Autonomous Navigation for Mobile Robots

Sagar Khadse | Dr. Zack Butler

Introduction

Mobile Robots are developed to move in an environment and perform specified tasks. These are especially helpful in industrial warehouses to move around goods efficiently and also in situations where it is unsafe for humans to operate. Making mobile robots autonomous allows the robots to perform repeatative tasks efficiently and without the need of individual control over each robot. Autonomous mobile robots need to be able to sense the environment and navigate through it which can be achieved using Simultaneous Localization and Mapping (SLAM).

Most SLAM algorithms generate maps and localize within them, they do not account for how these points corelate with the real world. We can find a corelation between the generated map and the floor plans of the building to get true localization. This also allows for higher level path planning using known features of the building such as room numbers, floors and other landmarks that can be easily mapped on the floor plan. This project aims to implement such a SLAM approach on mobile robots for indoor navigation and improve localization by mapping the robot location on the real world floor plans of the building.

Hardware

Microsoft Kinect

RGB Camera : 640x480, 30fps
IR Camera : 320x240, 30fps
Max Depth : 4m

Pioneer 3-DX

- Two wheel differential drive
- Wheel encoders for odometry
- 8 front + 8 rear sonar sensors
- ROS compatible (using p2os)
- Supports velocity control
- 8-10 hours of runtime

Compute Unit

Laptop running Robot Operating System (ROS) on linux (Ubuntu).
Pentium N4200 | 8GB DDR3 RAM | 240 GB SSD

System Overview

Floor Plan Localization

Converts the 2D occupancy grid generated by RTAB-Map into a binary mask and applied computer vision techniques such as morphology and feature based template matching to map the position of the agent onto the real world floor plans of the building.

Kinect Camera

Freenect
Interfaces with the Kinect camera and publishes RGB and depth images.

Robot Chassis

P2OS
Interfaces with the robot chassis and publishes robot odometry data.

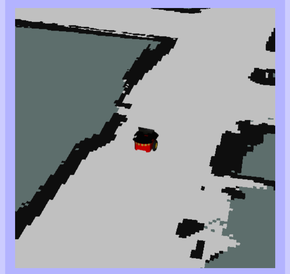
ROS

RTAB-Map

Mapping

Generates a 3D map of the environment using depht images from the camera and wheel odometry data from the robot. The RGB images are used to extract keypoints for loop closure and landmark recognition.

Localization



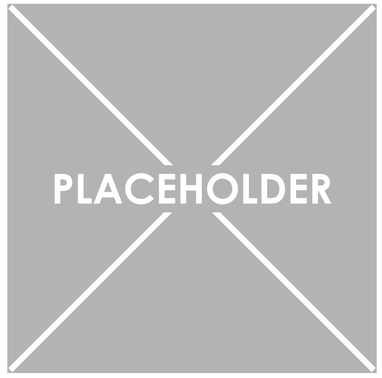
Determines the realtime position of the robot in the stored map by extracting keypoints from RGB images and matching them against the landmarks stored in the long term database updated during the mapping process.

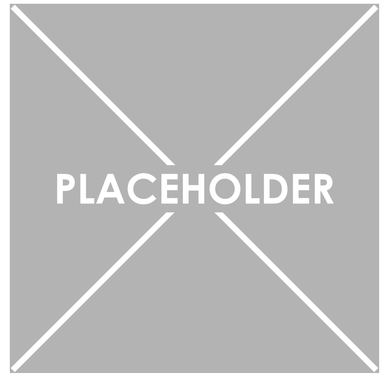
Long-Term Memeory

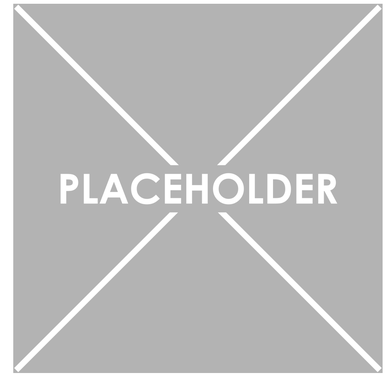
Stores local and global grid maps generated during the mapping process along with keypoints associated with landmarks. This is helpful for maintaining information across multiple mapping and localization sessions.

https://github.com/introlab/rtabmap

Results







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Conclusion

Future Work

[1] Sagarnil Das. "Simultaneous Localization and Mapping (SLAM) using RTAB-MAP". In: (2018). DOI: 10.48550/ARXIV.1809.02989. URL: https://arxiv.org/abs/1809.02989.

[2] Ilmir Z. Ibragimov and Ilya M. Afanasyev. "Comparison of ROS-based visual SLAM methods in homogeneous indoor environment". In: *2017 14th Workshop on Positioning, Navigation and Communications (WPNC)* (2017), pp. 1–6.

[3] Mathieu Labbé. "RTAB-Map as an Open-Source Lidar and Visual SLAM Library for Large-Scale and Long-Term Online Operation". In: 2018.