Development of a Robust Onboard VIO State Estimate

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Drones rely on state estimation algorithms such as VIO (Visual Inertial Odometry) to calculate an estimate of their state. VIO algorithms are typically used for indoor applications where sensors such as GPS are not available. These algorithms achieved outstanding progress in the field of indoor localization over the last few years, however they are easily affected by environmental conditions such as poor lightning of lack of features.

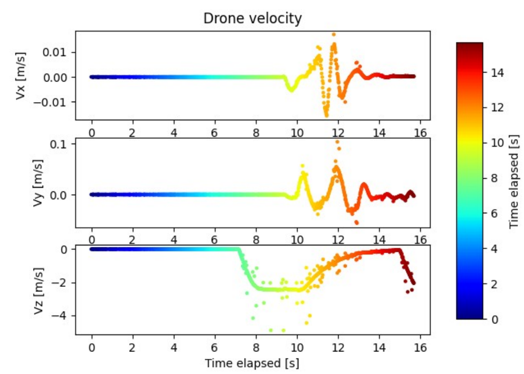
Given a VIO algorithm, Rovio, the goal is to develop a robust onboard state estimate for drones by using sensor fusion and identify ways of making the state estimate more robust in general.

Rovio algorithm in simulation

The first step of this project consisted in running a simulation of the drone in different scenarios in order detect the divergence of the state, to replicate the results of a previous student project and get familiar with the algorithm's behavior. Given prior knowledge on the Rovio library and the way the VIO operates, we focused on three cases where the algorithm diverges:

1) Depth miscalculation
2) Surface uniformity
3) High speed

It was observed, reproducing the results from the previous project, that the algorithm cannot perform in situations where the depth of the features visible to the algorithm cannot be estimated. Such cases include scenarios where the drone is facing very high depths such as the horizon or simply when there are no features with measurable depth present in proximity of the drone. In this case, the drone diverges rather quickly (6-8 seconds).



Drone velocity divergence

We have also observed that, like most VIO algorithms, lack of features is a problem for Rovio because of the constant need of features displacement which the algorithm depends on. This problem can occur when facing very uniform surfaces (or when the drone is flying at night). Problems related to surface uniformity happen rarely as the algorithm can handle cases where very few features are available.

We have also tested the robustness of the algorithm for high-speed applications and observed the weakness of Rovio when flying at high velocities for an extended amounts of time or when dealing with passing object. The divergence in this case is due to an accumulation of bias on the state estimate, mainly on the positional state and on velocities.

Finally, we concluded that Rovio is a performant state estimation pipeline and could reproduce the results from previous projects.

However, the main goal of the project, which was investigating ways of improving the state's stability could not be tackled. Nonetheless, it seems clear a redundant input on the velocity state of the drone could help the algorithm perform better. A potential sensor that could be suitable for fusion is an optical flow sensor.