Develop a 2D Occupancy Grid Map of a Room using Overhead Cameras

Alphonsa Abraham,Navneeth Krishnan,Sidharth V Menon,Vyshnavi Dipu

Saintgits Group of Institutions

July 14, 2024

Introduction

- The use of overhead cameras for indoor mapping and monitoring has become important due to their ability to provide comprehensive, real-time views of a room to detect and track object to identify the occupied and unoccupied spaces within the room.
- This project focuses on developing a 2D occupancy grid map of a room using overhead cameras.This approach has wide-ranging applications, in robotics for navigation, in smart building management for optimizing the space usage, and in security systems for monitoring unauthorized access.

Unique Idea Brief

1. Phase 1 : Static Environment Mapping
   - Arrange four overhead RGB cameras in a 2x2 pattern with overlapping fields of view.
   - Capture and stitch images from the cameras and merge the images into a single panoramic view.
   - Convert the stitched images into a 2D occupancy grid map, marking occupied and free spaces.
2. Phase 2 : Dynamic Environment Mapping
   - Continuously capture and process images to dynamically update the occupancy grid map as objects move.
   - Capturing images at 1s intervals and updating the positions using cv2's capture method works without the need for a model to be trained and semantic labels. It automatically adjusts the image that is sent to the Occupancy Grid Map generator to update the Grid Map

Unique Idea Brief

1. Simulation and Comparison in Gazebo
    - Add an AMR equipped with an onboard camera or LiDAR in the Gazebo environment and Implement SLAM using the ROS2 navigation stack to generate an occupancy grid map from the AMR's perspective.
    - Compare the map generated by the overhead cameras with the map created by the AMR using SLAM.

Process Flow

- Setup Cameras: Install and calibrate four overhead RGB cameras in a 2x2 grid.
- Capture and Stitch Images: Simultaneously capture images, detect features, and stitch them into a panoramic view.
- Generate Occupancy Grid: Convert to grayscale, apply thresholding, and create a 2D occupancy grid map.
- Real-time Updates: Continuously capture images, detect changes, and update the grid map in real-time.

Process Flow

- Object Detection: Implement object detection and add semantic labels
- Gazebo Setup: Model the room, objects, and cameras in Gazebo.
- AMR SLAM Mapping: Add AMR with onboard camera use ROS2 for SLAM
- Compare Maps: Compare overhead camera map with AMR's SLAM map for accuracy and effectiveness.

Architectural Diagram

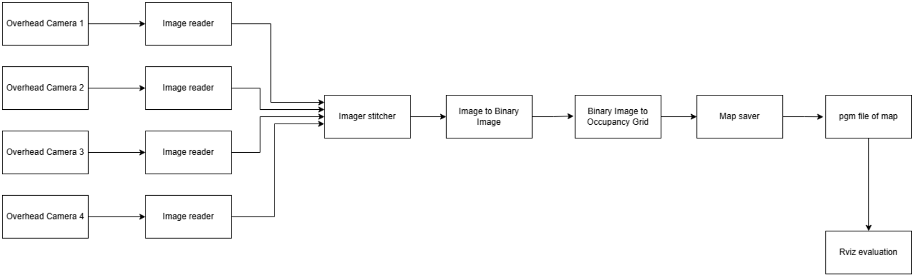

Figure: Caption

Technologies used

- Ubuntu 20.04 Focal Fossa
- ROS2 Foxy
- Turtlebot3
- Rviz
- OpenCV(cv2)
- Gazebo

Evaluation

- The main component used in evaluation was Rviz and we used it to compare distances between key points on the map of the house provided. The measurements came out to be as below:

Connection	Grid map Length
1	4.84m
2	5.63m
3	6.84m
4	7.24m
5	9.28m
6	6.86m
7	5.76m
8	3.73m

:

Team members amd contributions

- Navneeth Krishnan and Vyshnavi Dipu : Gazebo simulation environment, Initial image acquisition and stitching simulation,Integration with ROS2 Navigation stack
- Alphonsa Abraham and Sidharth V Menon : Real-time Image Processing Simulation,Object Detection and Semantic Labeling Simulation,Comparison and Analysis Simulation,Final Documentation and Report

Conclusion

- This project successfully demonstrated the creation of a 2D occupancy grid map using simulated overhead cameras in a virtual environment. By integrating image stitching, real-time image processing, and object detection simulations, we achieved a dynamic map that reflects changes in the environment.
- Comparison with a simulated AMR's SLAM-generated map highlighted the map's accuracy and suitability for path-planning and navigation tasks.