SLAM Benchmarking Analysis Report

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Comparison Summary

Metric	Run 1	Run 2	Run 3
Health Status	■ VALID	■ VALID	■ VALID
SLAM Algorithm	slam_toolbox_sync	cartographer_2d	gmapping
Dataset	tb3_sim_explore_modeA	tb3_sim_explore_modeA	tb3_sim_explore_modeA
Duration (s)	188.00	181.99	181.14
ATE RMSE (m)	0.0130	0.0151	0.0197
Coverage (%)	12.5	15.2	11.5
Acc. Coverage (%)	54.6	60.6	14.5
Occupancy IoU	0.1457	0.0079	0.1695
Structural Similarity	0.9175	0.8517	0.9212
Wall Thick. (cm)	9.70	13.54	10.28
Max RAM (MB)	1212.6	1068.1	1027.5
Max CPU (%)	196.9	1476.6	1284.8
Lidar Noise (std)	0.0000	0.0000	0.0000
Max Range (m)	10.0	10.0	10.0
Speed Scale (%)	100	100	100

Guide to Metrics

ATE RMSE (Absolute Trajectory Error): Measures the global consistency of the trajectory. Lower is better. Values < 0.1m indicate high precision; > 0.5m suggest significant drift or SLAM failure.

Coverage (%): Percentage of the Ground Truth free space that was successfully mapped as free or occupied. Higher is better.

Acc. Coverage (%): Coverage restricted to the area actually visited/approached by the robot. Useful to judge exploration efficiency independent of mission completeness.

Occupancy IoU (Intersection over Union): Measures how well the estimated obstacles match the Ground Truth walls. Ranges 0 to 1. 1.0 is perfect alignment. < 0.5 usually implies map distortion or offset.

SSIM (Structural Similarity): Visual similarity between generated map and Ground Truth. 1.0 is identical. Captures general structure better than pixel-wise metrics.

Wall Thickness: Average thickness of mapped walls. Thicker walls than reality (e.g. > 15cm) indicate 'blur' or uncertainty in the map.

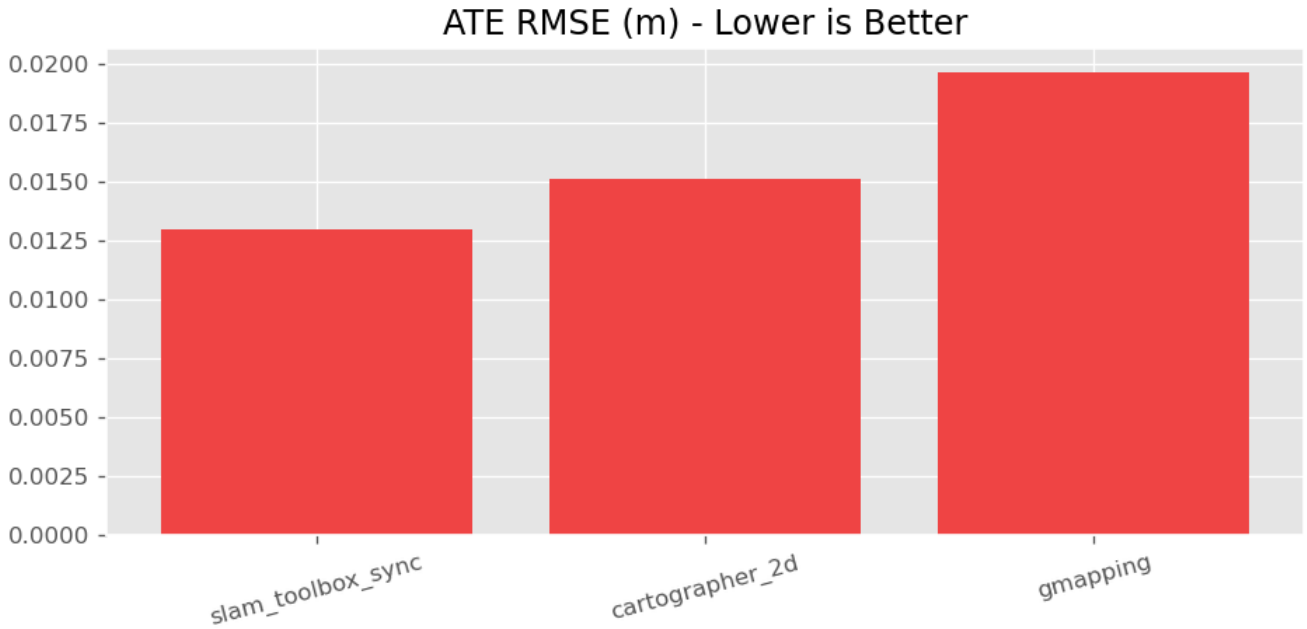
Duration (s): Total time to map the environment. Lower is better for efficiency, assuming map quality is maintained.

