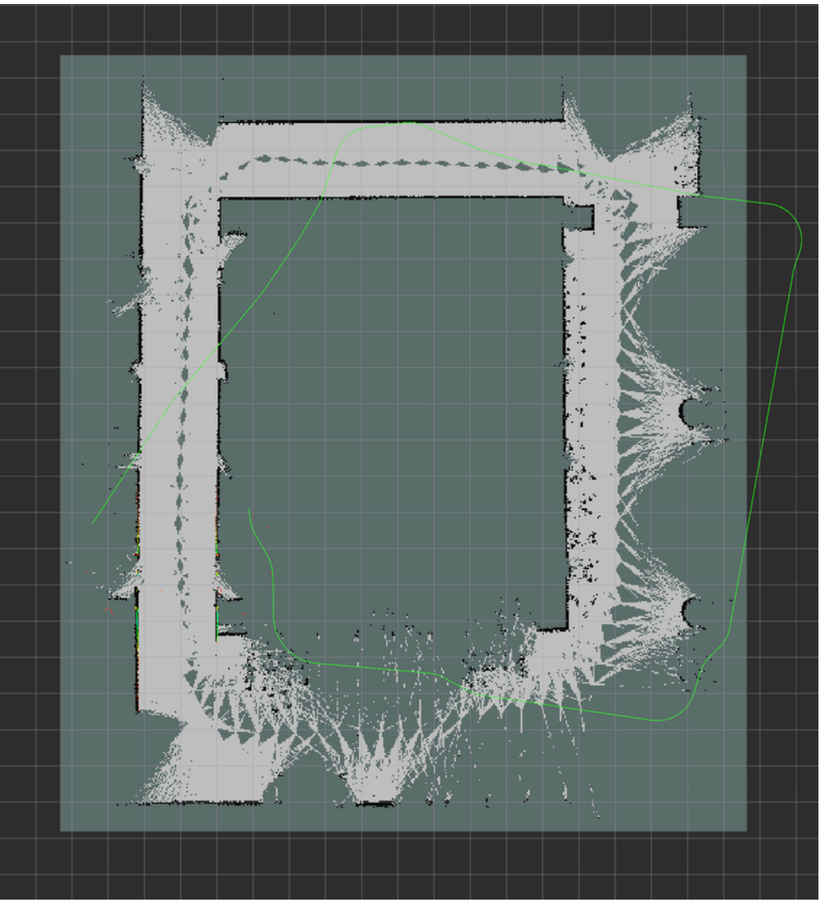
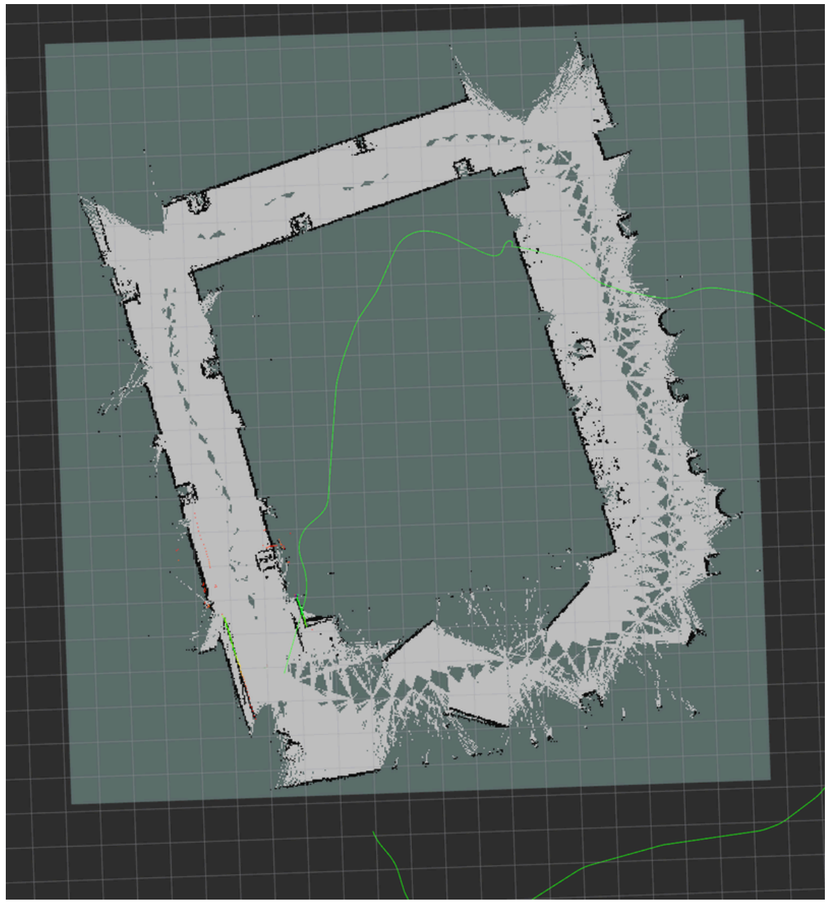
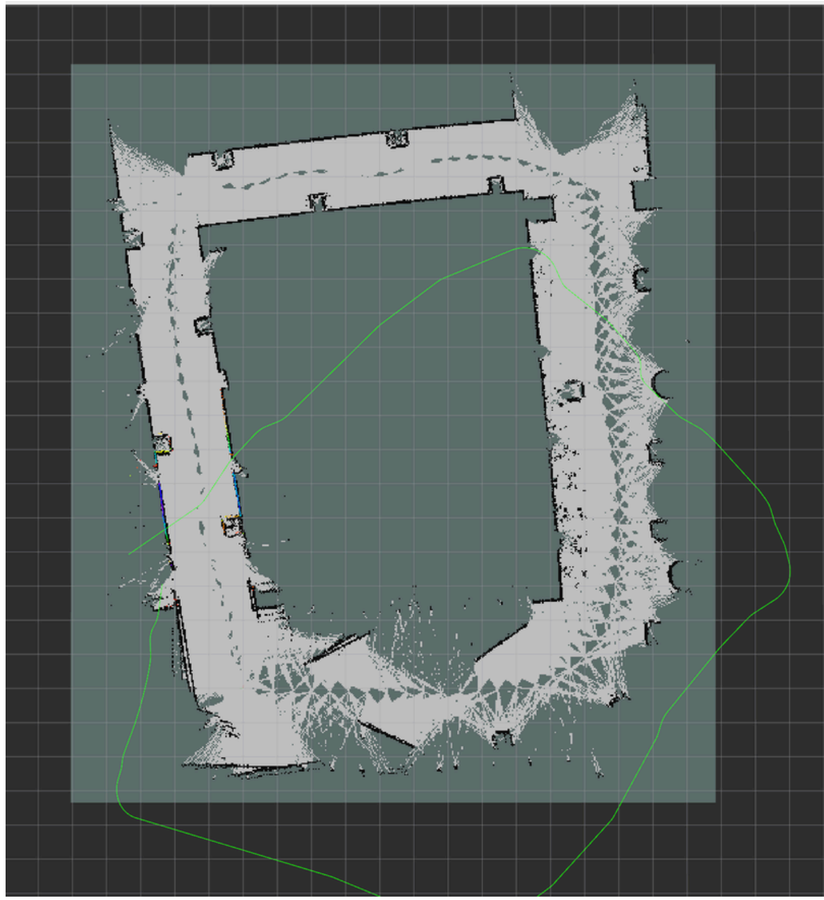


