Monocular ORB-SLAM3 on MBot: Challenges and Performance in Real Environments

Team 8

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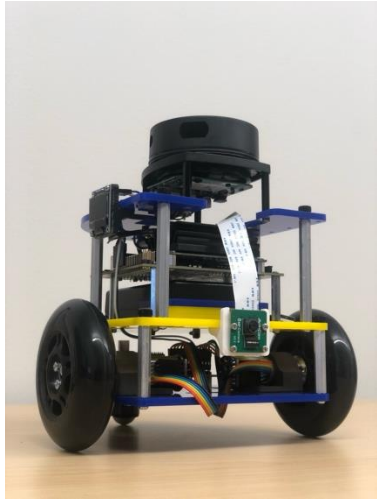
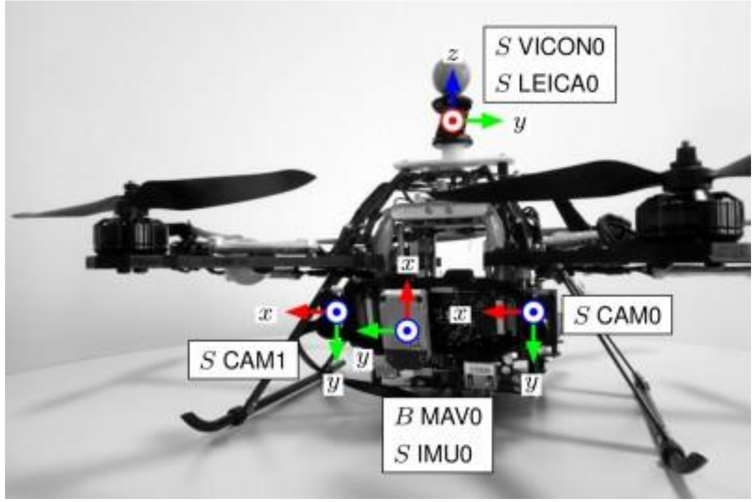
EECS 568/ROB 530 – Mobile Robotics

Motivation

- Visual SLAM is low-cost and has been a popular research area that has been broadly adopted in existing products.
- Can visual SLAM perform well-enough using **cheap monocular camera without inertial measurements**?
- What would the results of visual SLAM be deployed on **compact hardware with limitations**?