Max CPU (%): Peak processor usage during the run. Lower indicates better computational efficiency, critical for onboard operations.

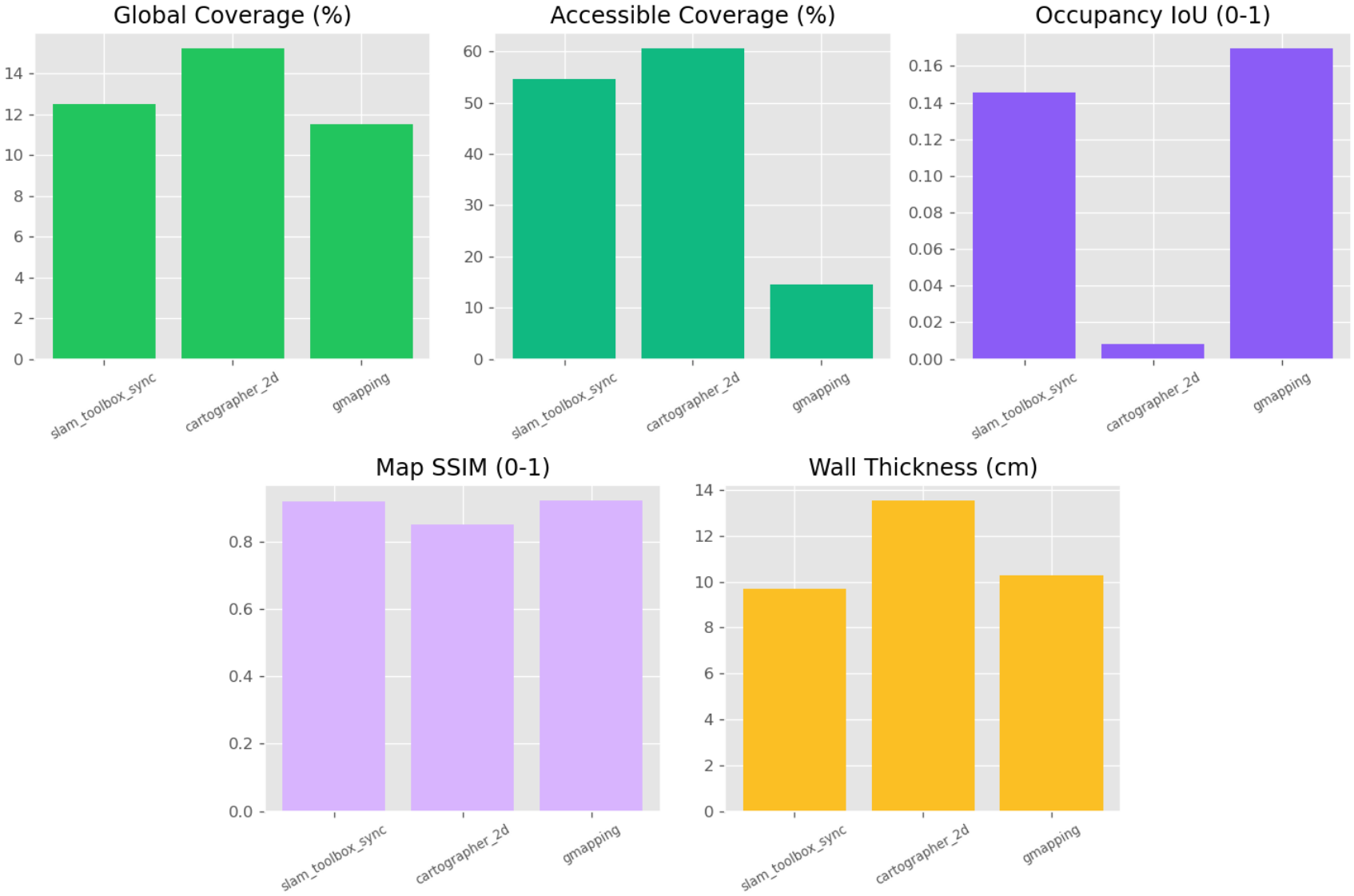
Max RAM (MB): Peak memory usage. Lower is better, especially for constrained hardware platforms.

