COLLABORATIVE PROJECT WITH INTEL

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

PROJECT TITLE :“Develop a 2D Occupancy Grid Map of a Room using Overhead Cameras”

University Name: GITAM University

Team Name : The Prefect Mix

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PROBLEM STATEMENT:“Develop a 2D Occupancy Grid Map of a Room using Overhead Cameras”

PROJECT OBJECTIVE:

*The objective of this project is to create a 2D occupancy grid map of an indoor environment using overhead infrastructure cameras. This map will be used to enhance the navigation capabilities of Autonomous Mobile Robots (AMRs).

*The occupancy grid map will provide a detailed representation of the environment, identifying both static and dynamic obstacles, thereby enabling AMRs to navigate safely and efficiently.

PROBLEM DEFINITION: This project aims to enhance the navigation capabilities of autonomous mobile robots (AMRs) in indoor environments by creating a detailed 2D occupancy grid map using overhead cameras. Similar to the maps generated by AMRs using ROS2-based SLAM algorithms, this map will provide a clear representation of the surroundings, identifying static obstacles such as chairs, tables, and boxes, while dynamically updating to reflect changes like the movement of furniture.

The primary challenge is to maintain the accuracy of the map despite variations in lighting, perspective distortions, and the dynamic nature of indoor spaces. Addressing this challenge will improve AMRs' ability to autonomously plan paths, avoid collisions, and navigate efficiently in environments with unpredictable conditions. This capability is essential for applications such as warehouse logistics, automated cleaning, and healthcare assistance, where AMRs must operate safely and effectively alongside humans.

Unique Idea Brief (Solution):

Environment Mapping for AMR navigation:

- Autonomous Mobile robots (AMRs) use on-board sensors to map the environment using SLAM.
- Map is then used for path-planning, obstacle avoidance and navigation
- Limitations of SLAM mapping:
    - Limited FoV: can only map area in front of AMR – cannot map entire environment in one shot, in real-time
    - Dynamic changes or obstacles not tracked until they come in view of the AMR
    - Each AMR maps separately – no common map

Camera Installation: We installed four overhead RGB cameras in a 2x2 pattern with overlapping fields of view to capture comprehensive room data.

Image Capture: Captured high-resolution images of the room, focusing on static objects like chairs, tables, stools, and boxes

The images captured are as follows:

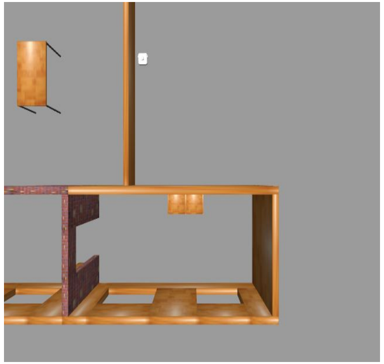
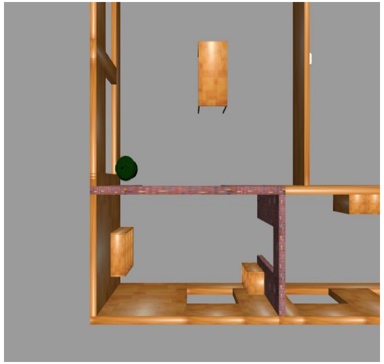
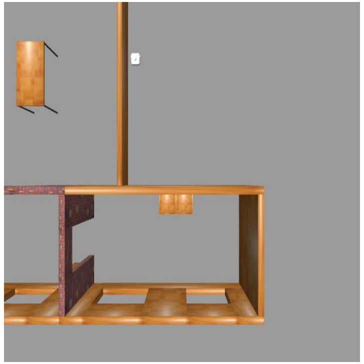
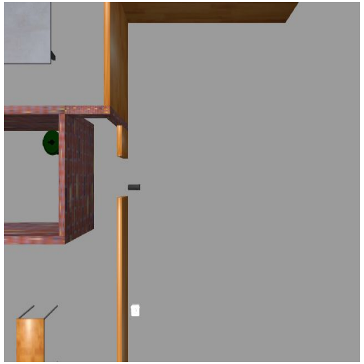
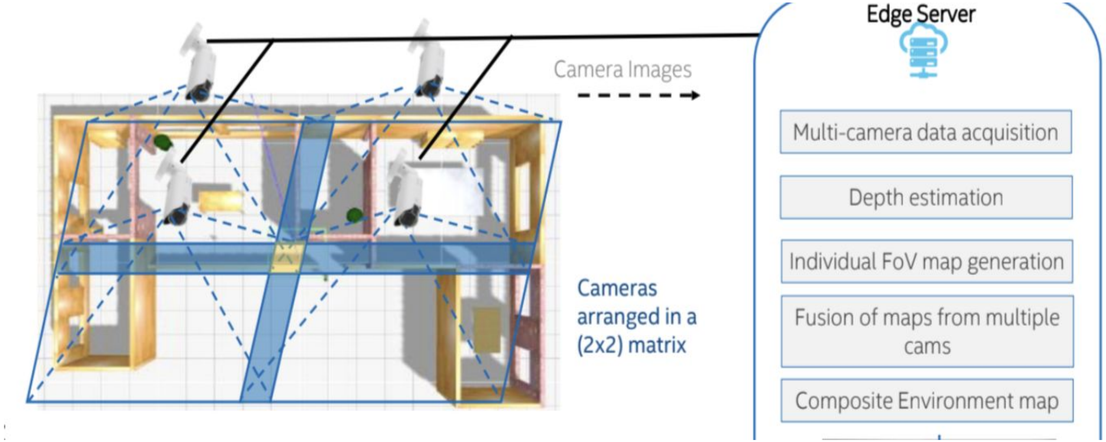
   