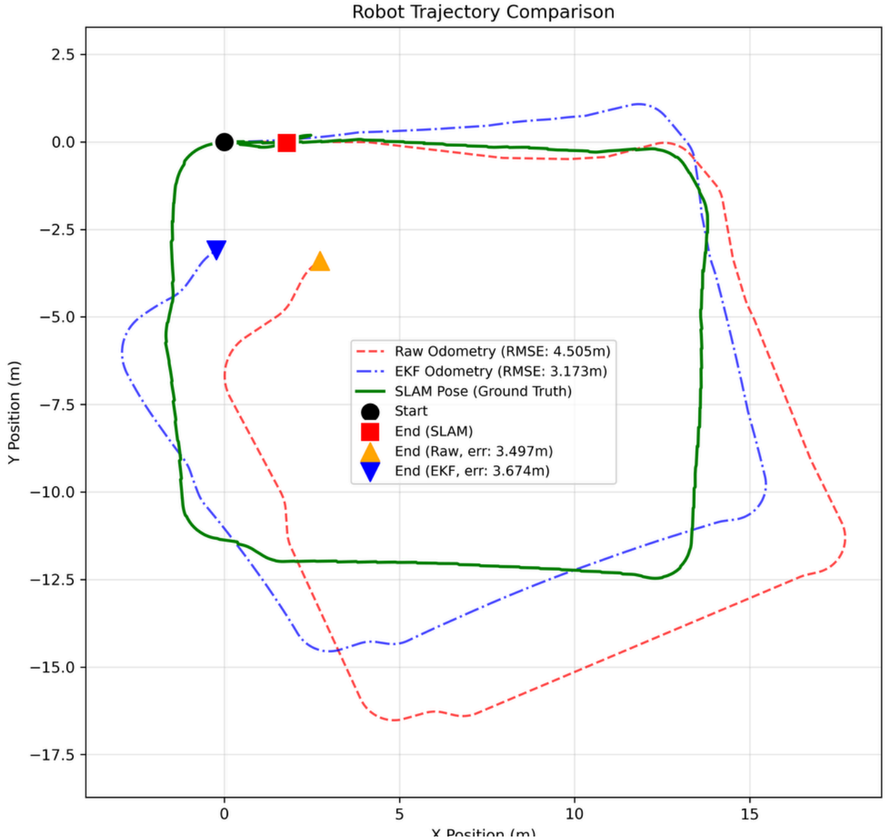
seq00_slam

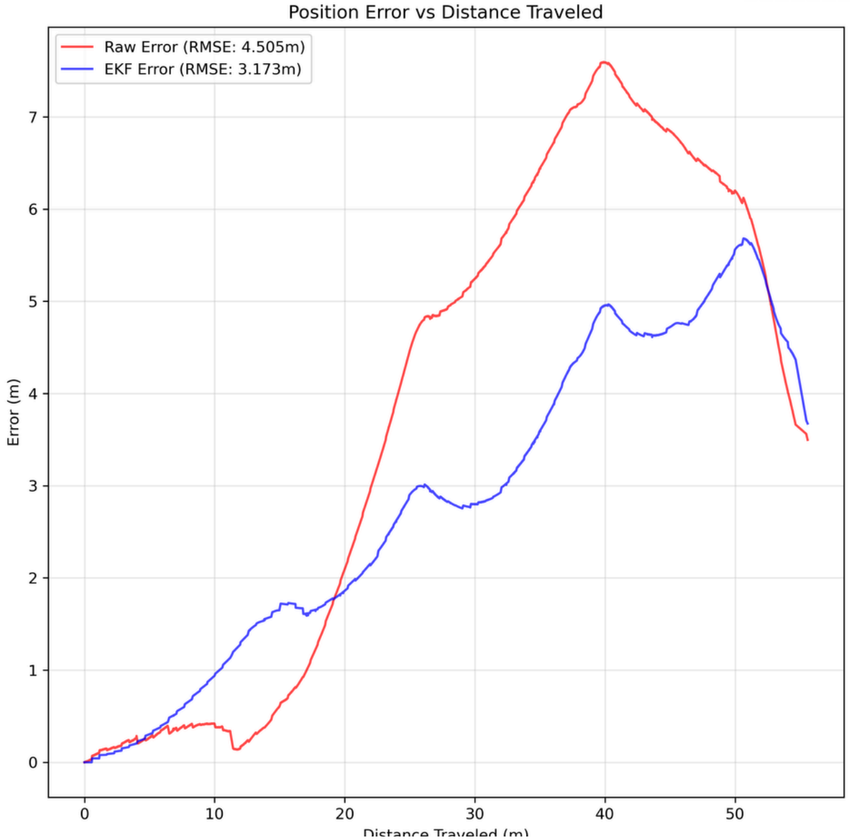


seq01_slam



seq02_slam





==========

ERROR STATISTICS (Compared to SLAM)

==========

Raw Odometry:

RMSE: 4.5050 m

Final Error: 3.4970 m

Max Error: 7.5940 m

EKF Odometry:

RMSE: 3.1725 m

Final Error: 3.6737 m

Max Error: 5.6815 m

Start-to-End Distance (Loop Closure):

SLAM: 1.7909 m

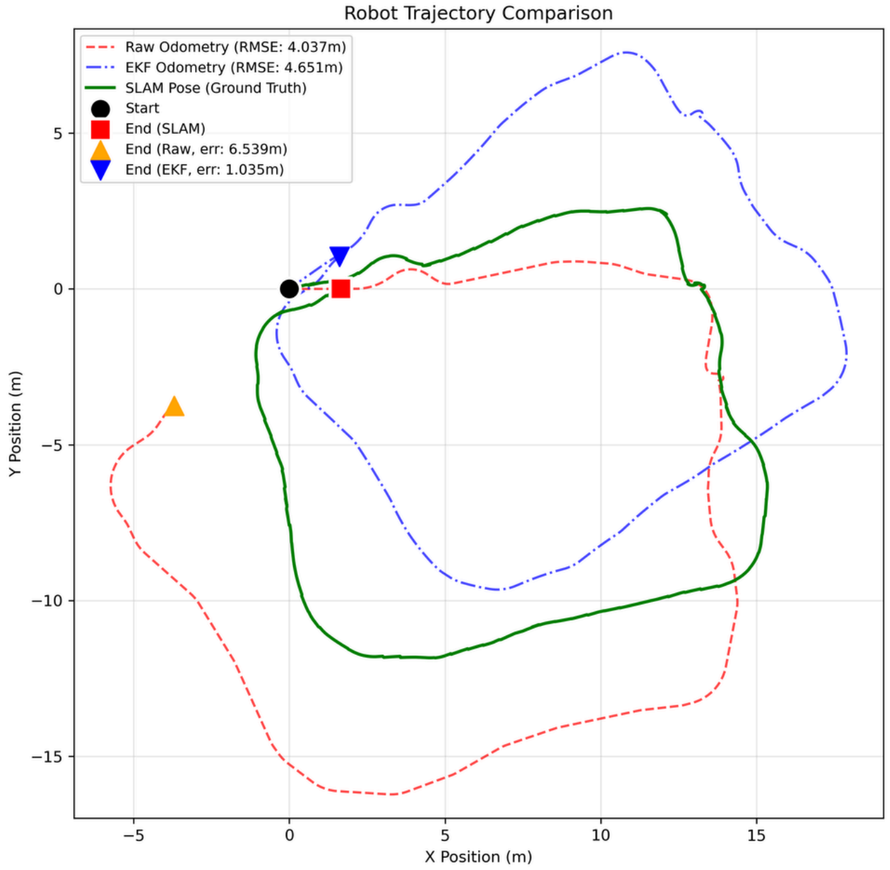
Raw Odom: 4.3575 m

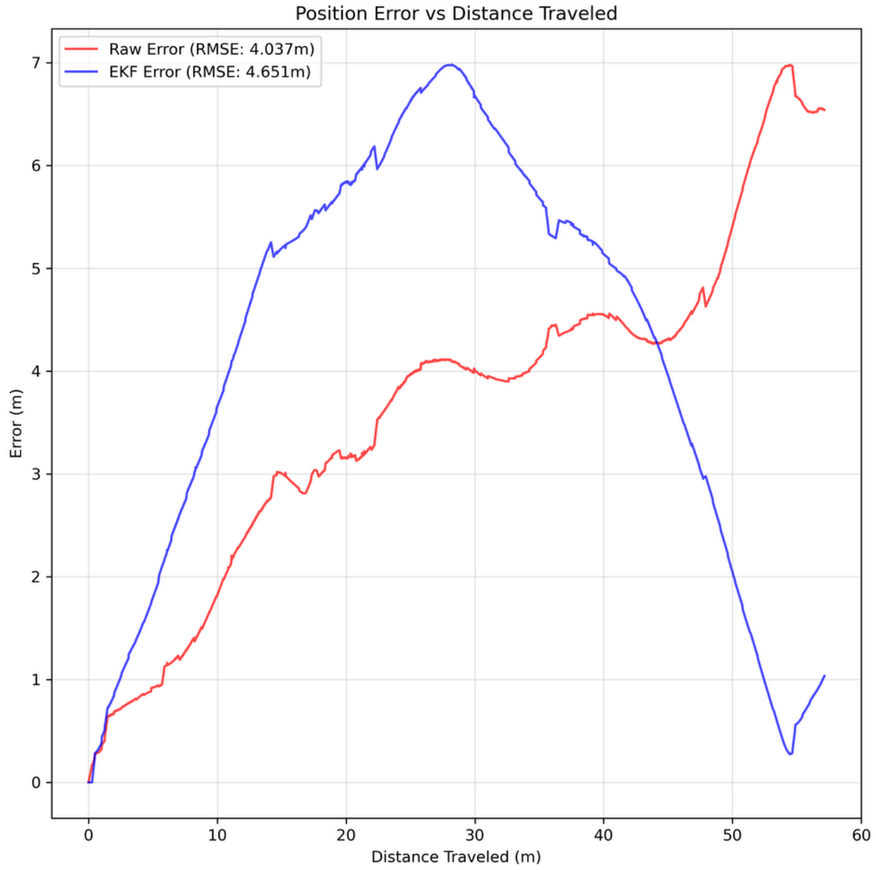
EKF Odom: 3.1077 m

Improvement (EKF vs Raw):