Metrics Visualization

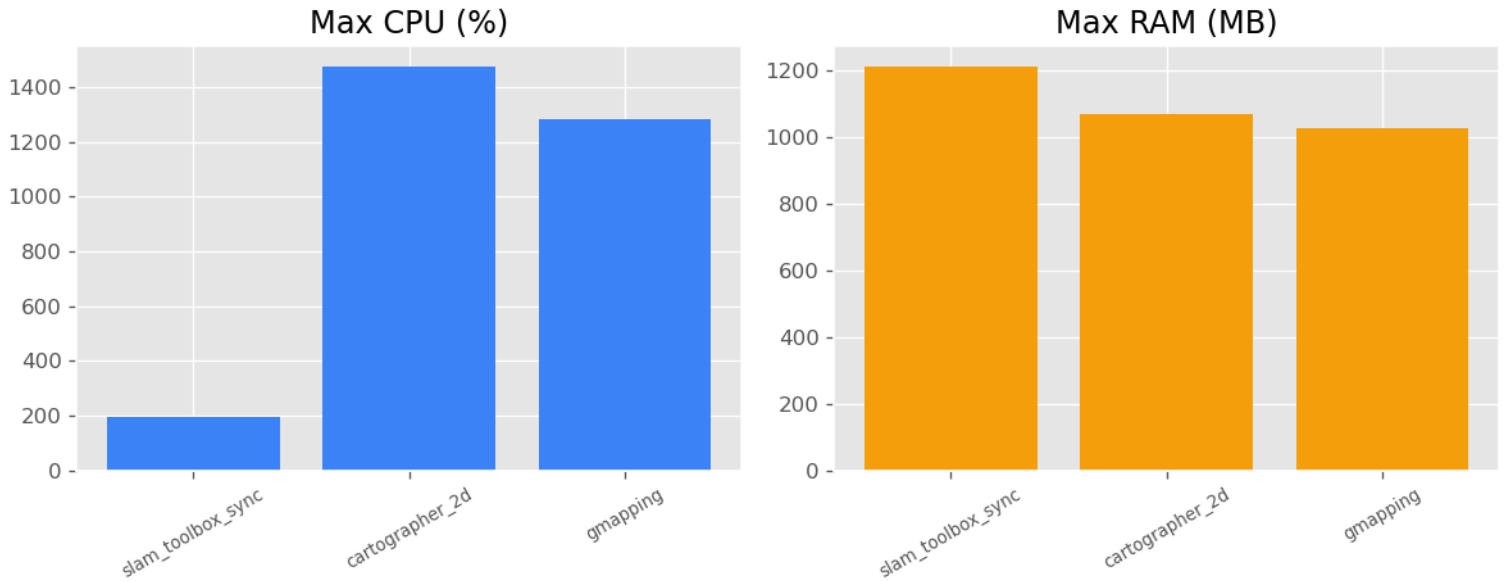
1. Trajectory Precision



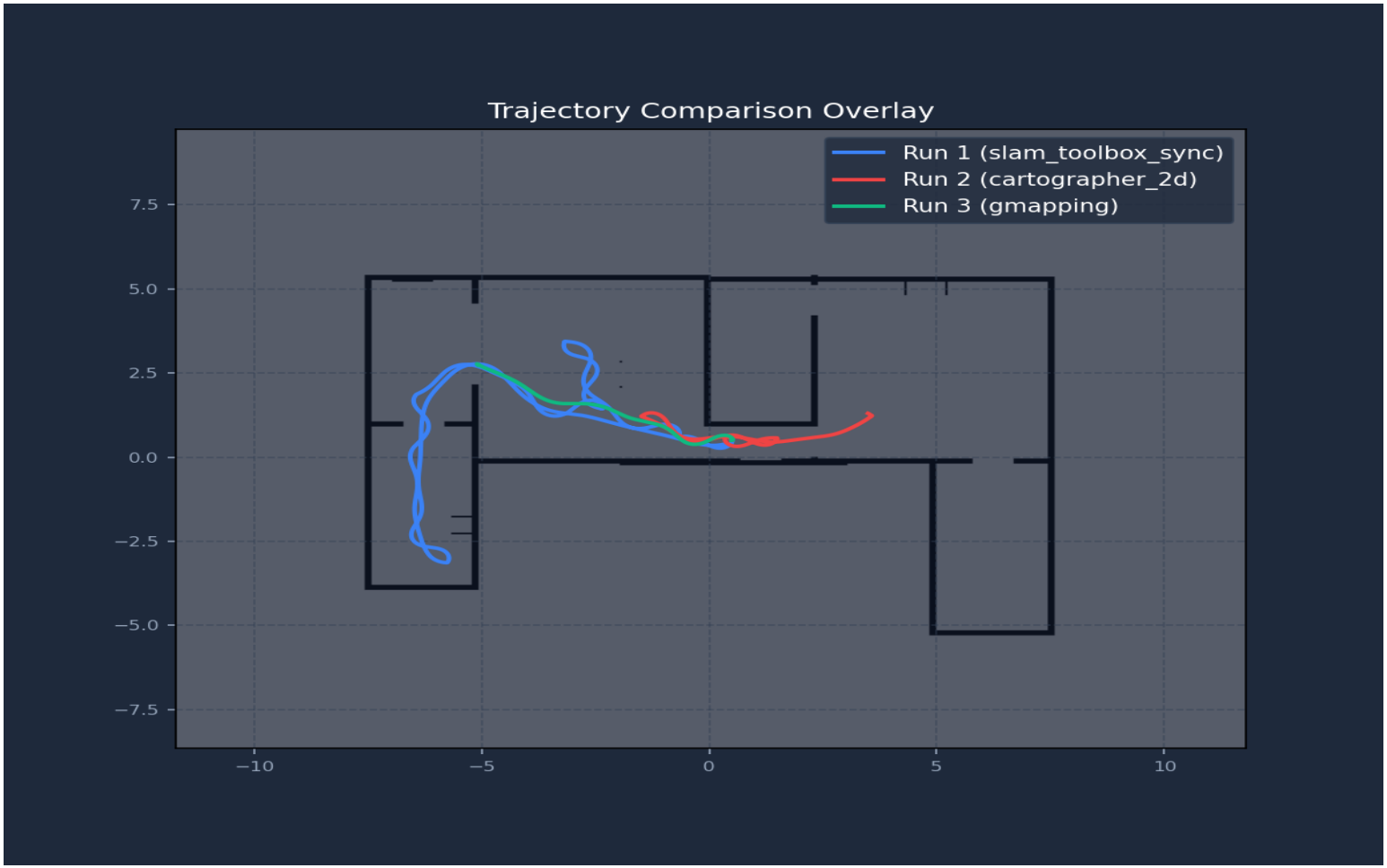
2. Map Quality


Global Coverage (%)
0
2
4
6
8
10
12
14
slam_toolbox_sync
cartographer_2d
gmapping
Accessible Coverage (%)
0
10
20
30
40
50
60
slam_toolbox_sync
cartographer_2d
gmapping
Occupancy IoU (0-1)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
slam_toolbox_sync
cartographer_2d
gmapping
Map SSIM (0-1)
0.0
0.2
0.4
0.6
0.8
slam_toolbox_sync
cartographer_2d
gmapping
Wall Thickness (cm)
0
2
4
6
8
10
12
14
slam_toolbox_sync
cartographer_2d
gmapping

