AUTONOMOUS NAVIGATION WITH TURTLEBOT

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Abstract

The goal of the autonomous mobile robotics is to navigate robots in the world efficiently by avoiding obstacles. In this paper we present with the approach of autonomous navigation of robots. This approach involves mapping of unknown world, localization of a robot in a map and effectively navigating the robot in a known map. Mapping is achieved using occupancy grid mapping or slam gmapping. Localization is implemented using AMCL. Navigation is acheived by computing robots motion using global and local motion planners. All the three concepts of mapping, localization and navigation are employed from class concepts.

Introduction

In the field of mobile robotics, one of the most important challanges is to navigate in the real world without colliding into obstacles and be able to remain within the boudaries of a map by using sensors. It also involves ensuring smooth trajectory of robot by allowing different possible movements to achieve the task. The main aim of the project is to build a map of the world, localize the robot in a map and navigate the robot to a goal pose by avoiding obstacles in its path. This idea of project is very interesting since by further extending the application of this project, we get to catapult the productivity and quality of various human activities such as package delivery, cleaning, agriculture, search & rescue, building and transportation by causing them to be automated.

Project Description

The following three main processes were involved in building this project and making it successful:

1. Mapping
   Maps in ROS are represented using a 2-D grid, where each cell in the grid is associated with a value in log-odds ratio of how likely a particular cell is occupied or free. For mapping we used two approaches namely occupancy grid mapping and SLAM Gmapping. In our first approach, occupancy grid mapping, the basic idea is to represent the map as a field of random variables arranged in a evenly spaced grid. This algorithm implements estimation of approximate posterior for random variables. For this algorithm we have taken 800x800 grid cells with initial value of 0.5 for each grid cell. As the robot moves and scan the world using laser scan, we assigned value of 1 for occupied cell and 0 for free cell. In second approach, slam gmapping, we assigned an initial map size of xmin=-10, ymin=-10, xmax = 10, ymax = 10, resolution of the map to 0.02, number of particles to a default of 30 particles and also other necessary parameters. Once a map is visualized properly, the map is saved as image

file along with YAML file that holds additional information, such as the resolution, where the origin of the map is, and thresholds for deciding if a cell is occupied or unoccupied.

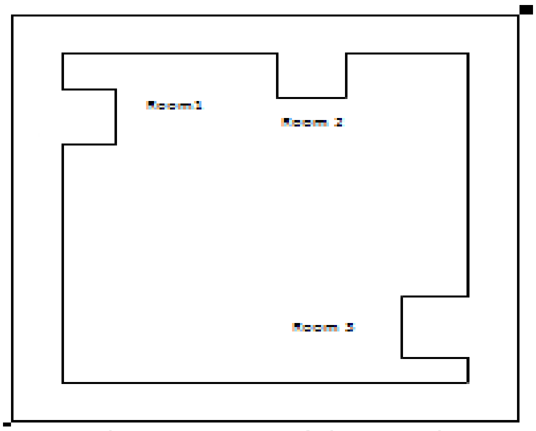


Figure-1: Map of the world

2. Localization

   To navigate a robot effectively across a known map one should be able to localize the robot to find where it is in map and to move around the map to reach a goal pose. For localization, we used Adaptive Monte-Carlo Localization. A pose is used to represent the location of robot, which is represented by a position and orientation in a map. AMCL preserves a set of poses where each pose has a probability associated with it. The robot is likely to be localized at higher probability poses. As the robot moves around the map, the sensor readings are compared to the expected readings at each candidate pose. For each candidate pose, if the readings are uniform with the map, then probability of pose increases else the probability of pose decreases. As it prolongs, the poses with higher probabilities are preserved[6].

   For this approach, we configured amcl with a minimum of 500 particles, maximum of 2000 particles, kld error of 0.05 and other parameters to localize the robot effectively.

3. Navigation

   Navigation in ROS is achieved using navigation stack. Using this, the robot can move around the world from initial pose to a goal pose by avoiding any obstacles in the path. First, the move base node is to be configured for navigating the robot. Move base node uses a occupancy grid to create a cost map. Cost map is also a grid in which each cell is assigned with a cost value that determines distance from an obstacle, a higher cost value denotes closer obstacle distance and a lower cost value denotes a distant obstacles. Using this, trajectory passing cells with lower cost is generated. Move base uses two cost maps, a global cost map for trajectory and a local cost map to determine motion of robot. For move_base node, a set of parameters for cost maps and trajectory planner are needed to be defined which are stored using YAML files. Then we wrote a python code to give a simple goal pose to move base to navigate the robot around the world.