Image Stitching: Used robust image stitching algorithms to combine images from the four cameras into a single panoramic view of the room.

Concept & Motivation: Mapping with infrastructure cameras

Demonstrate (in simulation) accurate and fast mapping (2D occupancy grid map) of indoor environments for AMR navigation using a network of RGB cameras in the infrastructure.

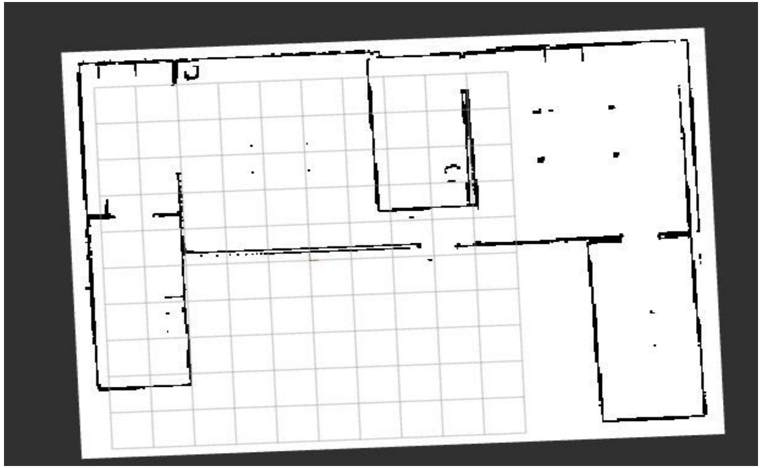
HOW IT ACTUALLY SEEMS TO LOOK LIKE:



SOFTWARE USED:

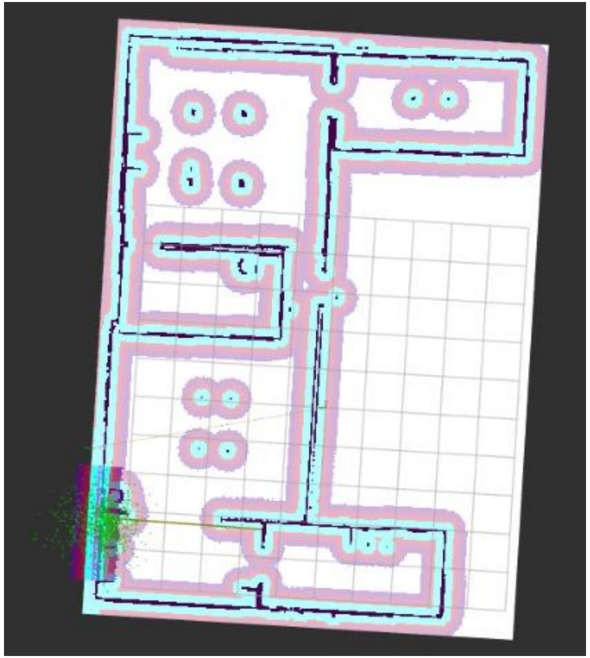
*Gazebo is a powerful robot simulation tool that integrates with ROS to create realistic simulations for testing and development.

*Robot Operating System,It allows developers to focus on high-level functionality by offering a structured approach to robotics software development,simulation, navigation, and control.

