SS 2020-2021, SMT-ROB, DISAL-SP148 Project Summary

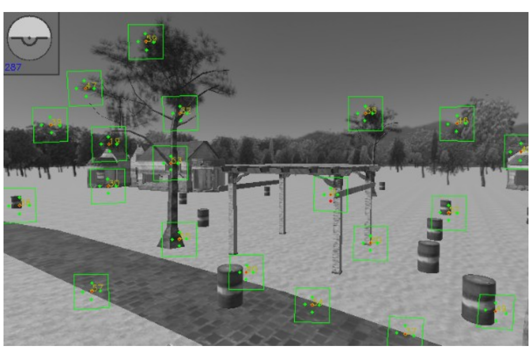
Integration of VIO in Simulation

Yannick Goumaz

Professor : Alcherio Martinoli
Assistant(s) : Lucas Wälti

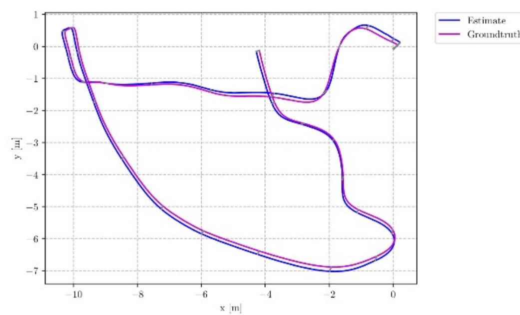
This work is carried out as part of a bigger project in the framework of the Distributed Intelligent Systems and Algorithms Laboratory (DISAL). The goal is to develop a realistic and complete drone simulation, which could greatly benefit the laboratory for further research, on topics like 3D odor mapping, model predictive control or autonomous indoor inspection.

This work focuses on the state-estimation part of the simulation. It aims to integrate and compare multiple visual inertial odometry algorithms within the Webots simulator. The goal is to explore the literature to find some existing VIO algorithms that are suitable for an integration in simulation. Such algorithms rely on a combination of IMUs and cameras and allow robots to estimate their position and orientation. In this work, methods that are implemented in the ROS ecosystem are preferred to facilitate their integration into the simulation. They are integrated on an independent module of sensors that can then be used as an extension on various robots. Here, tests are focused on a quad-copter model. The performances of the different state-estimates are evaluated, based on the ground truth offered by the simulation environment.



Features' visualization when running ROVIO in simulation.

Five state-of-the-art algorithms, representing the diversity of existing techniques, are reviewed for this project. Two of them are chosen to be integrated in simulation and their performance to be analyzed. The first selected algorithm is ROVIO. It is the less complex reviewed algorithm, which allows to easily setup a correct ROS environment and to test if such state-estimates can be used in simulation. The second algorithm is VINS-Fusion, which allows to see the impact of stereo cameras and SLAM module on the quality of the estimation and the CPU load.



Trajectory evaluation using VINS-Fusion (monocular configuration) in simulation

After reviewing all results, this work shows that state-of-the-art VIO algorithms can be implemented in simulation. The simulation environment has no noticeable impact on state estimators compared to the real world. This means that this kind of algorithms can be used without problem in a complete and realistic drone simulation.

The two algorithms studied and compared each have their strengths and weaknesses. On the one hand, ROVIO is a very low-cost algorithm in terms of computational cost. The estimates are in most cases very close to reality and the RMSE is rarely more than 3% of the evaluated trajectory. However, the algorithm is limited by the depth of the features. Abrupt changes in depth make the estimation difficult. ROVIO performs much better when the features are close and at constant distance, as in indoor scenarios. On the other hand, VINS is much more accurate than ROVIO. The mono configuration is already more powerful and robust to the depth of the features. The SLAM and stereo configurations allow to greatly improve the estimation. However, these performances have a cost, and the algorithm is logically very demanding in CPU resources. VINS also needs an initialization phase before it can be used in closed loop.