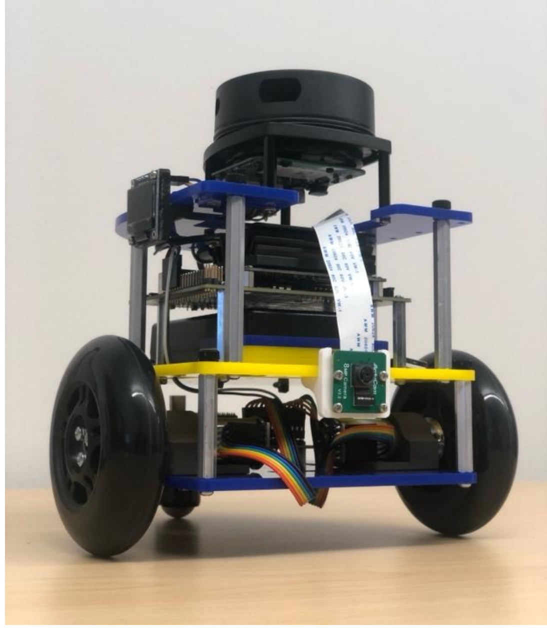
UMich Mbot Classic



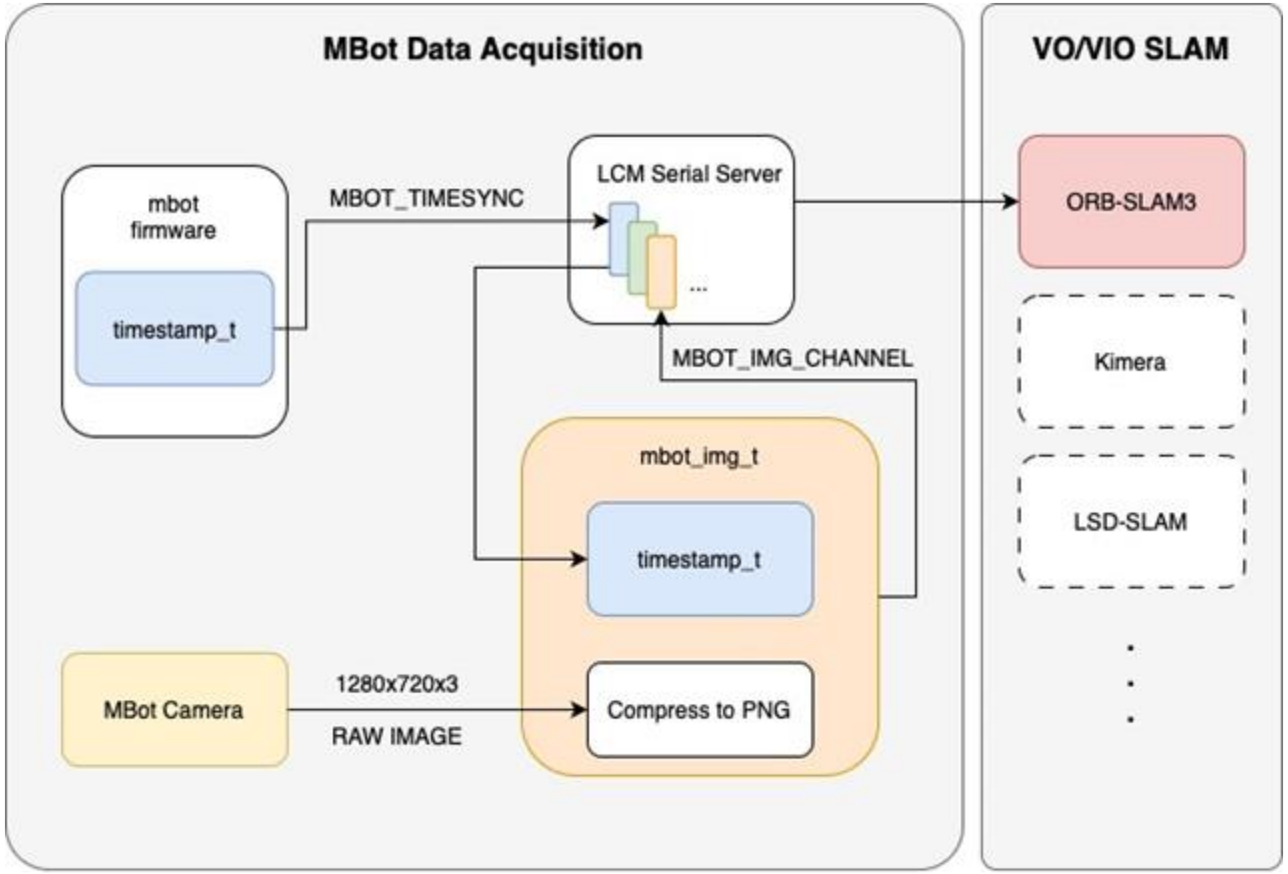
ETH EuRoC MAV

Methodology

Mbot Classic



RaspberryPi 5
+
$7 Camera



Methodology

LCM Message

- Rate:

  Image 10 Hz

  ~~IMU 25 Hz~~

  Time 100 Hz

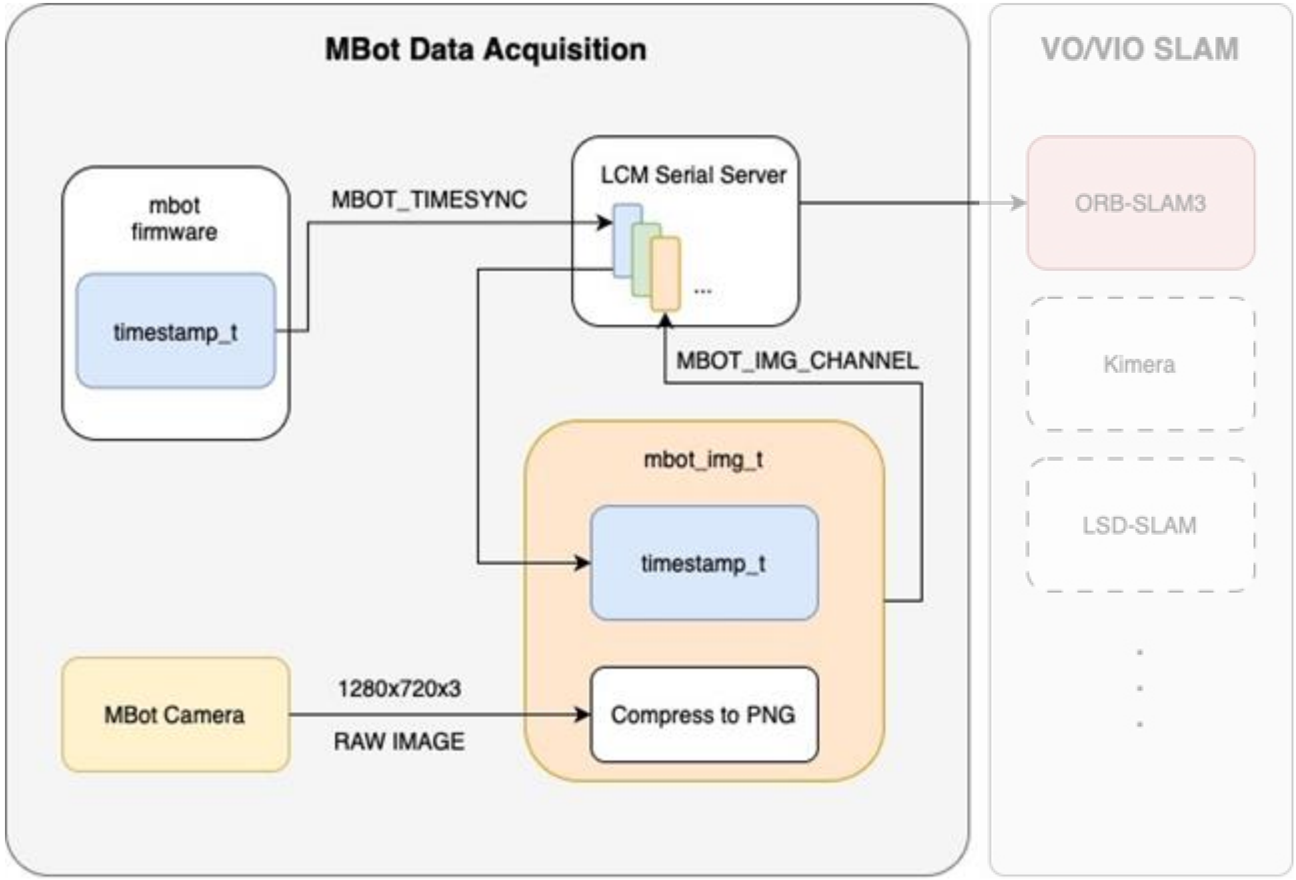
- Resolution: **480 x 240 pixels**
- Image Message (msg_img_t):

  utime: Timestamp

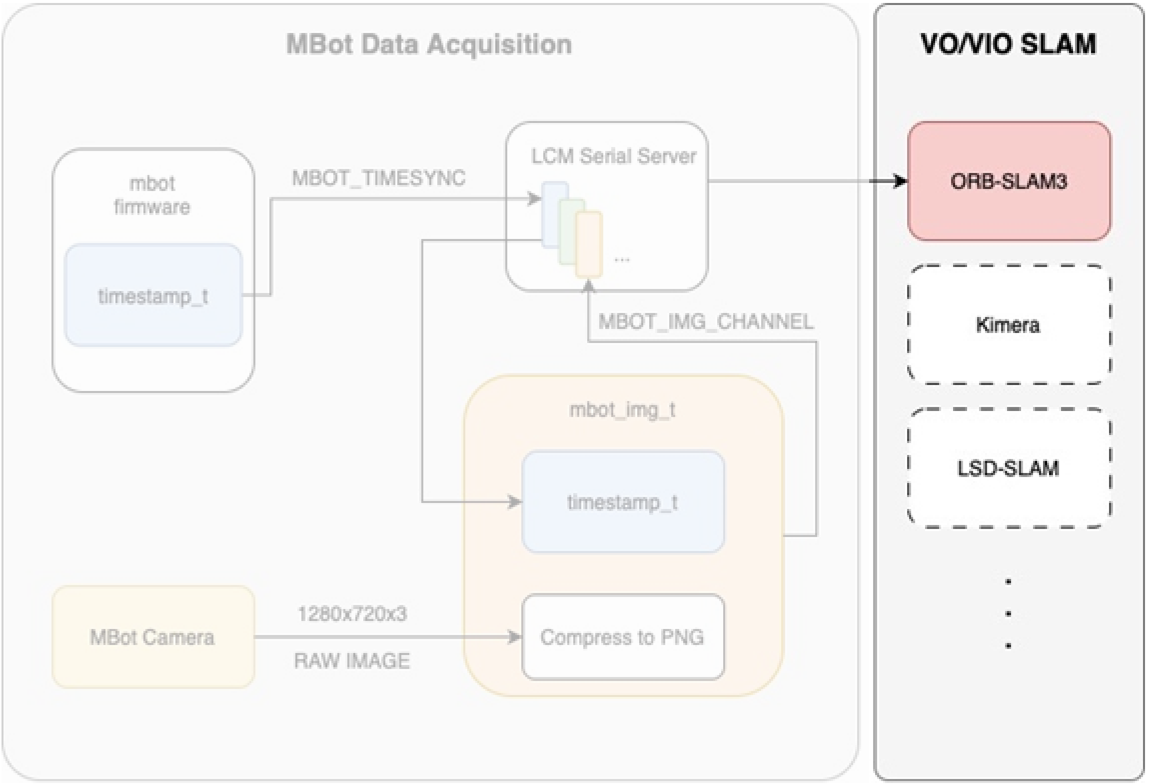
  img_name: Frame ID (timestamp)