RMSE Reduction: 29.58%

==========





==========

ERROR STATISTICS (Compared to SLAM)

==========

Raw Odometry:

RMSE: 4.0374 m

Final Error: 6.5392 m

Max Error: 6.9769 m

EKF Odometry:

RMSE: 4.6511 m

Final Error: 1.0355 m

Max Error: 6.9800 m

Start-to-End Distance (Loop Closure):

SLAM: 1.6604 m

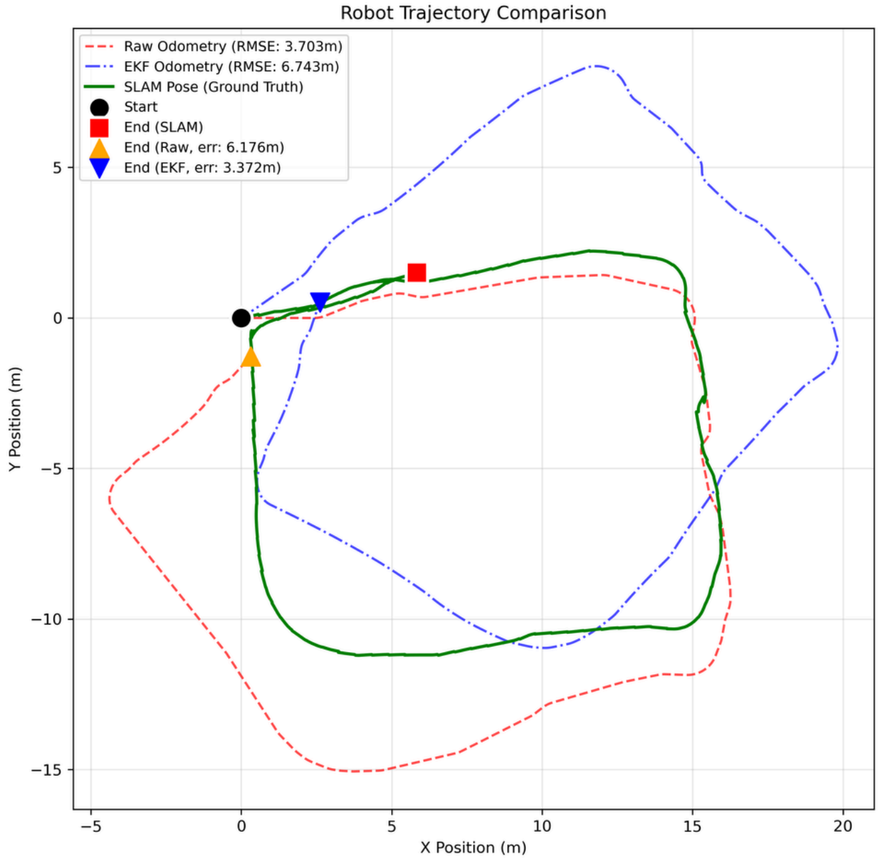
Raw Odom: 5.2659 m

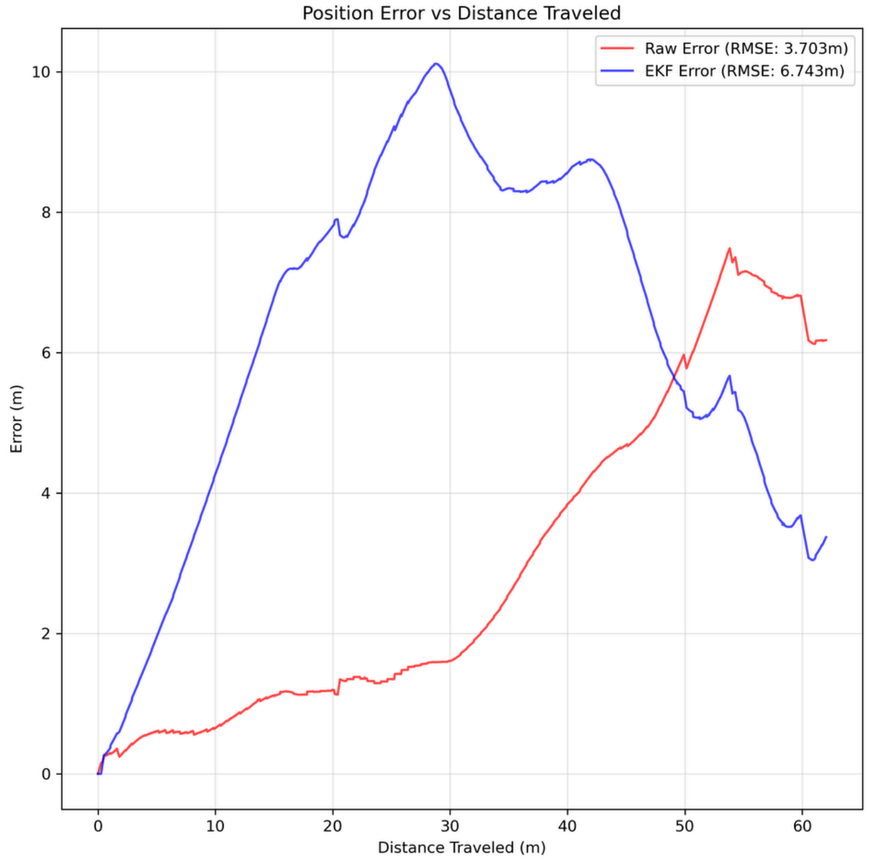
EKF Odom: 1.9148 m

Improvement (EKF vs Raw):

RMSE Reduction: -15.20%

==========





==========

ERROR STATISTICS (Compared to SLAM)

==========

Raw Odometry:

RMSE: 3.7027 m

Final Error: 6.1758 m

Max Error: 7.4832 m

EKF Odometry:

RMSE: 6.7435 m

Final Error: 3.3720 m

Max Error: 10.1115 m

Start-to-End Distance (Loop Closure):