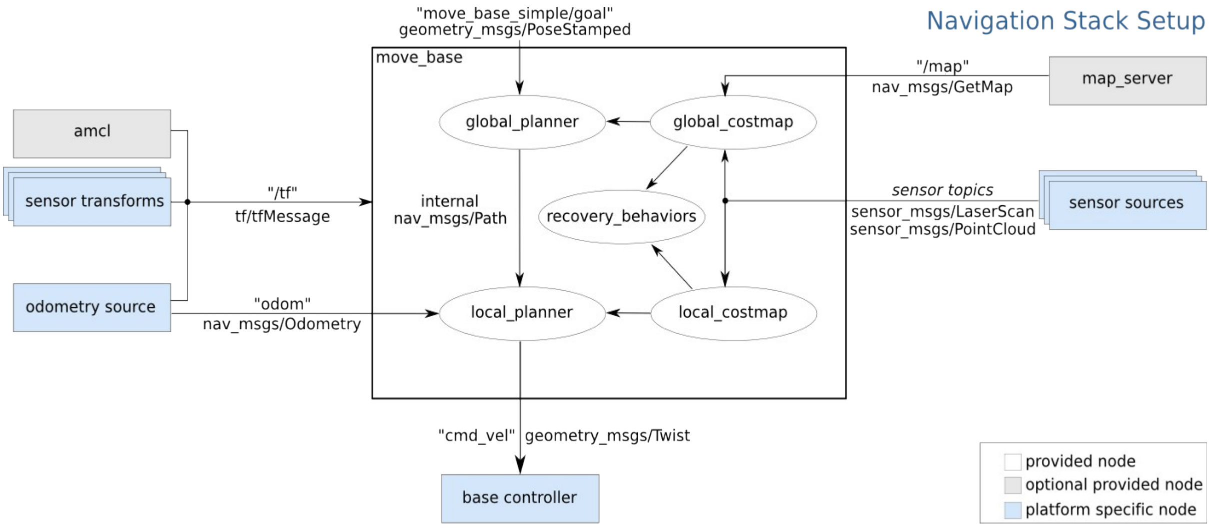


Figure-2: Move base implementation

Related Work

This project uses the work "*Improved Techniques for Grid Mapping with Rao-Blackwellized Particle Filters*"[1] which reduces the number of particles needed to build an accurate map. It also makes use of "*Adapting the Sample Size in Particle Filters Through KLD-Sampling*"[2] which uses Adaptive Monte Carlo Localization which uses particle filters to track the pose of a robot against a given map. This project also applies "*Layered Costmaps for Context-Sensitive Navigation,*"[3] which separates costmaps according to layers while navigating. This project can be utilized to extend the functionality of "*Autonomous Navigation for Urban Service Mobile Robots*"[4] which explains the use of robots in an urban environment in presence of narrow passages, ramps, holes, steps and staircases, as well as the ubiquitous presence of pedestrians, bicycles and other unmapped, dynamic obstacles. This project can be extended further to implement "*Function Sector Based Real-Time Autonomous Navigation for Outdoor Mobile Robots Equipped with Laser Scanners*"[5] which talks about representing height and range values in 2D scan to eventually produce an improved Angle Potential Field to find optimal steering angle to avoid obstacles.

Analysis of Results

The success of the project can be determined by:

1. Comparing the similarity between the world and the learned map. The map must show all major structural elements and obstacles as they were visible in the environment. Using occupancy grid mapping we were able to map the world effectively. So, we were able to achieve 95% of the expected result. Using SLAM Gmapping, we were able to acheive 80% of expected result, due to difficulties in configuring the parameters.

