

CHAPTER V

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This thesis investigated the design and evaluation of a robust indoor SLAM framework that integrates LiDAR-based localization with RGB-D-based mapping on the F1 TENTH autonomous platform. The main goal of the study was to enhance localization reliability and maintain map continuity in indoor environments where visual sensors alone may be affected by lighting conditions, occlusions, or temporary sensor failure.

The experimental results presented in Chapter 4 compared two SLAM approaches: a LiDAR-only SLAM system and an RGB-D SLAM system implemented using RTAB-Map. Both systems were evaluated against a predefined ground-truth trajectory. Under normal operating conditions, the results showed that each method was capable of tracking the robot's motion; however, trajectory deviations became more pronounced during extended motion and curved path segments. These errors reflect the cumulative nature of localization uncertainty and the limitations of relying on a single sensing modality.

A robustness evaluation was conducted by disabling the camera during runtime to simulate a loss of visual information. In this scenario, the RGB-D SLAM system was unable to continue updating its trajectory and mapping process due to the absence of visual features. In contrast, the proposed system maintained stable localization using LiDAR data, allowing the robot to continue navigating the environment. When the camera was reactivated, dense map generation resumed without requiring system reinitialization. This behavior demonstrates the advantage of decoupling localization and mapping tasks across different sensors.

The findings indicate that LiDAR provides consistent and reliable localization in feature-degraded environments, while RGB-D sensors significantly enhance environmental representation when visual data is available. By combining these complementary sensing capabilities, the proposed system achieves greater robustness and operational continuity compared to single-sensor SLAM approaches.

In summary, this research confirms that a hybrid SLAM architecture is effective for indoor autonomous navigation, particularly in scenarios involving sensor degradation or partial sensor failure. The proposed approach improves system resilience and mapping reliability, making it suitable for real-world robotic applications. Future work may extend this framework through tighter sensor fusion, dynamic weighting strategies, and validation in more complex and dynamic indoor environments.

5.2 RECOMMENDATION

5.2.1 Due to the relatively high operating speed of the vehicle, localization performance may be negatively affected. Rapid motion increases the difficulty of accurately estimating the robot's position, as sensor measurements and odometry updates may not be captured with sufficient temporal resolution, leading to increased localization error.

5.2.2 A higher-performance processing board is recommended to improve system responsiveness and computational efficiency. Enhanced processing capability would allow faster sensor data handling, more stable SLAM computation, and reduced latency during real-time operation.