SLAM: 6.0291 m

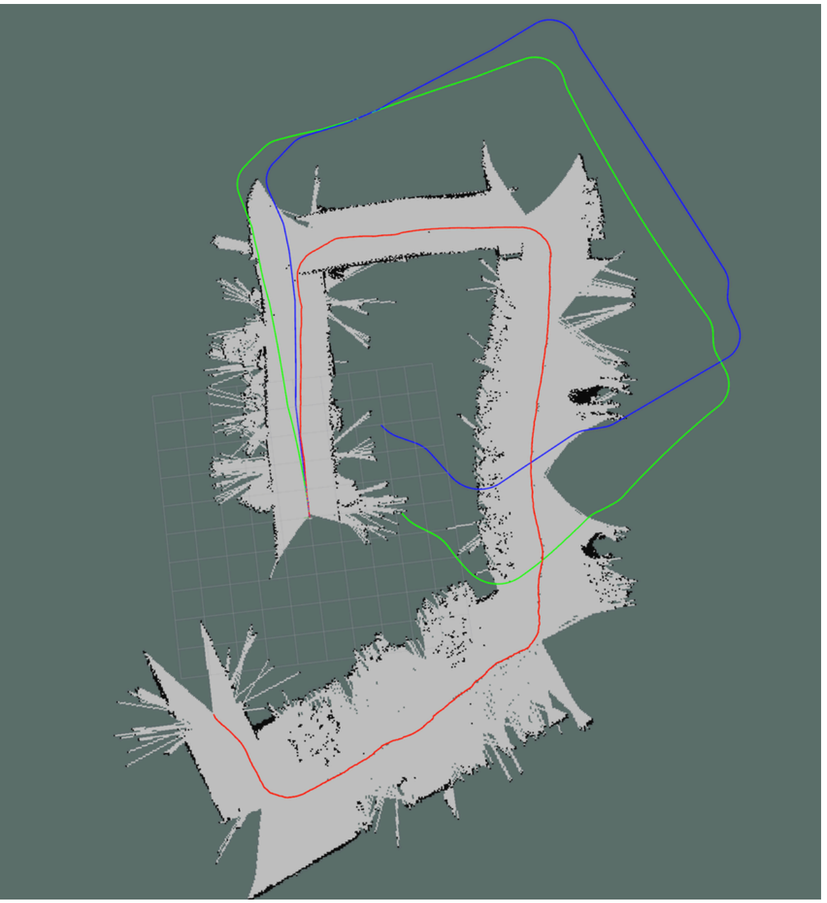
Raw Odom: 1.3106 m

EKF Odom: 2.6646 m

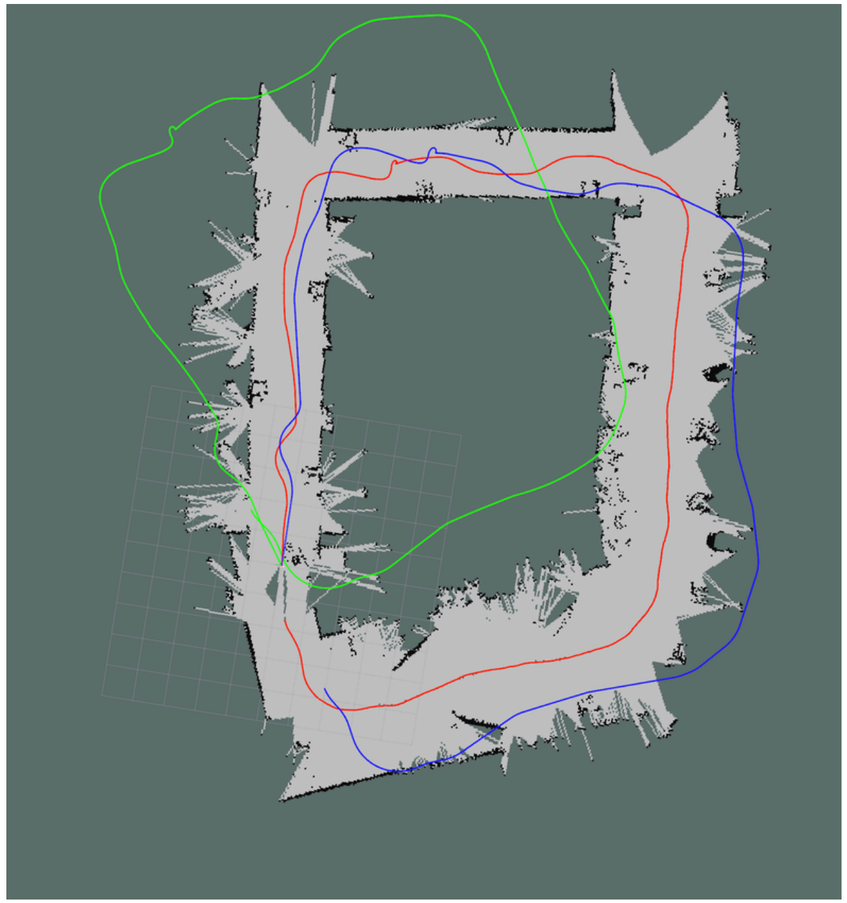
Improvement (EKF vs Raw):

