EE346 - Mobile Robot Navigation and Control

Fall 2024
Laboratory #5 (4%)
Due Date: Wednesday November 27, 2024
LiDAR-Based SLAM on TurtleBot3

Objectives

- Study robot simultaneous localization and mapping (SLAM) and ROS Navigation Stack by running the classic SLAM algorithm GMapping in both simulation and a real environment.

Part I: SLAM with TurtleBot3 in Simulation

In this part of the lab, you will use RViz and Gazebo to perform a robot mapping experiment in simulation. Read Sections 10.8 of the textbook on "TurtleBot3 Simulation Using RViz". Follow the instructions so that you are able to start the simulated robot, teleoperate it, and visualize its operation as is shown in Figures 10-12 and 10-13, which display the robot path and the coordinate frames of interest on TurtleBot3. Also make sure that you can display the `tf` tree of the experiment in Figure 10-14 with the help of `rqt_tf_tree` command and with the TF Tree plugin in `rqt`. There is an online description related to this experiment at:

https://emanual.robotis.com/docs/en/platform/turtlebot3/simulation/#gazebo-simulation

Once you are comfortable with running the simulated TurtleBot3, follow the instructions in Section 10.9 to create a map of a simulated environment with the help of `turlebot3_slam` package - which runs a SLAM algorithm called GMapping by default. In addition, your robot will use the map to navigate in that environment, i.e., plan a collision-free path and move to a specified destination. Details on how to use GMapping can be found in Chapter 11 of the textbook. The navigation operation is accomplished with the help of the amcl and move_base packages, launched in `turtlebot3_navigation.launch`, which perform robot localization and path planning respectively. Verify the operation of TurtleBot3 in Gazebo by reproducing Figure 10-19 to display the camera view and the LDS scan. Once you have completed the mapping of the environment, save the map with the map_saver command, which should be similar to that in Figure 10-21. There is an online description of this experiment at:

https://emanual.robotis.com/docs/en/platform/turtlebot3/slam_simulation/

Demonstrate the experiment to a TA by showing the steps marked in red in the above description and be prepared to answer related questions.

Finally, as a challenge, think of a solution where you can move your simulated TurtleBot3 with RC-100 to complete the mapping task.

Part II: SLAM on the real TurtleBot3

In this part of the lab, you will repeat Part II in a real environment that has been set up in the lab. Read Section 11.1 of the textbook. Then follow the instructions in Section 11.2 to build a map by tele-operating your robot *using* RC-100 (not the computer keyboard) and running GMapping to process the information from robot odometry and the LDS. Once you have completed the steps, display the map you have built, which should be similar to that in Figure 11-8. Finally, run the steps on p. 310 of the text so that your real robot TurtleBot3 (not the simulated one) is able to navigate autonomously to an arbitrarily specified destination using amcl and move_base. Make sure that you use the right map file, and your initial position of the robot is set properly. Note that Sections 11.3.2 – 11.3.5 provide information in high level terms about to this part of the lab. Once your robot is able to navigate autonomously, demonstrate it to your TA by showing the steps marked in red in the above description. Refer to the following pages for additional help with this part of the lab.

https://emanual.robotis.com/docs/en/platform/turtlebot3/slam/

Marking

If you are able to complete the demos before the due date, you will receive:

Part I: 40%
Part II: 60%

If you are not able to complete any parts of the demo before the due date, you will get a 20% penalty, and an additional 20% for each day of delayed demo.