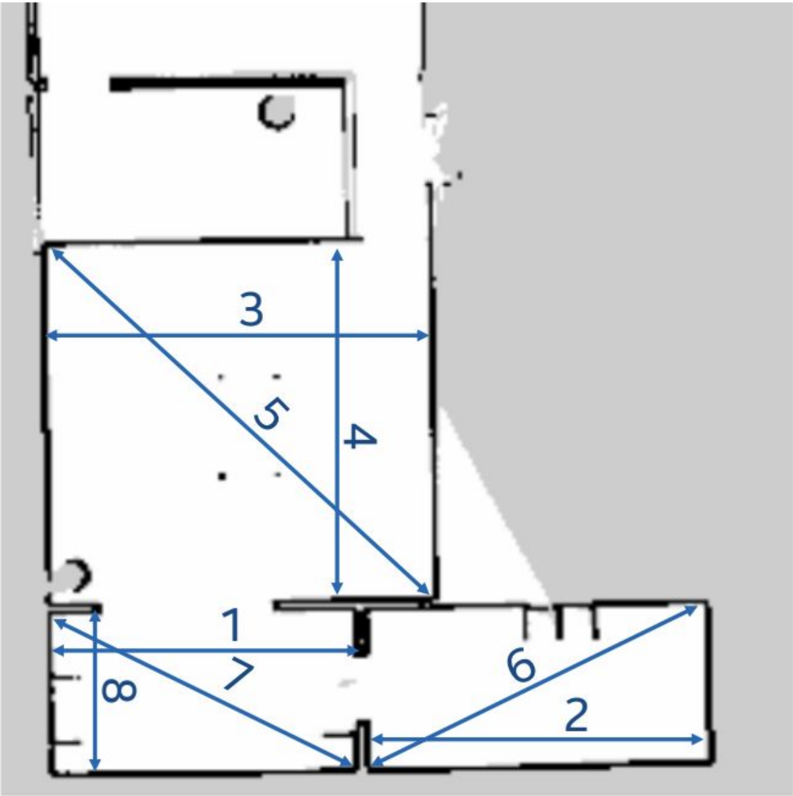


Ground map from Gazebo :

Generated Map read by the robot:



Reference map and 8 Key-points for measurement



1 – ? m
2 – ? m
3 – ? m
4 – ? m
5 – ? m
6 – ? m
7 – ? m
8 – ? m

Error estimates of the mapping algorithm:

How to evaluate the generated map?

Using Rviz to find distance between key points and the data we got was mentioned below:

Generated distance	Grounded truth distance	Percentage error(%)
4.5	5.0	5.2
6.0	6.5	5.023
7.0	7.0	0.0
9.5	10.0	5.03
10.5	11.5	10.023
7.5	9.5	25.7
3.5	5.0	15.4

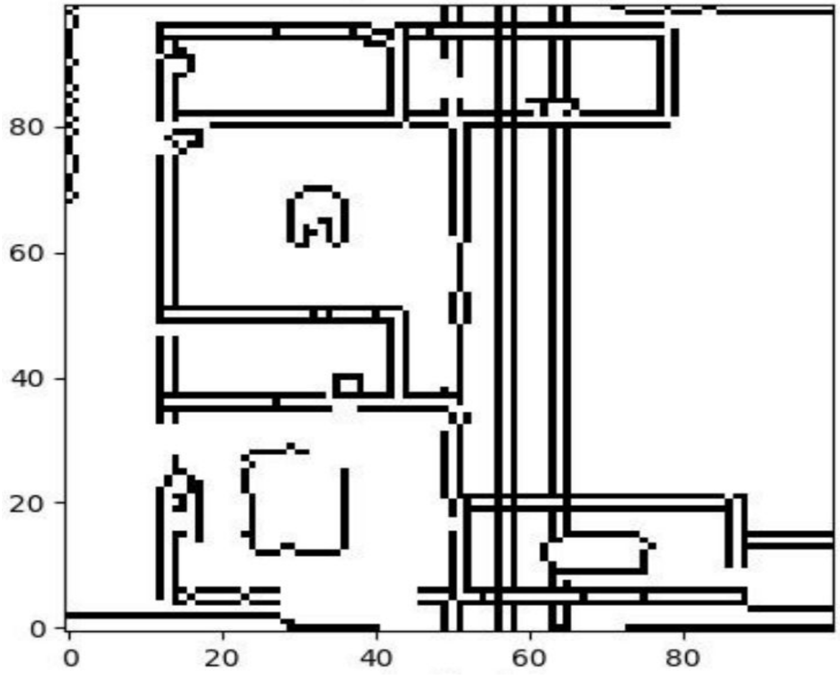
The conclusions are as follows:

- Average Absolute Error: 1.3125
- Minimum Absolute Error: 0.0
- Maximum Absolute Error: 4.0

Overview Steps of the project:

1. **Initialize Project**
2. **Set Up Hardware and Software Environment**
3. **Load Predefined Environment in Gazebo**
4. **Configure ROS Nodes for Image Capture**
5. **Capture Images from Overhead Cameras**
6. **Implement Image Stitching Algorithm**
7. **Preprocess Captured Images**
8. **Generate 2D Occupancy Grid Map**
9. **Validate Grid Map Accuracy**

Final Output 2D grid map :



Team members and contribution:

Gowhasri.D : Has contributed in the report,repo in the github and did the image stitching work.

Sai Bhargavi.D : Has contributed with the software download and working process.

Sadia Tasneem : Has contributed with the working of cameras, worked with ubuntu and with the working process.

Conclusion:

Developing a 2D occupancy grid map using overhead RGB cameras has been an incredibly valuable experience. This project provided practical exposure to SLAM algorithms, improved our understanding of dynamic environment mapping, and enhanced our skills in integrating hardware and software. By creating precise and adaptable maps, we showcased the practical potential of robotics and autonomous systems. This project not only enriched our technical expertise but also deepened our appreciation for the practical applications of advanced technologies. Our systematic approach supports the creation of effective navigation solutions and contributes to the advancement of autonomous robotic systems.

Thank You