RMSE Reduction: -82.12%

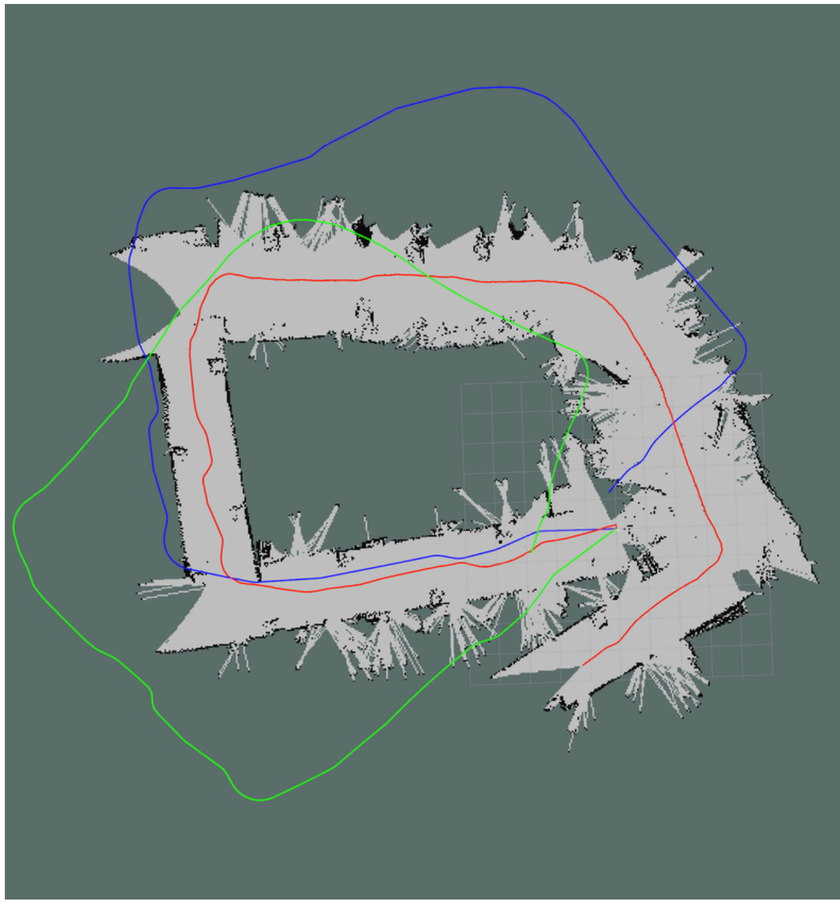
==========



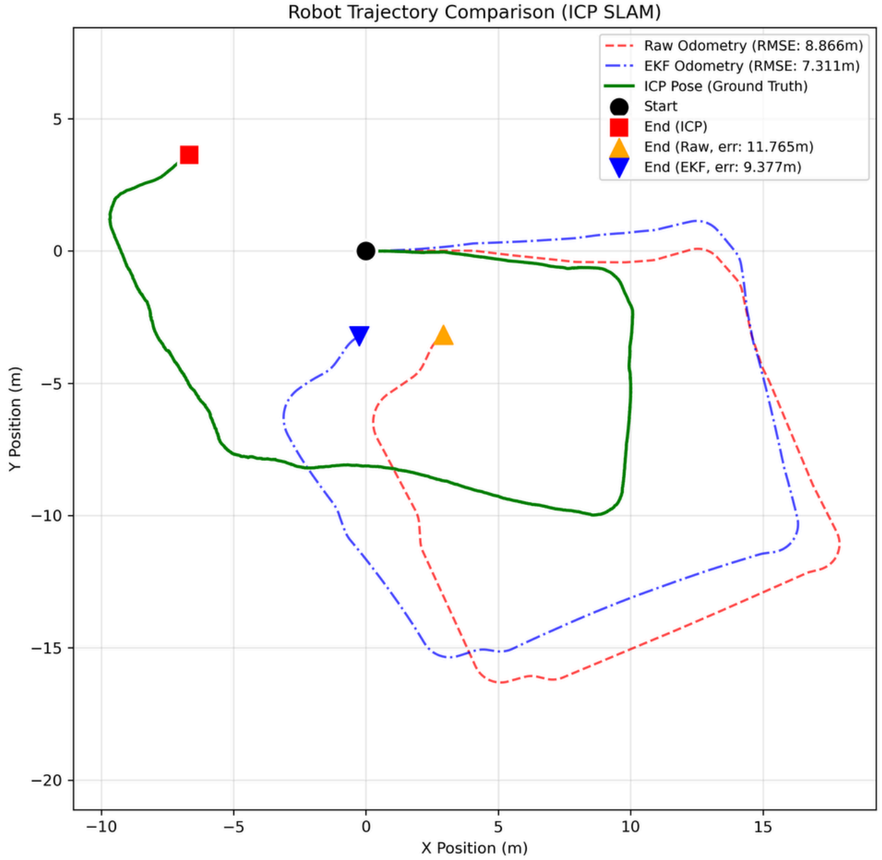
seq00_icp

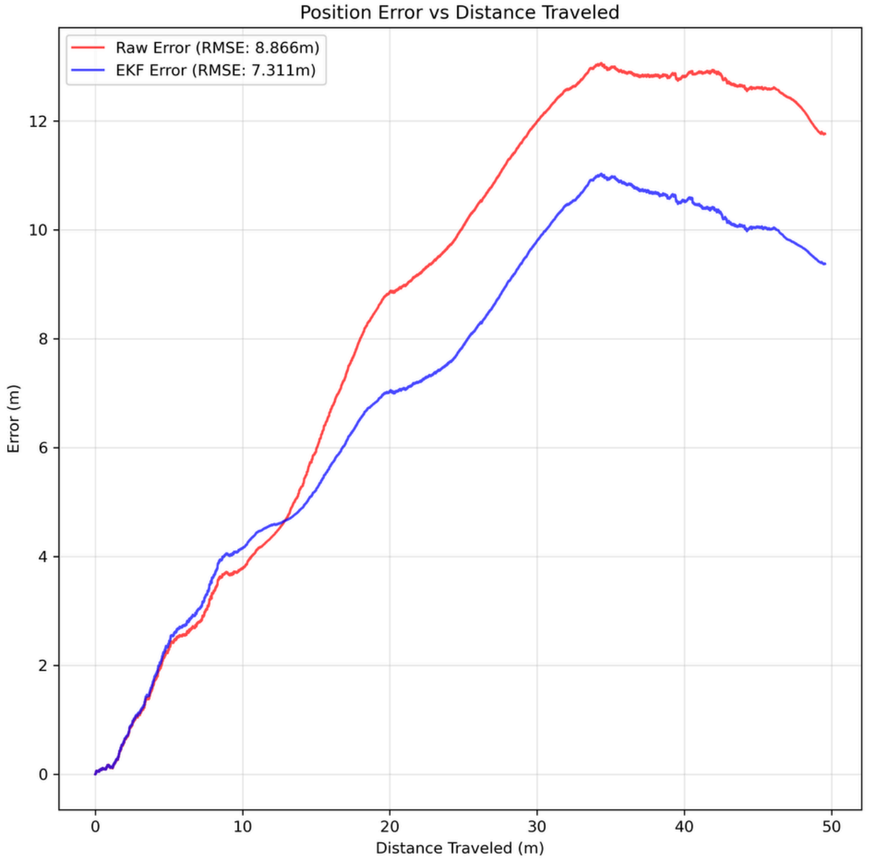


seq01_icp



seq02_icp





==========

ERROR STATISTICS (Compared to ICP SLAM)

==========

Raw Odometry:

RMSE: 8.8663 m

Final Error: 11.7651 m

Max Error: 13.0639 m

EKF Odometry:

RMSE: 7.3113 m

Final Error: 9.3769 m

Max Error: 11.0312 m

Start-to-End Distance (Loop Closure):

ICP: 7.5960 m

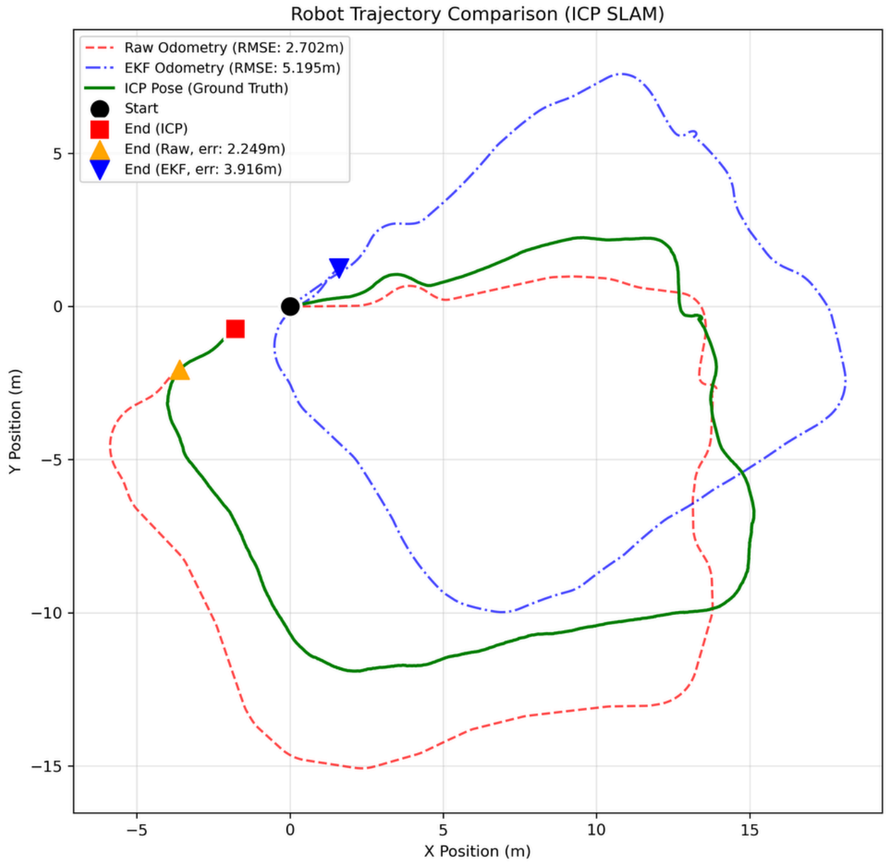
Raw Odom: 4.3151 m

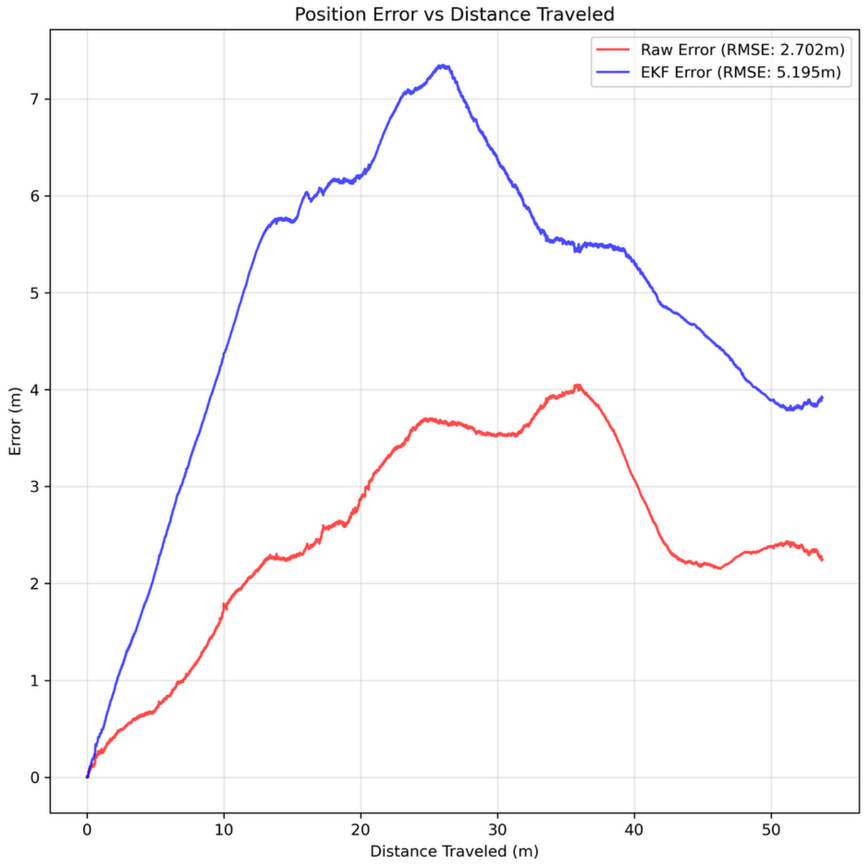
EKF Odom: 3.2227 m

Improvement (EKF vs Raw):

RMSE Reduction: 17.54%

==========





==========

ERROR STATISTICS (Compared to ICP SLAM)

==========

Raw Odometry:

RMSE: 2.7017 m

Final Error: 2.2495 m

Max Error: 4.0504 m

EKF Odometry:

RMSE: 5.1952 m

Final Error: 3.9157 m

Max Error: 7.3481 m

Start-to-End Distance (Loop Closure):