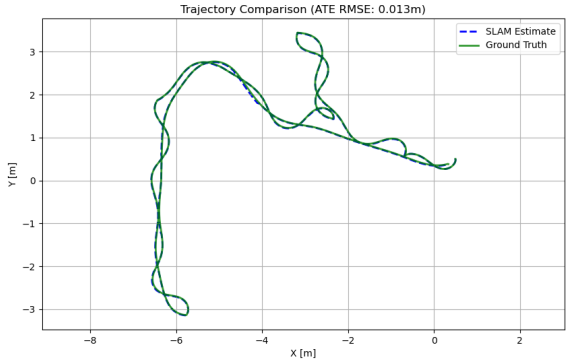
3. System Consumption



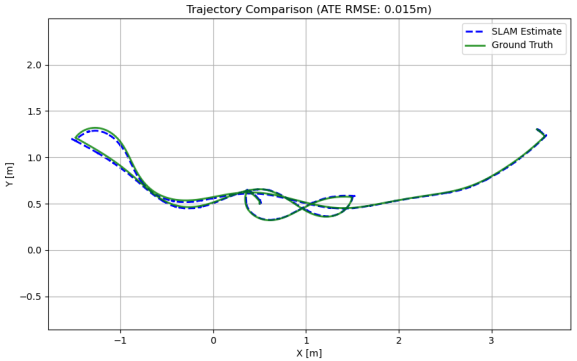
Trajectory Visualization


Trajectory Comparison Overlay
Run 1 (slam_toolbox_sync)
Run 2 (cartographer_2d)
Run 3 (gmapping)
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
−10
−5
0
5
10

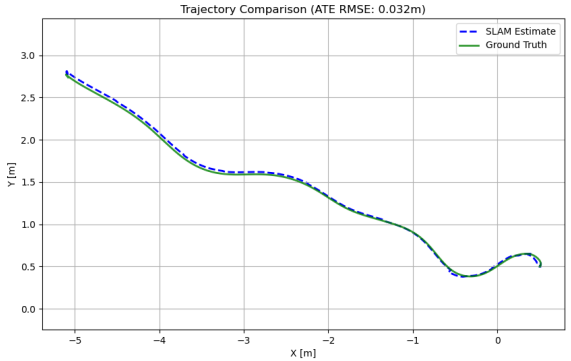
Trajectory Analysis (GT vs Estimate)



slam_toolbox_sync (ATE: 0.013m)



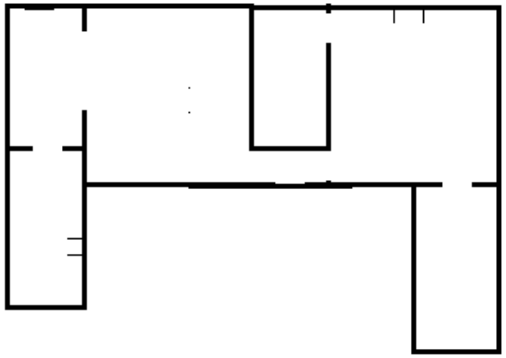
cartographer_2d (ATE: 0.015m)



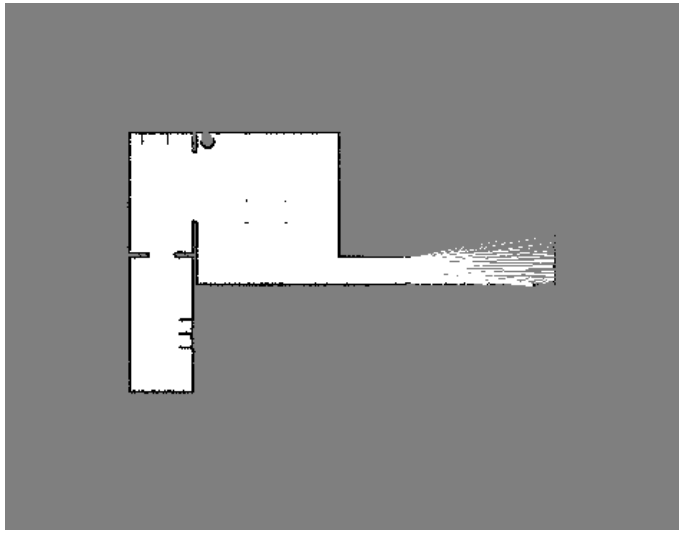
gmapping (ATE: 0.020m)

