Lidar-IMU SLAM System for RAD

Project Overview:

This project aims to develop a real-time Lidar-IMU SLAM system that can be used for autonomous driving scenarios. The proposed SLAM system will be optimized for robustness, accuracy, and efficiency. The project will follow a three-step approach, which includes LiDAR-inertial initialization, point-to-point matching using the Kiss-ICP method, and odometry using the HybVIO method.

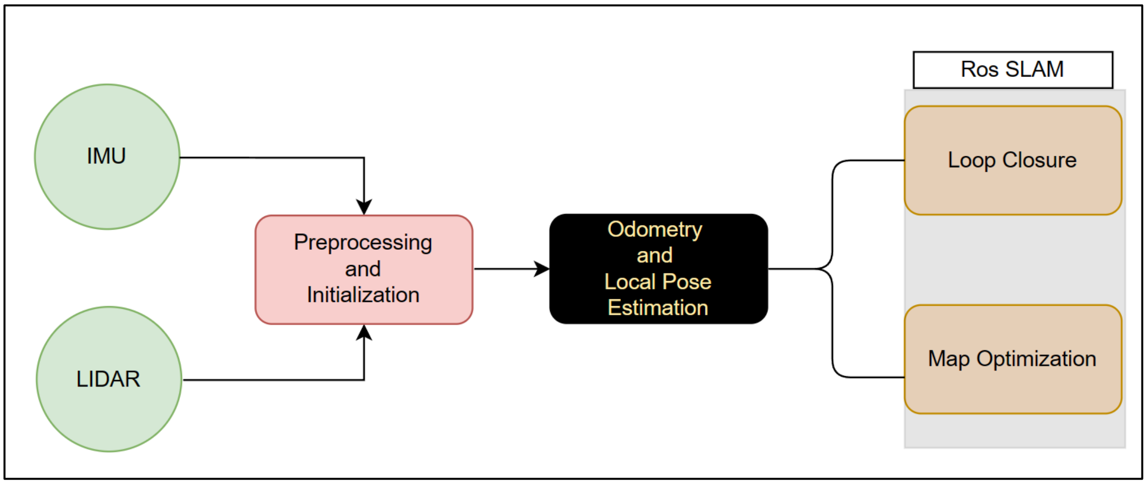

Figure 1: Project work Flow

Context:

Autonomous driving is an emerging technology that has the potential to revolutionize the transportation industry. However, autonomous vehicles' reliability and accuracy depend on their perception systems' quality. Lidar-IMU SLAM systems have been shown to be effective in addressing the challenges of localization, mapping, and odometry in autonomous driving scenarios. This project aims to improve the performance of such systems by optimizing the initialization, point-to-point matching, and odometry processes.

Methodology:

The proposed Lidar-IMU SLAM system will follow a three-step approach:

1. **LiDAR-inertial initialization:** The initialization process will be based on the **robust real-time LiDAR-inertial initialization method**. The point-to-plane method used for calculating the Lidar angular and linear velocity will be replaced with the point-to-point method to reduce the computation load. Additionally, the incoming Lidar scan will be split into smaller sections to minimize the effects of the constant velocity assumption.
2. **Point-to-point matching:** The Kiss-ICP method will be used for point-to-point matching. This method involves a double sub-sampling technique to maintain a dense map while using a smaller dataset during frame alignment and local pose estimation.
3. **Odometry:** The method from the HybVIO paper will be adapted for Lidar-Imu odometry. This method uses a Quaternion EKF, and the measurement residual is done by triangulation. For the Lidar-IMU case, the error residual from ICP will be used.

Estimated Timeline:

- End of February: Implementation and unit testing of the initialization process and point-to-point matching process.
- March [Week 1 and 2]: Implementation of the odometry process
- March [Week3 -4]: Integration and testing

Potential Challenges:

One of the potential challenges of this project is the storage requirements. The proposed system will use two Kalman filters, the IEKF for the Lidar odometry during the initialization stage and the Quaternion EKF during pose estimation. These filters can be storage-heavy and may require optimization to maintain real-time performance. Another challenge is the complexity of the proposed system, which may require significant computational resources to ensure real-time performance.

Conclusion:

Overall, the proposed Lidar-IMU SLAM system has the potential to improve the accuracy and robustness of autonomous driving scenarios significantly. The proposed system will provide more reliable and efficient navigation for autonomous vehicles by optimizing the initialization, point-to-point matching, and odometry processes.

The current stage can be found on GitHub [https://github.com/Oreoluwa-Se/Lidar-IMU-SLAM] in the main branch.