ICP: 1.9306 m

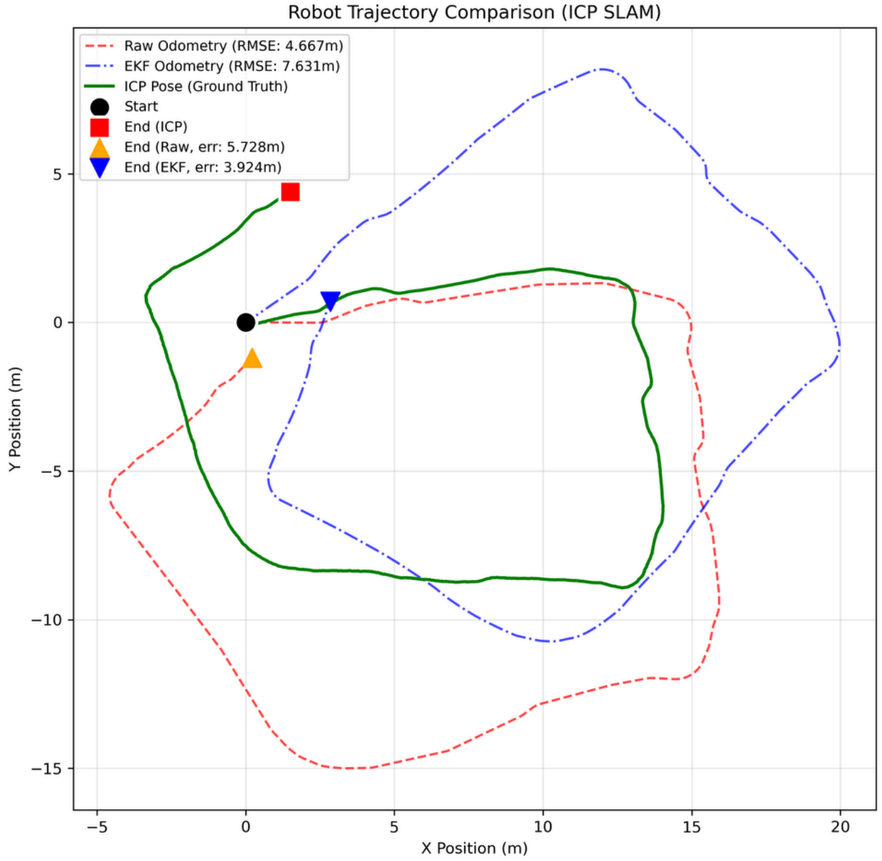
Raw Odom: 4.1504 m

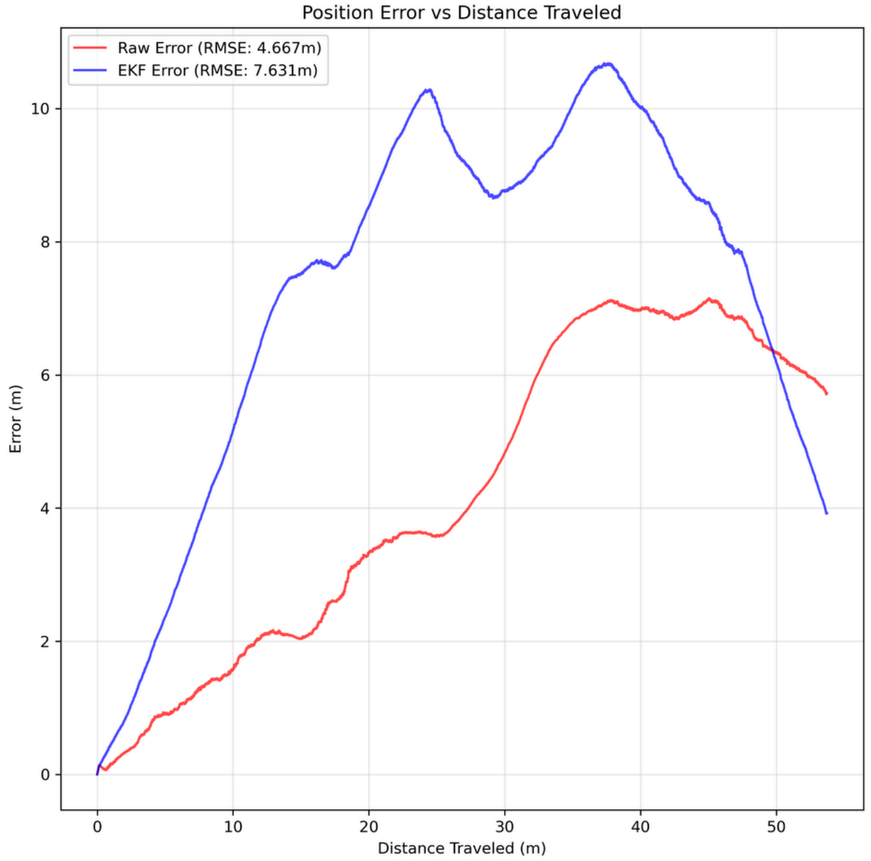
EKF Odom: 2.0212 m

Improvement (EKF vs Raw):

RMSE Reduction: -92.30%

==========





==========

ERROR STATISTICS (Compared to ICP SLAM)

==========

Raw Odometry:

RMSE: 4.6666 m

Final Error: 5.7284 m

Max Error: 7.1512 m

EKF Odometry:

RMSE: 7.6310 m

Final Error: 3.9239 m

Max Error: 10.6817 m

Start-to-End Distance (Loop Closure):