  data_size: Image size (bytes)

  img_data: PNG-compressed image

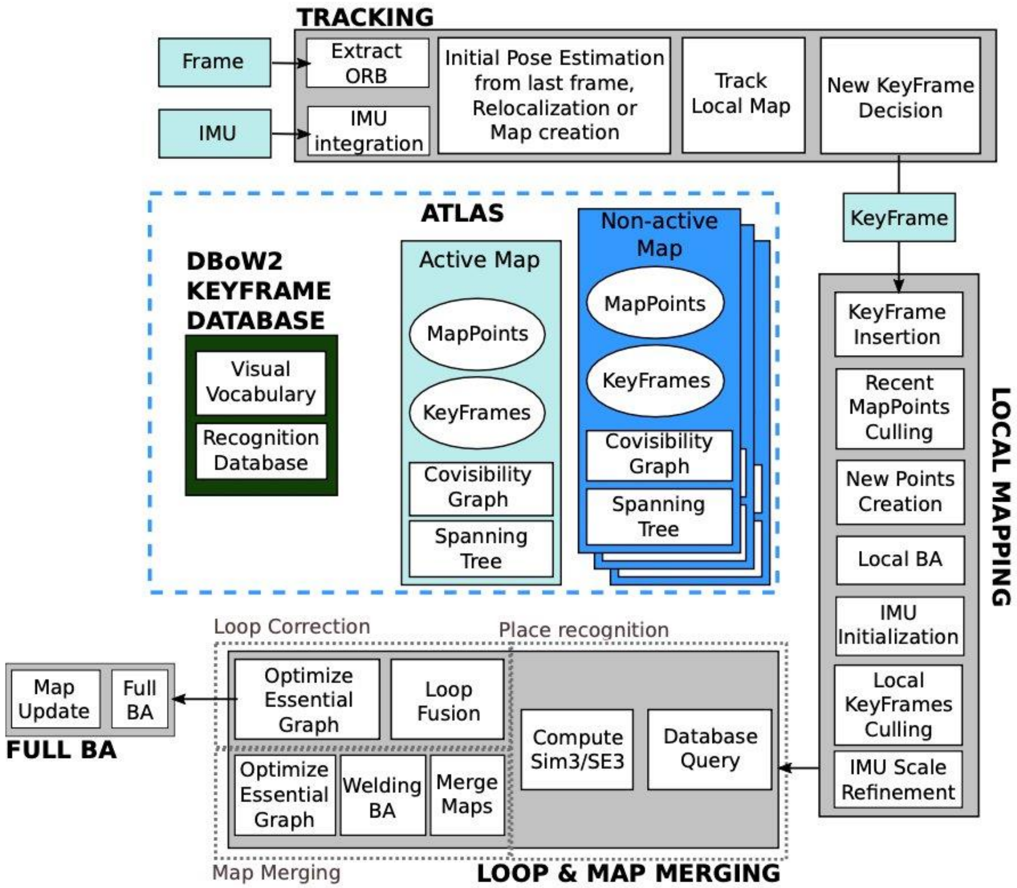


Methodology



	ORB-SLAM3	Kimera
Mono Odometry	✅	❌
Stereo Odometry	✅	❌
Mono Inertial Odometry	✅	✅
Stereo Inertial Odometry	✅	✅

Methodology



1) Front-End Tracking

- ORB extraction, descriptor formation and inter-frame matching.
- Pose prediction via constant-velocity model and refinement with Perspective-n-Point (PnP).
- Keyframe creation governed by match-count and baseline criteria.

