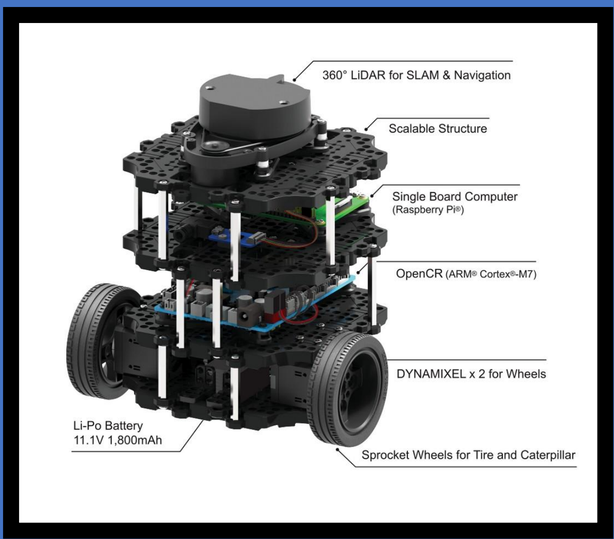
PROJET GSE 2021-2022

Indoor real-time navigation for robot vehicles



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I. Introduction

The goal of this project is to implement a real-time navigation system for robotic vehicles and set up a complete demonstrator based on the existing robot Turlebot 3 Burger running under the ROS framework. SLAM refers to the ability of an autonomous robot to construct a map autonomously in an unknown environment and locate itself according to the map. During the experiment, the Hector SLAM algorithm was used to realize SLAM mapping, and the autonomous navigation function of this robot was completed.

II. Project overview

The whole system is divided into three modules, namely the lidar data collection module, the remote PC control module and the mobile robot module.

Acquisition devices based on portable autonomous laser scanners acquire information through lidar, which will be used to generate maps of the indoor navigation environment. The map acquisition stage is actually created using the distance information obtained by the sensor and the pose information of the robot itself.

We can watch the map created/updated in real time on the remote control PC by moving the laser scanner and collecting data with it. After the Turtlebot3 is assembled and the Raspberry Pi is configured, we can use the remote PC to control it. Import the map obtained by the lidar into the Turtlebot3, and then use the remote PC for control, so that the robot can automatically move to the target. move.

III. Software design

TurtleBot3 supports a simulation development environment, and can use virtual robots for programming and development in simulation. There are two development environments, one using fake nodes with 3D visualization tool RViz, and one using Gazebo, a 3D robot simulator.

A. Gazebo simluation

Gazebo is a 3D physical simulation platform that emphasizes the creation of a virtual simulation environment. We can create a robot world in gazebo that simulates not only the motion function of the robot, but also the sensor data of the robot. And these data can be displayed in rviz, so when using gazebo, it is often used in conjunction with rviz. Simulation is often a very useful tool when we do not have robotic hardware at hand or when the experimental environment is difficult to build.

B. Navigation simulation

Rviz is a 3D visualization tool that emphasizes the visualization of existing data; rviz provides many plug-ins that can display images, models, paths and other information. Navigation enables the robot to move from the current pose to the target pose specified on the map by using the map, the robot's encoders, IMU sensors, and distance sensors.

Initial pose estimation must be performed before running the navigation, as this process initializes AMCL parameters that are critical in navigation. The TurtleBot3 must be positioned correctly on the map, with the LDS sensor data fully overlapping the displayed map. You also need to set the navigation target to specify the robot's destination. Once the destination information is set, TurtleBot3 will start moving to the destination immediately.

IV. Hardware design

The project is to realize automatic navigation on Polytech's map by using turtlebot3 equipped with lidar sensor.

A. Turtlebot3

Turtlebot3 is a ROS-based mobile robot. Turtlebot3 can run a SLAM algorithm to build a map, and it can drive around a room and can be controlled remotely from a laptop. The navigation uses a map (.yaml file) created by SLAM, and using the visualization software rviz, the robot can be controlled to move from the current position to the target position specified on the map.