ICP: 4.6410 m

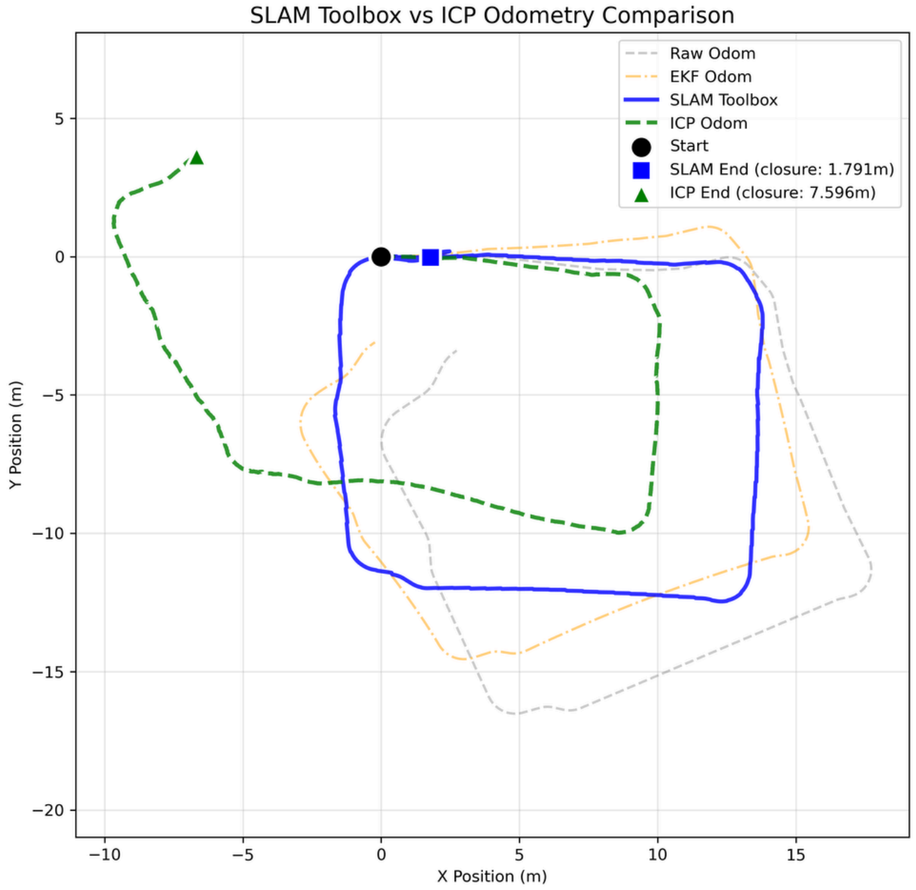
Raw Odom: 1.2091 m

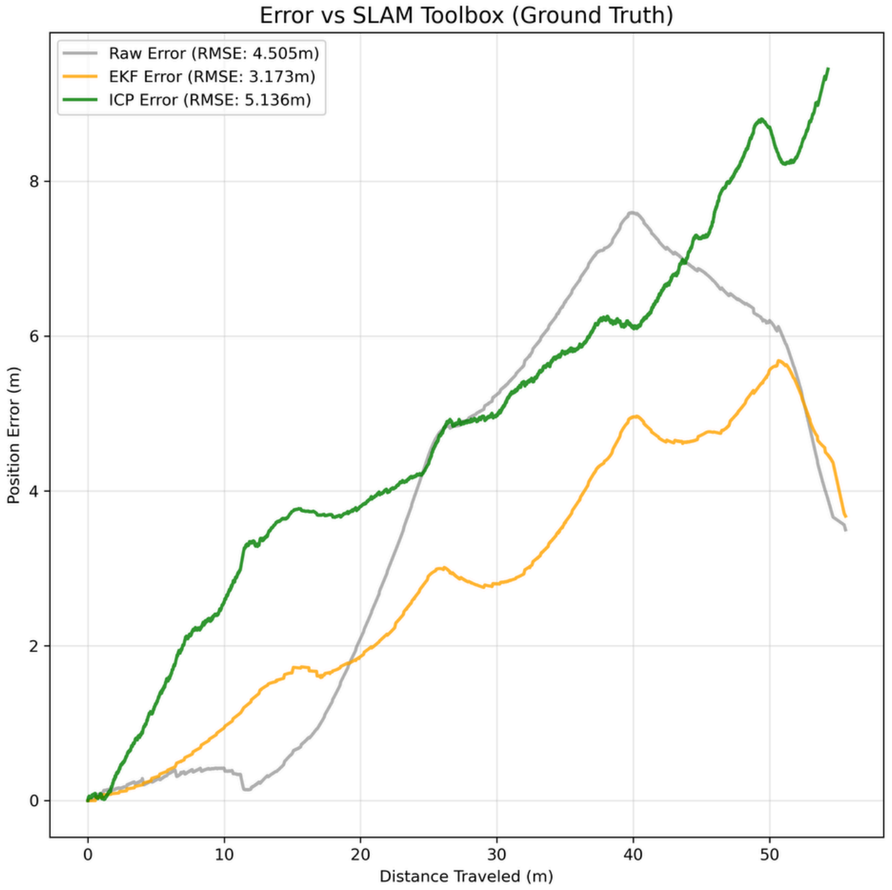
EKF Odom: 2.9281 m

Improvement (EKF vs Raw):

RMSE Reduction: -63.52%

==========





==========

ERROR ANALYSIS (SLAM Toolbox as Ground Truth)

==========

Loop Closure (Start to End Distance):

SLAM Toolbox (GT): 1.7909 m

Raw Odometry: 4.3575 m

EKF Odometry: 3.1077 m

ICP Odometry: 7.5960 m

RMSE vs SLAM Toolbox:

Raw Odometry: 4.5050 m

EKF Odometry: 3.1725 m

ICP Odometry: 5.1357 m

Max Error vs SLAM Toolbox:

Raw Odometry: 7.5940 m

EKF Odometry: 5.6815 m

ICP Odometry: 9.4478 m

Final Position Error vs SLAM Toolbox:

Raw Odometry: 3.4970 m

EKF Odometry: 3.6737 m

ICP Odometry: 9.4478 m

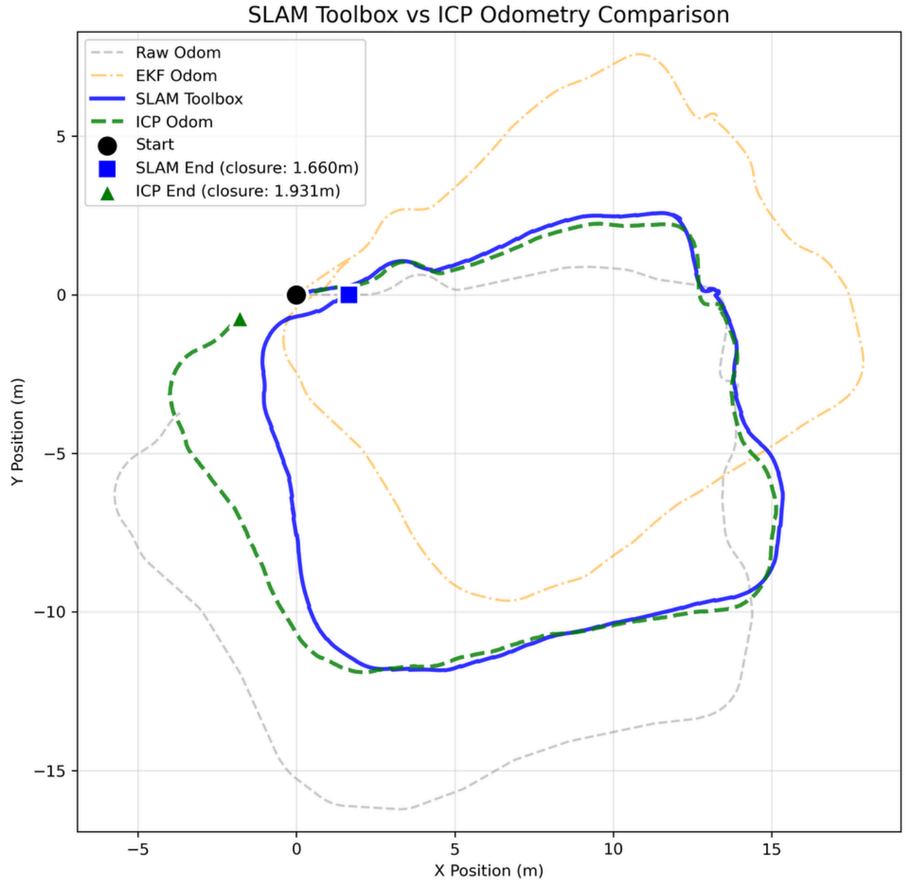
Improvement (EKF vs Raw):

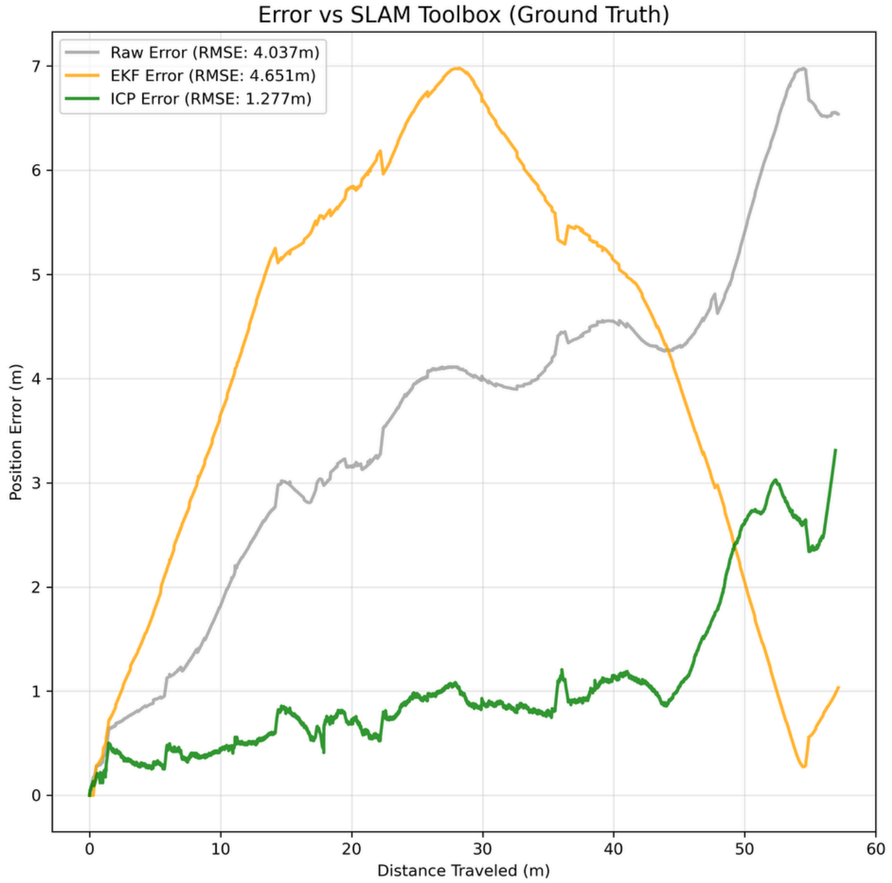
RMSE Reduction: 29.58%

Comparison (Best Method):

Best Method: EKF with RMSE = 3.1725 m

==========





==========

ERROR ANALYSIS (SLAM Toolbox as Ground Truth)

==========

Loop Closure (Start to End Distance):

SLAM Toolbox (GT): 1.6604 m

Raw Odometry: 5.2659 m

EKF Odometry: 1.9148 m

ICP Odometry: 1.9306 m

RMSE vs SLAM Toolbox:

