SS 2025-2026, SMT-ROB, DISAL-SP208 Project Summary

Using LiDAR to Localize and Track MAVs

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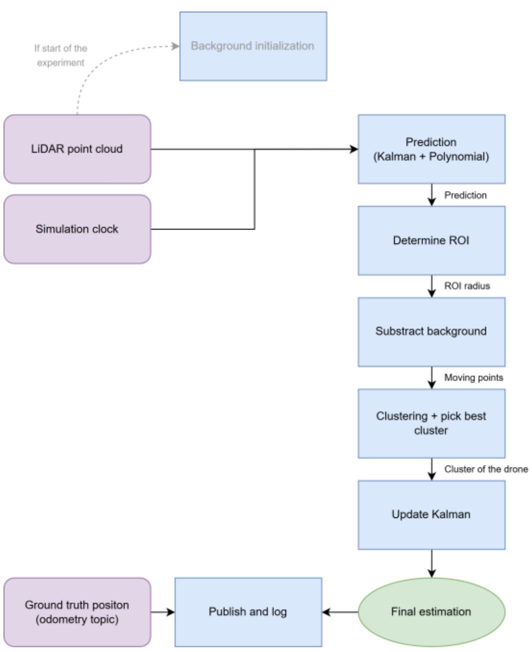
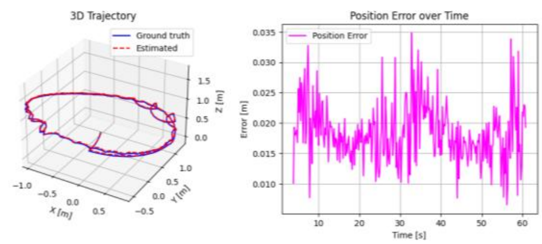
The localization and tracking of Micro Aerial Vehicles (MAVs) has become an increasingly important topic in robotics due to the growing use of drones. To implement these localization algorithms, LiDAR sensors offer several advantages, including robustness to lighting conditions and accurate 3D measurements. Therefore, this project aims to design a localization algorithm, and to build a simulation framework in order to test it and to evaluate its performance for different situations and LiDAR specifications. The framework combines Gazebo Sim, allowing realistic simulation of drones, LiDAR, and background elements ; and ROS2, allowing to design controllers connected to Gazebo (including the localization algorithm, a drone controller, and a supervisor).



Structure of the localization algorithm

The localization algorithm developed relies on several processing stages. First, a background model is constructed from multiple LiDAR point clouds of the initial static background. Then, at each step, a prediction for the future position of the drone is done by combining the results from a Kalman filter and a polynomial fit. A spherical Region Of Interest (ROI) is then fitted around the prediction, whose radius grows with the uncertainty on the drone's position, computed from the Kalman filter. The background reference model is subtracted from the new points in this ROI, to keep only the points corresponding to moving objects. These points are clustered and the cluster considered the best fit for the drone is kept, and then used to update the Kalman filter and get the final estimations, including position, velocity, and acceleration.



Example 3D plot of estimated position versus ground truth position, and graph of the position error over time

The algorithm was also extended to handle the localization and tracking of multiple drones, either creating new tracks, updating existing ones, or deleting old tracks, at each step depending on the new measurements and their association to existing tracks.

Some metrics were defined to evaluate the algorithm performance, including the position RMSE and the lost ratio, the ratio of steps where the position error was larger than 1 meter.

Then a grid search algorithm was implemented, capable of automatically testing numerous combinations of LiDAR specifications, localization algorithm parameters, and drone trajectory configurations.

The results showed that for a Crazyflie drone flying at an appropriate distance to the LiDAR, an accuracy of the order of the centimeter could be achieved for the position estimation. The appropriate flight distance to get this performance is dependent on the resolution of the LiDAR.