2) Local Mapping Back-End

- Covisibility graph Gc maintenance.
- Triangulation of new map points; redundancy culling.
- Sliding-window local bundle adjustment (BA)

3) Loop Closure/Map-Merging

- Appearance-based place recognition (BoW).
- Sim(3) alignment, essential-graph optimization
- Global BA in a detached thread for final refine-

Results

Loop Closure Experiment:

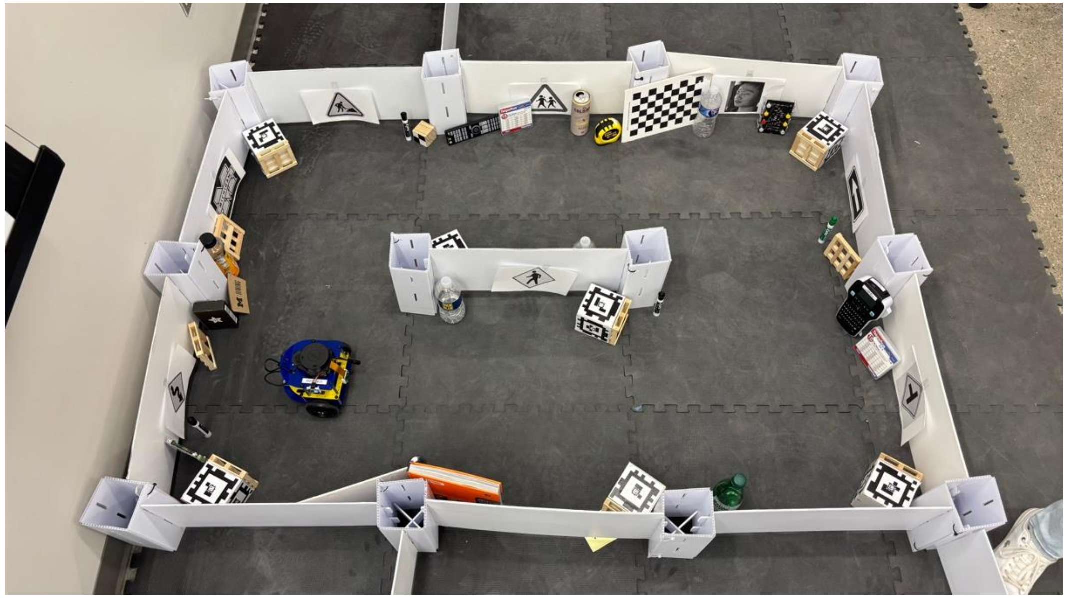


Fig: Rectangular Route for Testing Loop Closure

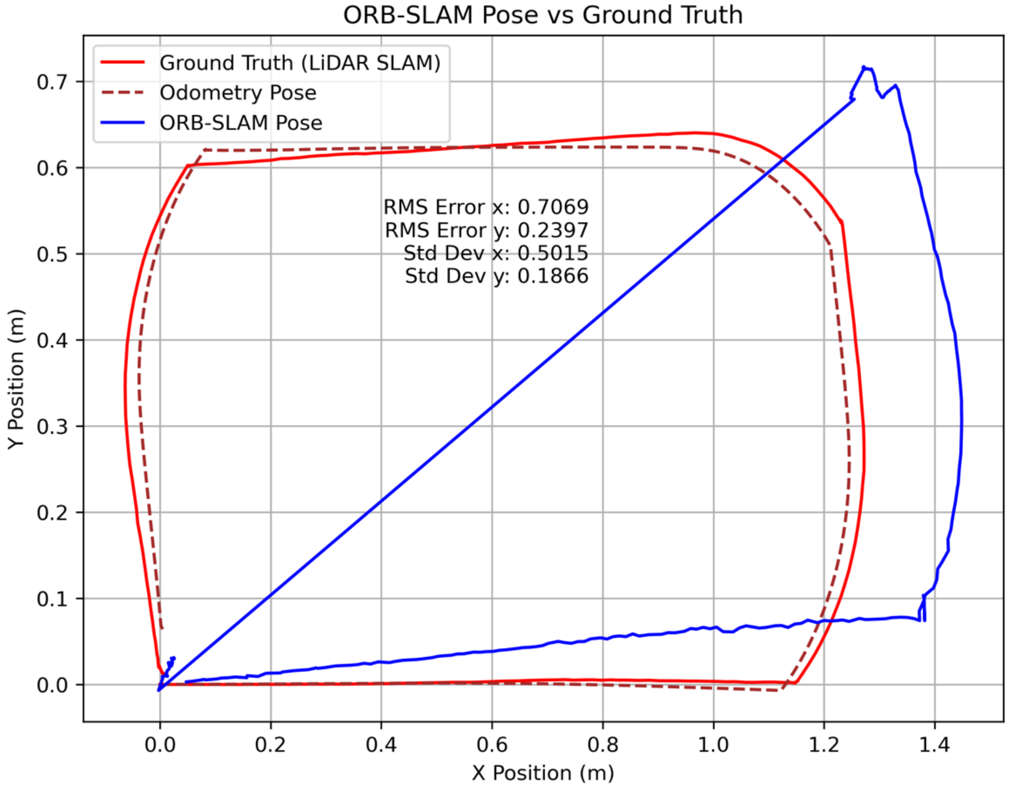


Fig: ORB-SLAM3 Pose Estimation in Rectangular Route

Results

Maze Experiment:

Fig: Maze Route to Chellenge Mono ORB-SLAM3

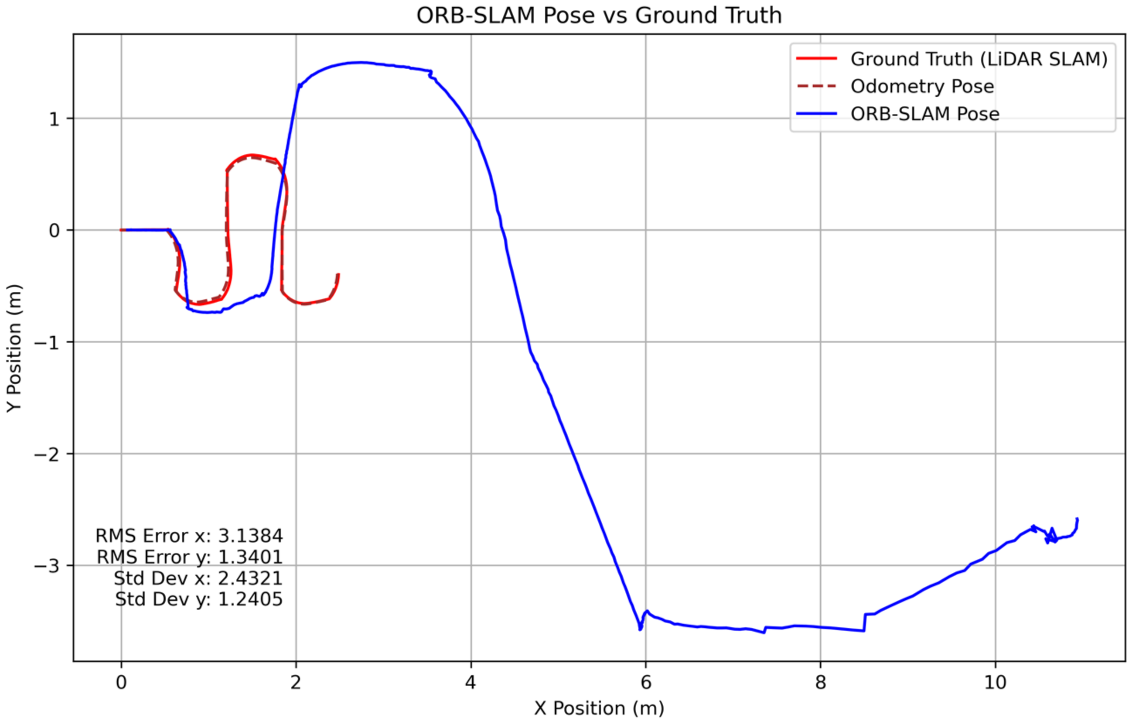


Fig: ORB-SLAM3 Pose Estimation in Maze

Discussion & Conclusion

- The hardware must support high-speed read/write operations to prevent packet loss during data transmission.
- ORB-SLAM3 with a monocular camera captures the overall route structure, but struggles with accurate distance estimation.
- Pose estimation is unreliable during **pure rotational motion** due to the inability to triangulate new map points without translation.
- **Loop closure** is essential in monocular SLAM to correct drift and ensure relocalization.

Future Work

- Improve sensor quality and image update rates
- Enhance actual distance with depth information (RGB-D camera, stereo camera)
- Integrate Inertial measurements using IMU
- Subscribe to real-time ROS messages to retrieve odometry data