Raw Odometry: 4.0374 m

EKF Odometry: 4.6511 m

ICP Odometry: 1.2770 m

Max Error vs SLAM Toolbox:

Raw Odometry: 6.9769 m

EKF Odometry: 6.9800 m

ICP Odometry: 3.3106 m

Final Position Error vs SLAM Toolbox:

Raw Odometry: 6.5392 m

EKF Odometry: 1.0355 m

ICP Odometry: 3.3106 m

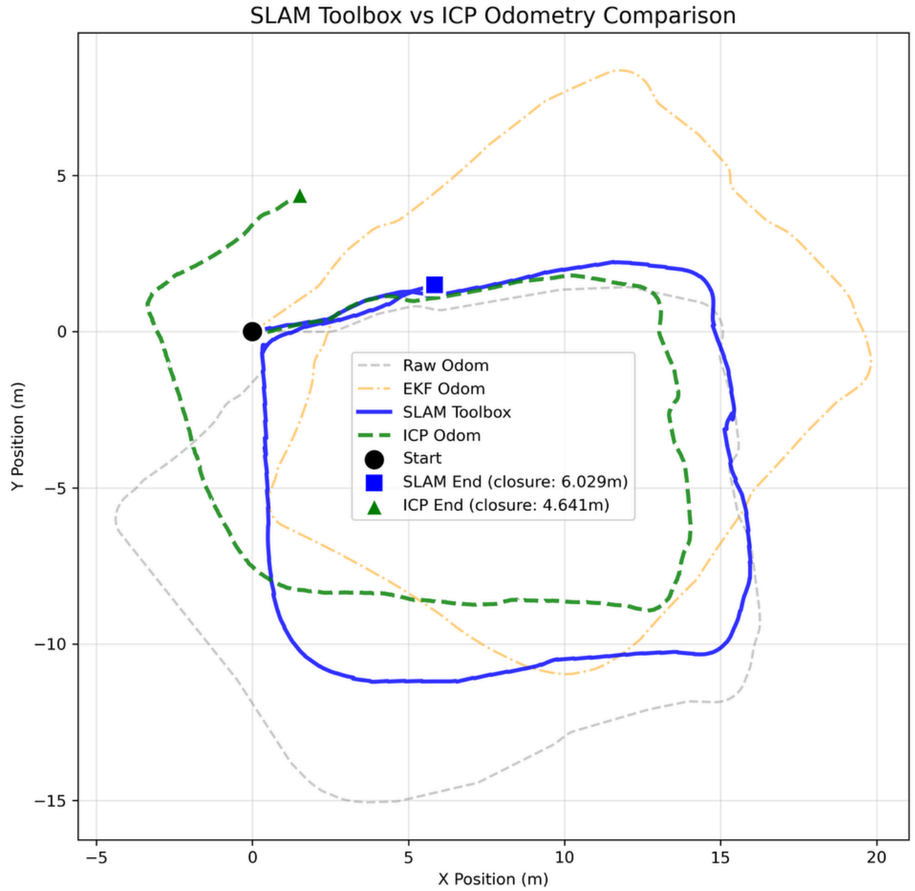
Improvement (EKF vs Raw):

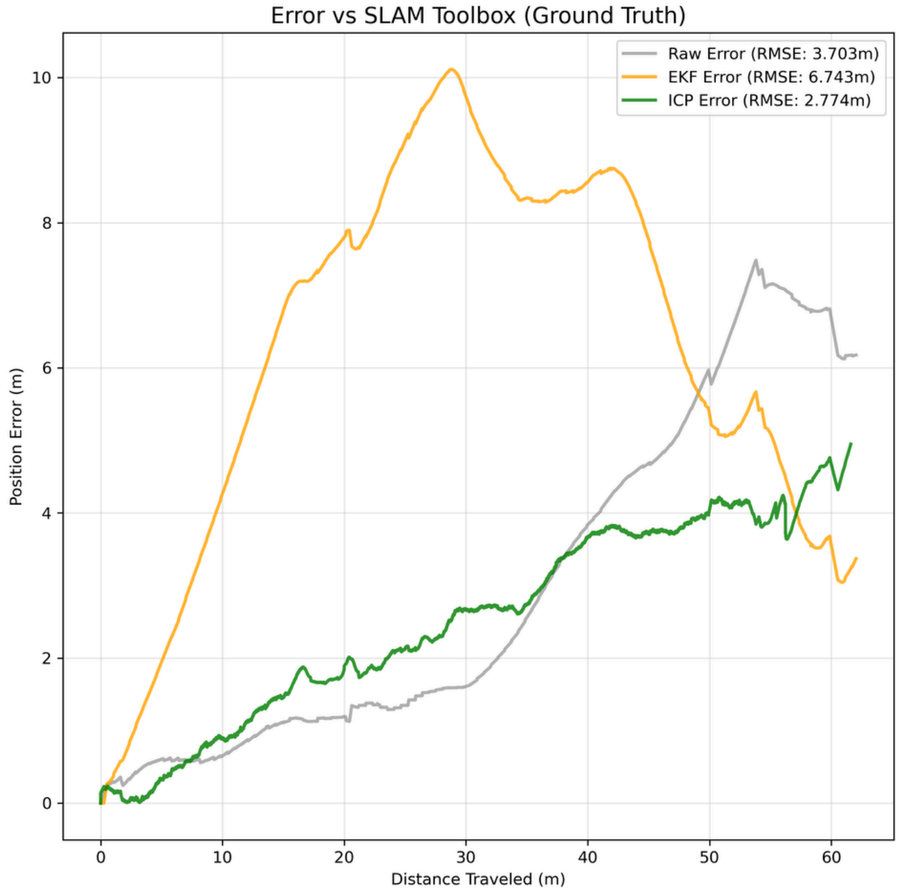
RMSE Reduction: -15.20%

Comparison (Best Method):

Best Method: ICP with RMSE = 1.2770 m

==========





==========

ERROR ANALYSIS (SLAM Toolbox as Ground Truth)

==========

Loop Closure (Start to End Distance):

SLAM Toolbox (GT): 6.0291 m

Raw Odometry: 1.3106 m

EKF Odometry: 2.6646 m

ICP Odometry: 4.6410 m

RMSE vs SLAM Toolbox:

Raw Odometry: 3.7027 m

EKF Odometry: 6.7435 m

ICP Odometry: 2.7741 m

Max Error vs SLAM Toolbox:

Raw Odometry: 7.4832 m

EKF Odometry: 10.1115 m

ICP Odometry: 4.9484 m

Final Position Error vs SLAM Toolbox:

Raw Odometry: 6.1758 m

EKF Odometry: 3.3720 m

ICP Odometry: 4.9484 m

Improvement (EKF vs Raw):

RMSE Reduction: -82.12%

Comparison (Best Method):

Best Method: ICP with RMSE = 2.7741 m

==========

discussion

Accuracy & Precision

- SLAM (Global): Highest Accuracy. Uses global optimization to correct errors.
- Observation: Serves as "Ground Truth," though it struggled in Seq02 (6.0m closure error).
- ICP Odometry (Local): High Precision (Conditional). Extremely accurate when geometric features are present.
- Observation: Best performer in Seq01 (1.27m RMSE) but failed in feature-poor Seq00.
- EKF Odometry (Local): Variable. Dependent on sensor tuning.
- Observation: Currently suboptimal; noise integration caused it to perform worse than Raw Odometry in Seq02.
- Raw Odometry (Local): Low. Baseline accuracy; purely mechanical.

Drift Characteristics

- Raw Odometry: Linear drift accumulation. Error grows primarily with distance traveled and during rotations.
- EKF Odometry: In this dataset, exhibited non-linear drift (spiraling). The filter integrated IMU noise, causing "phantom motion" even when the path should have been straight.
- ICP Odometry: Zero-drift in feature-rich areas (locks to map), but susceptible to "Geometric Slip" (infinite drift) in corridors where walls look identical.
- SLAM: Bounded Drift. Uses "Loop Closure" to recognize previously visited locations and "snap" the entire trajectory back to reality, cancelling out accumulated drift.

Method	Robustness	Vulnerability
Raw Odom	**High**	Wheel slip (gravel/mud) & uneven terrain.
SLAM	**Med-High**	"Perceptual Aliasing" (confusing two similar hallways).
EKF Odom	**Medium**	Sensor noise & magnetic interference (if using magnetometer).
ICP Odom	**Low**	Geometric Slip (long hallways) & dynamic objects.

Problem

- **ekf tune(not tune properly)**
- **converting joint state to wheel odom**