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CS 5891: Special Topics - The Algorithms of Robotics

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Final Project Report

For our CS 5891 final project, we have implemented automatic navigation for a TurtleBot3 Waffle Pi in a simulated "house" environment using the ROS Navigation Stack. We also integrated Rapidly-exploring Random Trees (RRT) algorithms for this project. The robot has successfully performed round trip tasks, illustrating its ability to autonomously navigate between different rooms within the house.

The objective of this project was to enable a TurtleBot3 Waffle Pi to autonomously navigate within a simulated "house" environment using the ROS Navigation Stack. We were aimed to replace the default planner with an RRT-based planner for improved path planning and for autonomous exploration of the environment. Then, we were asked to complete the navigation part of the Home Service Mission.

We used the TurtleBot3 Waffle Pi as the robot platform and Gazebo for simulation. The "house" environment was launched using the turtlebot3_gazebo package.

We utilized the SLAM algorithm provided by the turtlebot3_slam package to create a map of the environment. The robot was initially teleoperated using the turtlebot3_teleop package to explore the environment and generate a complete map.

The ROS Navigation Stack was employed for autonomous navigation. The move_base node was configured with appropriate parameters for path lanning. The turtlebot3_navigation package was used to launch the navigation stack. As a result, we were able to successfully navigate between different rooms in the "house" environment using the ROS Navigation Stack. It was able to avoid obstacles and reach the specified goal locations.

We integrated RRT by modifying explore.py that is located in the nodes folder of Turtlebot3-Navigation-with-SLAM.. This improved path planning compared to the default planner. The RRT creates a full map of the house, which can then be used, by selecteing certain points on the RRT to represent each individual room, to do the traversal.

We encountered two critical challenges during the project. First, while installing the necessary packages and following the Tutorial, we had a hard time figuring out what to exactly do for the project. The Tutorial did not have much information so we had to employ other sources including ChatGPT. While ChatGPT was useful for us to grasp the overall picture, it was not useful in actual coding. Second, we had a hard time understanding the code given from various GitHub repositories. Hence we have asked ChatGPT for source code summarization.

In terms of division of the work, Youngjae has worked on how to set up for this project and determine the exact tasks to do for this project. We both worked together modifying explore.py but Rubin did a lot more work on this. Hence we decided to use Rubin's work for final submission. We were both stuck figuring out which files to exactly create or modify in what ways (including debugging). Yet it was Rubin that figured out how to resolve these problems. Thus, Youngjae has mostly done writing up this final project and final presentation. We decided to present together in class on May 2nd.

To go beyond this project, we can do several things. First, we could perhaps further tune the navigation stack parameters or use different path pathing algorithms for better performance. Second, we can perhaps use machine learning and the python opencv library to figure out the location of each room in a more clever manner. Last but not least, we could complete the Home Service mission.

In conclusion, we have implemented autonomous navigation for a TurtleBot3 Waffle Pi in a simulated "house" environment using the ROS Navigation Stack. The robot performed round trip tasks between different rooms, demonstrating its capability to autonomously navigate within the environment. The integration of RRT for environment exploration and global path planning allowed us to improve the robot's performance in complex environments.

References

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