INTEL UNNATI INDUSTRIAL TRAINNING PROGRAM

PROJECT REPORT

TEAM ELECTRON

INDEX

PROBLEM DEFINITION

OBJECTIVE:

- To create a 2D occupancy grid map of an indoor environment using overhead infrastructure cameras, which can be used for AMR (Autonomous Mobile Robots) navigation.

CHALLENGES WITH CURRENT SLAM SOLUTIONS:

- **Limited Field of View:** On-board sensors of AMRs can only map the area in front of them.
- **Dynamic Obstacles:** Changes or obstacles are not tracked until they come into the AMR's
- **Separate Maps:** Each AMR generates its own map, leading to a lack of a unified view.

GOAL:

Develop an accurate and real-time mapping solution that uses multiple RGB cameras placed overhead to provide a comprehensive and dynamic view of the environment.

SOLUTION APPROACH

- **The solution involves using four overhead RGB cameras arranged in a 2x2 matrix to capture images of the entire environment.**
- **These images are processed and stitched together to create a composite 2D occupancy grid map.**

NOVELTY OF THE APPROACH

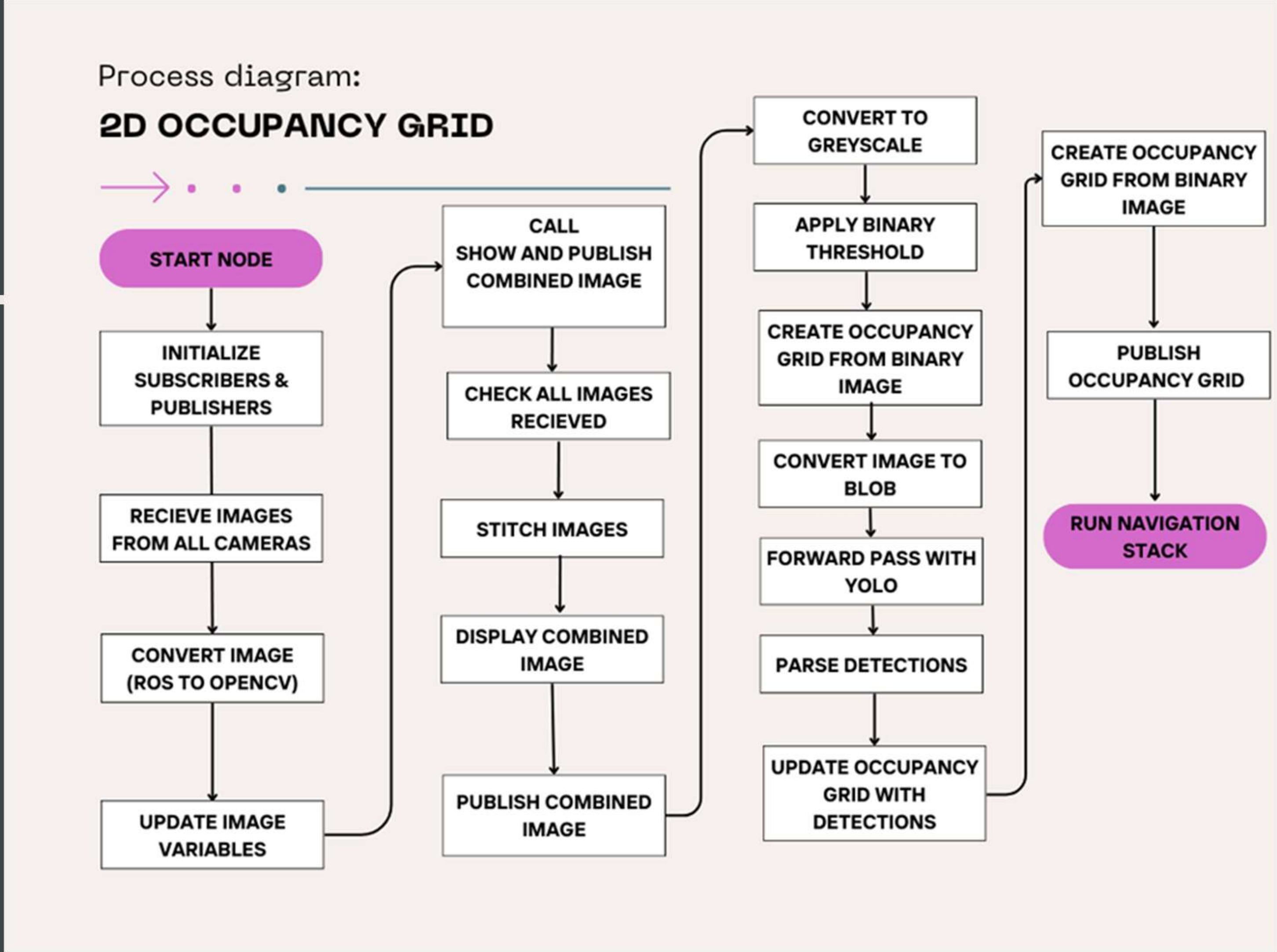
COMPARISION WITH PRIOR METHODS

- Traditional SLAM methods use on-board sensors like LiDAR and depth cameras.
- These methods have limited FoV and struggle with dynamic environments.

NOVELTY

- **Full Environment Coverage:** The overhead cameras provide a complete view of the environment in one shot.
- **Real-Time Mapping:** Moving obstacles are tracked in real-time.
- **Cost-Effective:** Reduces the need for expensive sensors on AMRs.
- **Enhanced Coordination:** Facilitates better path planning and coordination for multiple robots.

METHODOLOGY



METHODOLOGY

Simulation Setup:

- Utilize ROS2 and Gazebo to simulate the environment.
- Place four cameras in a 2x2 matrix at a height of ~8 meters.

Image Acquisition:

- Set up ROS2 topics to stream images from the cameras.
- Write a Python script to subscribe to the camera topics and acquire images.

Image Processing and Calibration:

- Implement algorithms for multi-camera calibration.
- Align the FoVs of all cameras.

METHODOLOGY

Depth Estimation and Map Fusion:

- Process images to estimate depth.