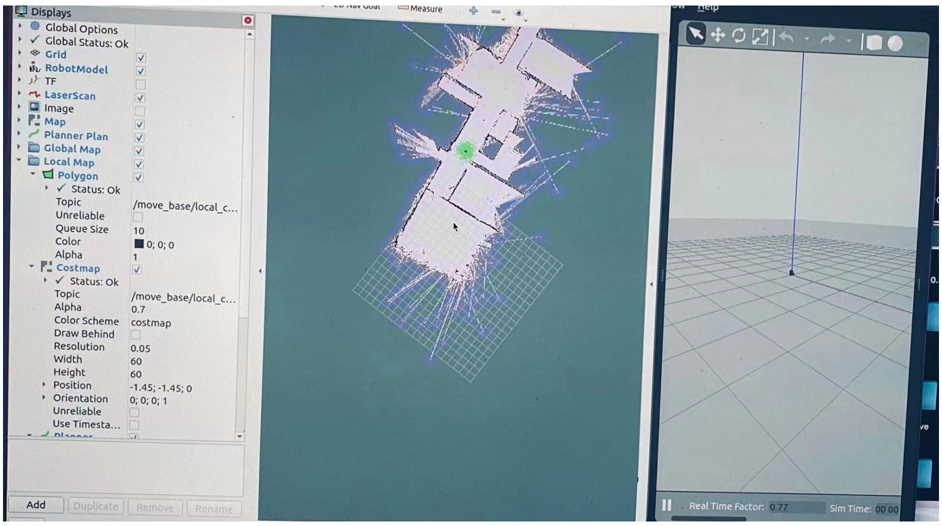
B. Rplidar

The acquisition device is based on a lidar sensor controlled by a laptop and can communicate via a serial/USB connection. Lidar data is streamed to a remote PC base station running SLAM and visualization software. The acquisition device and the remote base station are connected through a personal hotspot and follow the ROS communication mode, which can remotely collect lidar samples and build an indoor navigation map in real time.

V. Results

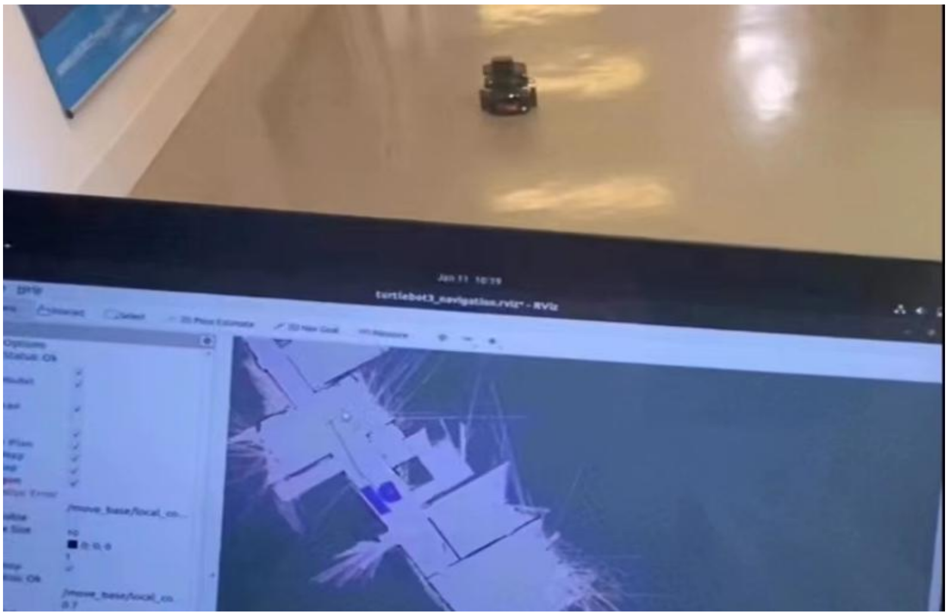
A. Navigation en simulation

The image below shows a scenario where we tested simulated navigation, with the robot moving along a given target location in Rviz, while seeing synchronized motion in Gazebo's simulator.



B. Robot en navigation

The image below shows a scenario where we test the robot in a live environment and the robot will navigate correctly to our given destination.



VI. Conclusion

Although this paper has initially realized the autonomous navigation function of the robot, the Turtlebot robot can reach the designated location correctly. During the navigation process, the Turtlebot robot can also avoid obstacles newly added on the original route. But sometimes, the lidar will directly hit the obstacle and not avoid it in time. This is related to less real-time environmental information obtained by LiDAR, because LiDAR can only scan the plane on which it is located.

Through experiments, it can be found that the effect of lidar in the SLAM mapping process is better and the speed is faster, because the lidar is scanning 360° when building the map. This feature also makes the robot move more smoothly when equipped with lidar for autonomous navigation, and rarely stops for re-positioning and scanning. Moreover, maps generated by lidar mapping are rarely misaligned. But there is still a long way to go before it can be put into production and use. Especially in terms of security and accuracy, there is still a lot of room for improvement.

VII. References

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