Map My World Robot Project for Udacity's Robotics Software Engineer Program

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Abstract—**The Map My World Robot projects evaluate the effectiveness in using SLAM (Simultaneous Localization and Mapping) technique in mapping the robot's environment. It was found that RTAB-Map may be the best solution for implementing SLAM due to it speed and memory requirements. The previous created robot is used to generate a 2D occupancy grid and 3D octomap of two environments.**

Project one will use a supplied environment. The previous project robot is upgraded sensors to supply the necessary messages for the RTAB-Map. The robot is teleoped around the room to generate the map.

Project two uses the same robot as in project one in a individual created environment. The same technique is used to generate the robot's customized environment map.

INTRODUCTION

A Robot new to an environment or in a changing environment must have a way of navigating its environment. Although maps can be generated for a given location, these maps can quickly become outdated dues to changes in the environment. This requires the robot to be able to generate its own map as it transverse it environment.

There are many different techniques for robot generating maps. This project will use a SLAM technique called RTAB-Map (Real Time Appearance Based Mapping). A robot is able to map its environment as it travels through it surroundings. The information obtained is used to allow the robot to generate a map to use in navigation.

This project will map a given and and created simulated environment to create a 2D occupancy map and a 3D octomap using the SLAM technique known as RTAB-Map. The goal of the project is to map the environment(s) in the least number of passes with at least 3 closures.

Rtabmapviz is used to provide a visual representation of the mapping in real time. The generated map is stored in a local database that can be viewed at a later time using rtabmap-database Viewer.

BACKGROUND/FORMATION

Acquiring information to generate a map is a difficult process. The challenges exist in the following areas:

Size - the larger the size of the environment in respect to the perceptual range of the robot, the larger the challenge in generating the map

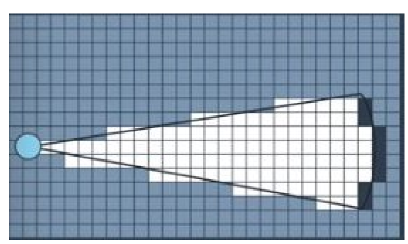
Noise – Sensor have noise. This adds to the complexity of generating a map

Perceptual ambiguity - Similar looking places visit by the robot at different times present the problem of distinguishing these locations

Cycles – Returning to a given points from multiples paths (not necessarily a straight line) present a problem for the robot to adjust. (odometry reading may differ greatly)

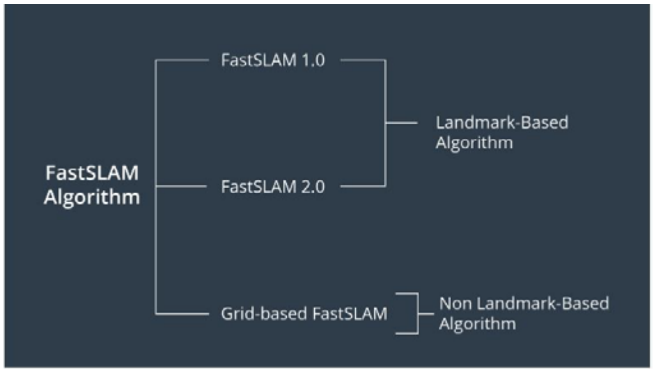
The Udacity Software Robotics program introduces the following mapping methods:

Occupancy Grid Mapping - Each grid cell of a Occupancy Grid Mapping is identified as Unknown/Undiscovered Zone, Free Zone, or Occupied.