- Fuse individual maps to create a composite 2D occupancy grid map.

Validation:

- Compare the generated map with the ground truth map from Gazebo.
- Measure positions/distances between key points and calculate error estimates.

LIMITATIONS

- Computational Complexity: Image processing and map fusion require significant computational resources.
- Latency: The algorithm's performance needs to be optimized to reduce latency.

ADVANTAGES

- Accuracy: Provides a detailed and accurate map of the environment.
- Scalability: Can be scaled to cover larger areas by adding more cameras.
- Real-Time: Tracks dynamic changes and obstacles in real-time.
- Cost-Effective: Reduces the cost of AMRs by eliminating the need for expensive on-board sensors

RESULTS

Fused Map of the Environment:

- Composite Map: The generated 2D occupancy grid map accurately represents the environment.
- Comparison: The map is compared with the ground truth map from Gazebo.

Computational Latency:

- Test System: Intel i7 (12700H) computer.
- Latency Measurement: Time required to process image frames and create a composite map.
- Results: Latency: 900ms – 1200ms per occupancy map.

GitHub Repository

- Repository Link: GitHub Repository

ERROR ESTIMATES

KEYPOINT	GROUND TRUTH(m)	MEASURED BY CAMERAS (m)	DIFFERENCE(m)	ERROR(%)
1	4.16	4.25	0.09	+2.16%
2	4.64	4.80	0.16	+3.44%
3	5.23	5.44	0.21	+4.01%
4	4.82	5	0.18	+3.73%
5	7.1	7.42	0.32	+4.5%
6	5.01	5.15	0.14	+2..79%
7	4.56	4.66	0.10	+3.8%
8	2.14	2.22	0.08	+3.73%

LEARNINGS

- **ROS2 and Gazebo:** Gained hands-on experience with simulation and robot operating systems.
- **Image Processing:** Improved understanding of multi-camera calibration and image fusion techniques.
- **Real-Time Systems:** Learned about the challenges and solutions for real-time mapping and navigation.

CONCLUSION

- **The developed solution successfully creates a 2D occupancy grid map using overhead cameras, providing a comprehensive and real-time view of the environment.**
- **The approach is cost-effective, scalable, and accurate, addressing the limitations of traditional SLAM methods.**

THANK YOU

TEAM ELECTRON

9533112237

kjagannathsagar@gmail.com

GITAM UNIVERSITY