Map Reconstruction Comparison

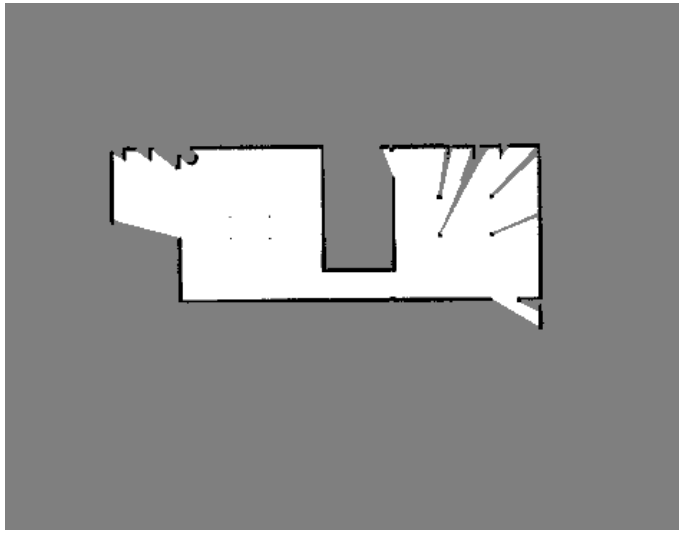
Ground Truth Map



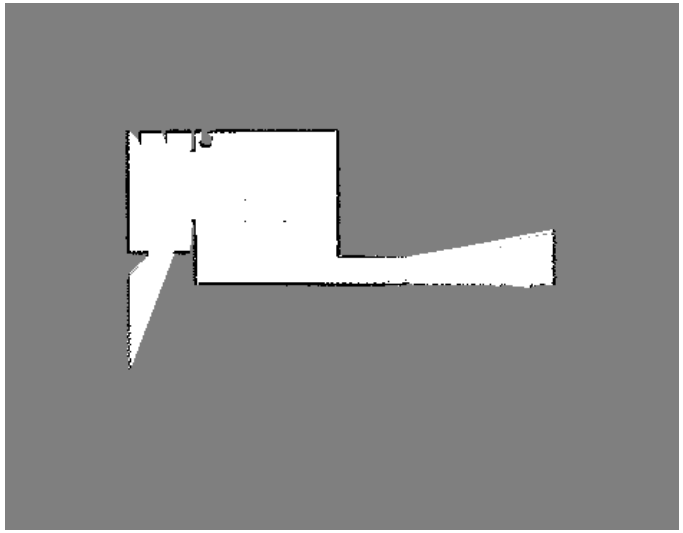
Generated Maps



slam_toolbox_sync (IoU: 0.15)



cartographer_2d (IoU: 0.01)



gmapping (IoU: 0.17)

Detailed Analysis: Run 1

`ID: 2026-01-05_19-14-03__tb3_sim_explore_modeA__slam_toolbox_sync__seed0__r0`

Performance Summary:
The algorithm **slam_toolbox_sync** demonstrated **excellent localization accuracy** with negligible drift. Exploration was **minimal**. The map quality is **poor**, with little overlap with the actual environment.

Detailed Analysis: Run 2

`ID: 2026-01-05_18-59-51__tb3_sim_explore_modeA__cartographer_2d__seed0__r0`

Performance Summary:
The algorithm **cartographer_2d** demonstrated **excellent localization accuracy** with negligible drift. Exploration was **minimal**. The map quality is **poor**, with little overlap with the actual environment.

Detailed Analysis: Run 3

`ID: 2026-01-05_18-56-30__tb3_sim_explore_modeA__gmapping__seed0__r0`

Performance Summary:
The algorithm **gmapping** demonstrated **excellent localization accuracy** with negligible drift. Exploration was **minimal**. The map quality is **poor**, with little overlap with the actual environment.