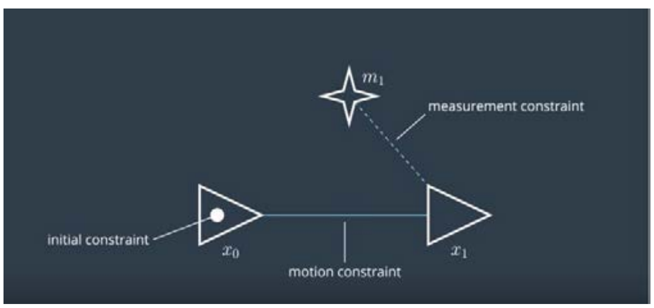
Field of a sensor used in Occupancy Grid Mapping

Grid based FastSLAM - FastSLAM(SLAM - Synchronized Location and Mapping) algorithm uses particle filter approach to solver the SLAM problem. Each particle keeps a guess of the robot trajectory. This reduces the mapping to known poses. With only known poses, it is limited to processing landmark based environments. The Grid Based FastSLAM algorithm incorporates SLAM with the MCL (Monte Carlo Localization) method and the Occupancy Grid Mapping. Incorporating Grid Based Mapping solves the problem of needing predefined landmarks.



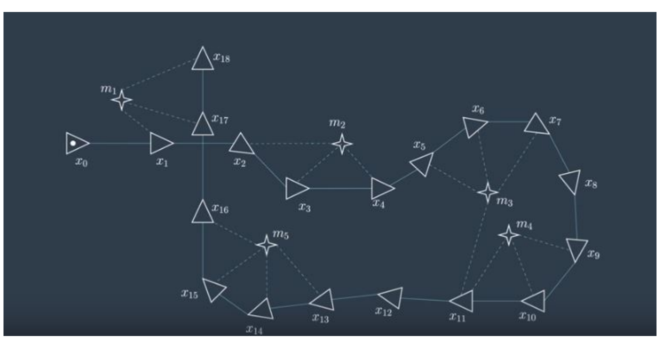
Grid based FastSLAM advantage for FastSLAM

Graph-SLAM - Graph-SLAM uses a graph based technique consisting of poses, features, motion constraints(between two poses) and measurement constraints(connection between a feature and a pose) to generate a environment map. Graph-SLAM represents poses and features as shown.



GraphSLAM poses, features, motion constraint and measurement constraint

As the robot moves and explores its environment, the map is updated.



Updated GraphSLAM map

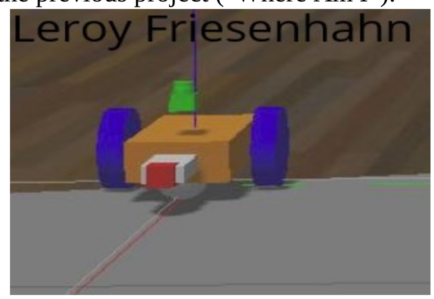
RTAB-MAP - RTAB-MAP (Real Time Appearance Based) mapping based on the GraphSLAM method. Using vision sensors, data is collected to localize the robot and map the environment. A concept called loop closure is used to determine if the robot has seen this location previously. Loop closure with Visual Bag of Words provides optimization for the process.

Loop closure detection uses working memory to limit the number of images being searched. Working and long term memory is used to decrease the search time.

RTAB-Map produces 2d occupancy grid map, 3doctomap, or 3D point cloud.

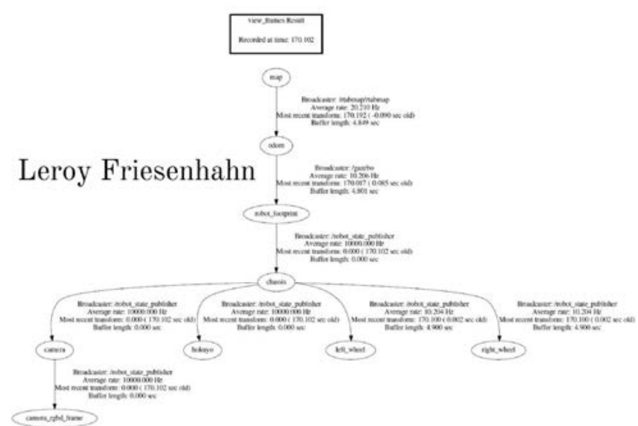
ROBOT CONFIGURATION

THE robot used for this project was based on the robot used in the previous project ("Where Am I").



