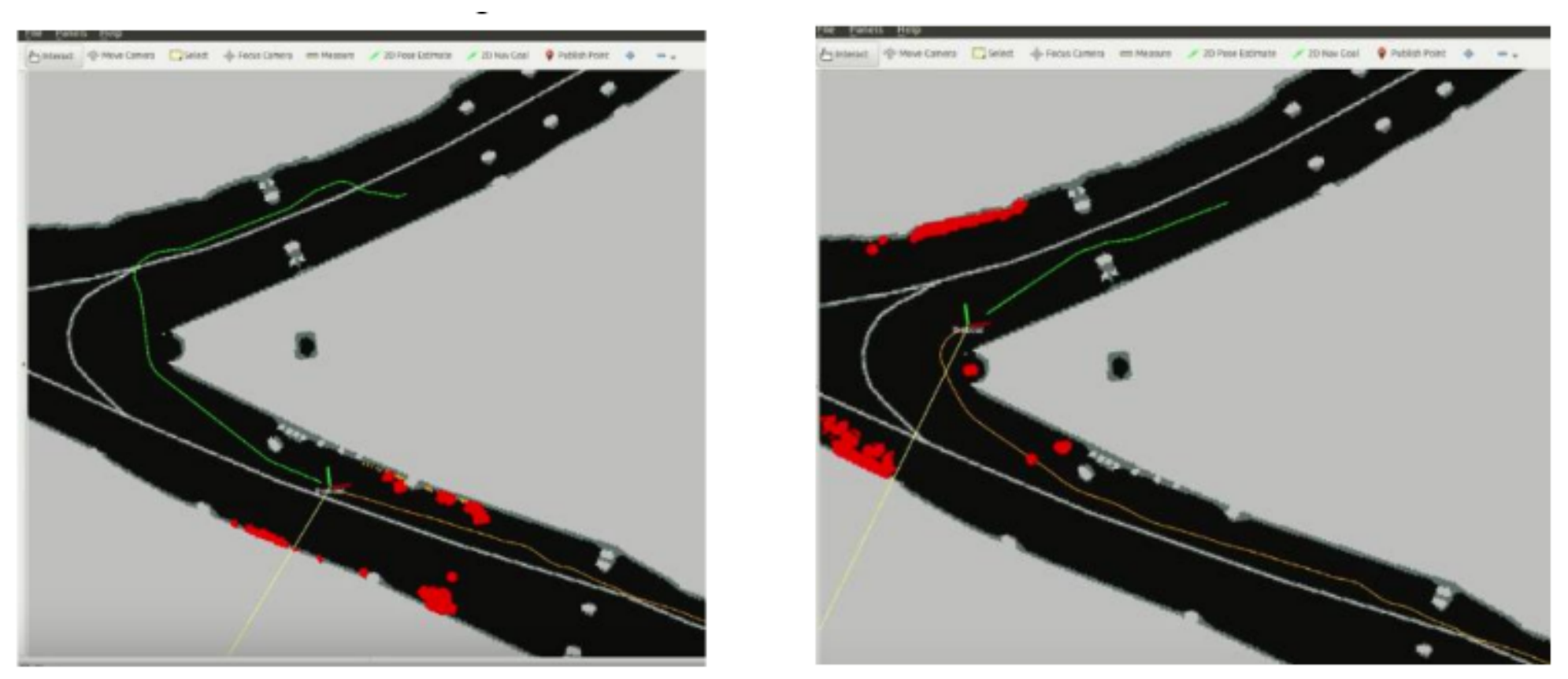
Path Completed: 24%

Result

Autonomous Navigation



Following Rules-of-the-road



In terms of our performance requirements, our system is able to:

- Arrive within 15 meters of the destination
- Traverse 2 miles in less than 15 minutes
- Detect 85% of obstacles of minimum size 2m x 2m x 2m

Future Work

Future work on the project includes –

- Extend the current functionality to track and estimate the trajectory of dynamic obstacles.
- Improve the path planner so that it can run in real time and generate smoother paths.
- Figure out how to autonomously dock the boat.