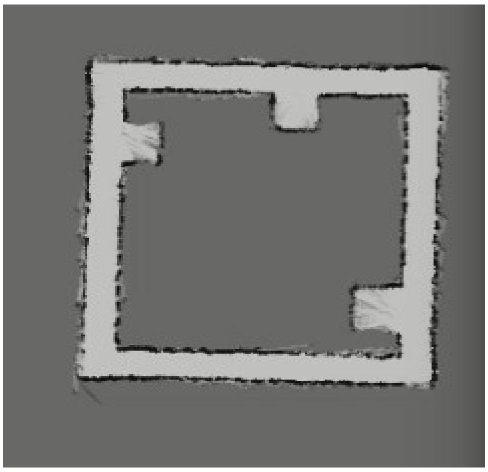


Figure-3: Occupancy grid Mapping

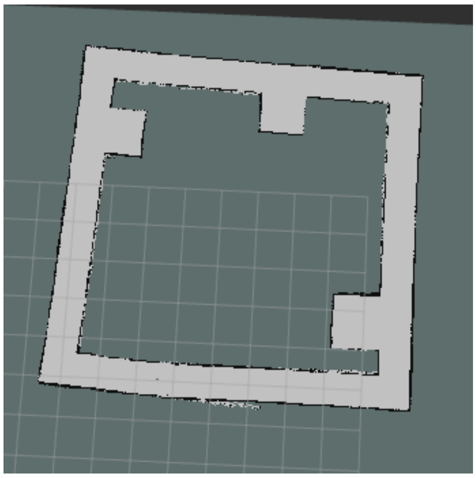


Figure-4: SLAM Gmapping

2. Exact localization of robot in a map using Adaptive Monte-carlo Localization. We configured the amcl file properly and were able to localize the robot efficiently. So, we acheived 100% of the expected result.

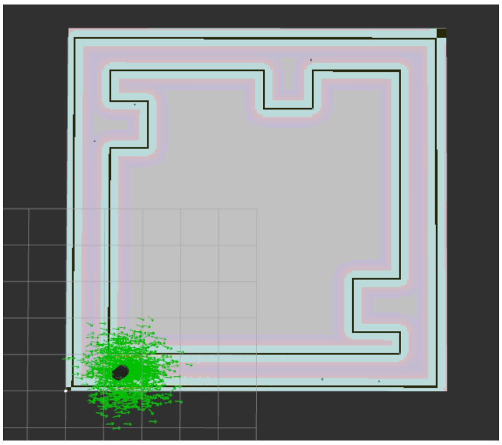
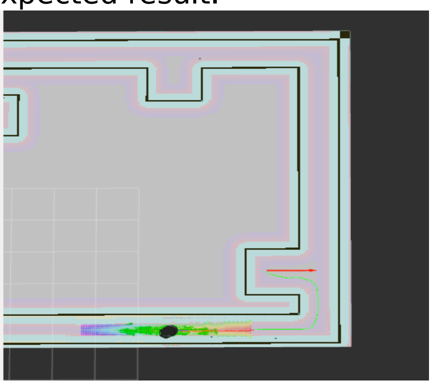


Figure-5: Localization using AMCL

3. Effective path finding and navigating the robot in the planned path with minimal deviation. We acheived this as expected and were able to navigate to a goal pose from initial pose. So, we acheived 100% of the expected result.



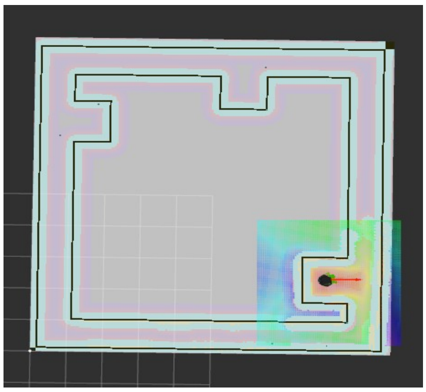


Figure-6: Navigating to a goal pose

Discussion

After implementing this project, I am able to fully understand the occupancy grid mapping, and got a simple understanding of slam gmapping. I was also able to learn about AMCL and was able to configure the amcl file with appropriate parameters. I was also able to understand how move base node works and what are all needed to be configured to use it to send a simple goals. Since, I was able to move to any location in a map using navigation stack, had got good enough understanding of it and how to use it.
If I were to redesign the project, I would be implementing the same project in Gazebo and adopt the project to this. I would also be interested to write a global planner and use it as a plugin. Since I was not fully satisfied with my implementation of slam gmapping, I would be more keen to explore its full functionality and use it appropriately.

Partnership

My contribution to the project was to map the world using slam gmapping and to configure move base using which wrote code to send simple goals to navigate the robot in a known map using localization. I also worked to collabarate both my work and my partners work. Also helped my partner with localization.

My partners contribution was to map the world using occupancy grid mapping and to localize the robot in a known map using AMCL.

Conclusions

In this project, we were able to successfully map the world using occupancy grid mapping as well as slam gmapping. Also, we were able to localization the robot in a map efficiently. Successfully configured move base node and was able to publish simple goals to move the robot from initial pose to goal pose.
The next steps for continuning the project, we would implement the same using gazebo and would also try to implement own slam algorithm to implement mapping. Also, I would try to write a own plugin for implementing the global path planner.

Acknowledgements

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References

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