Map My World Robot

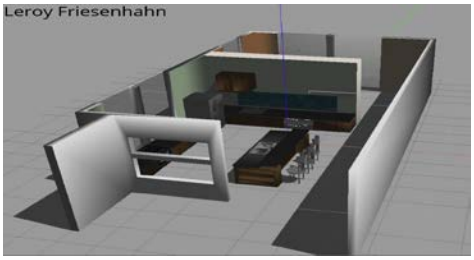
A few modifications were made to accommodate the mapping data need for this project. The main upgrade was replacing the camera with an RGB-D sensor. The RGB-D sensor measures depth which is need in the RTAB-Map method. A joint was added to assist in rotating the RGB-D sensor 180 degrees. The new joint compensated for the problem of RGB-D point cloud pointing up. The RGB-D sensor was extended from the front of the robot to give it better visibility.



Visualization of the robot frame

SCENE(S)

THE simulated robot environment(s) consisted of a supplied one - kitchen_dining.world and a customized



Kitchen_dining.world

My_new_world

one – my_new_world.world.

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The customized world was created using gazebo. A café model was selected. Additional items such as a tables, fountain, dumpster were added to the scene.

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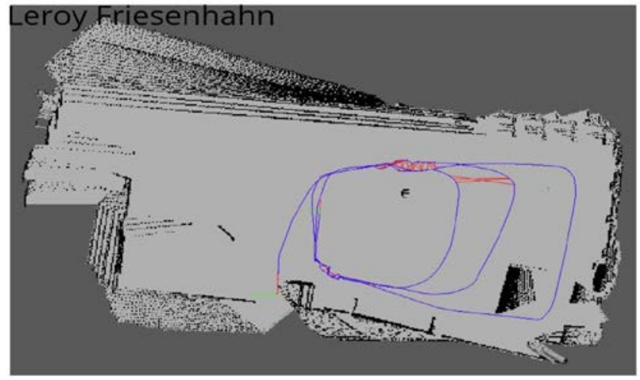
RESULTS

Mapping the environment consisted of traveling around the areas a minimum of three times. The kitchen-dining room was divided into two sections. The kitchen was mapped followed by the dining room. The customized world was mapped in one session consisting of three loops in the area.

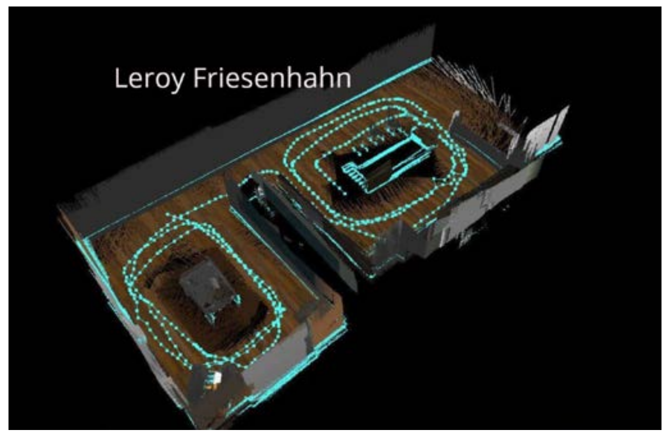
The 2D mapping of the provided environment and the created environment appear below.

2D map of provided environment



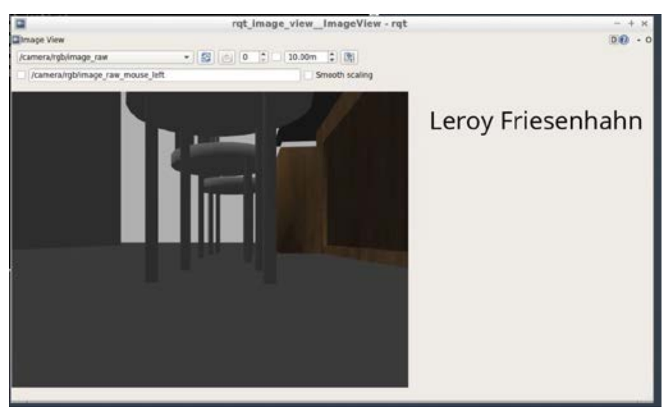
2D Map of my_new_world

The following 3D map are the results of looping thru the area at least three times.



3D map of given environment

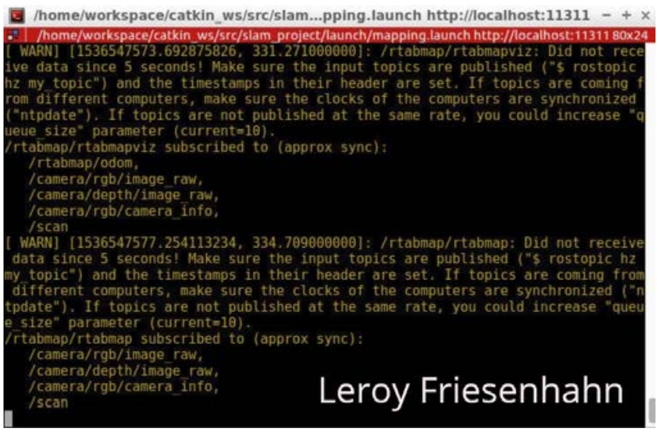
3D map of created environment



Rqt_image_view of the provided environment

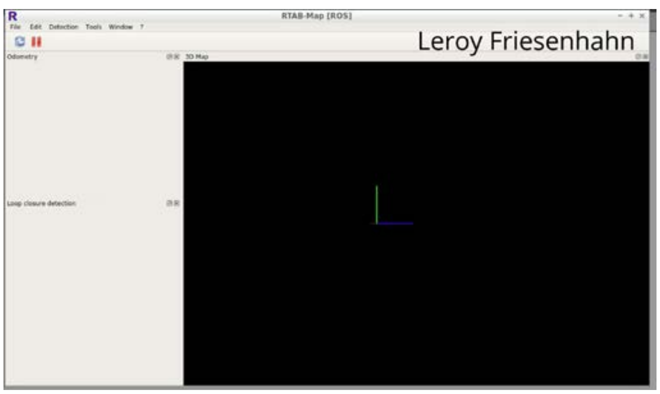
DISCUSSION

The program was completely developed and executed with no errors. The rtab_run_1 procedure was executed and ran correctly except for the mapping_1.launch procedure. The mapping_1.launch procedure included command to invoke the rtabmpviz procedure. After considerable debugging, the issues were identified as mapping of topics and the ninety degree ship in the cloud mapping between Gazebo and rtabmap solutions.



Output from topics mapping error

Output from rqt_image_view



RTAB-Map Output with cloud mapping set incorrectly

Loop closure allows to robot to identify a location to realize it has returned to a previous mapped location. Depending on the surfaces being mapped and silhouette of objects in the room, the robot loop closure may not be generated or generated prematurely.

The 3D map of the kitchen-dining was more effective than the mapping of the created café environment. The surfaces and the objects within the kitchen-dining environment were an advantage for 3D mapping algorithm. The created café environment provided several hurdles for the 3D mapping algorithm to overcome. The walls were flat with area of open windows outlined in brick. The window being identical and spaced next to each other provided a false positive for loop closure. The robot would believe it has already mapped this location and in reality it had not.

The objects in the kitchen-dining environment were featured rich. That is the object had distinct feature allowing the mapping routine to properly map the object and it location. The café environment has a minimum number of objects. The fountain object would appear to be the same from numerous angles therefore the potential of confusing the robot. The remaining objects were simple objects as compared to more complex objects within the kitchen-dining environment.

The noise generated within the café environment could be reduced by introducing addition distinct object. Placing objects in front of pattern walls (brick inlayed windows side by side) to change the mapping view.

Conclusion/Future Work

The project is finally complete. The techniques presented in this challenge are valuable in the real world. Mapping areas not accessible by a human such as a distance plant or a highly contaminated environments, makes these techniques extremely important. A considerable amount time was spend on this project and it feels as if a considerable more time is needed to fully understand all that is involved in the mapping the environment.

Additional time would be needed to optimize the placement of sensors on the robots to improve the mapping results. Enhancing the environment would provide additional information on object that decrease or increase the noise present in the mapping.

I wish to thank to my fellow classmates for assisting me in completing this project.