SS 2023-2024, SMT-ROB, BURDICK-DISAL-MP54 Project Summary

The Autonomous Streamlined Quick Unfolding Investigative Drone - moving into the wild.

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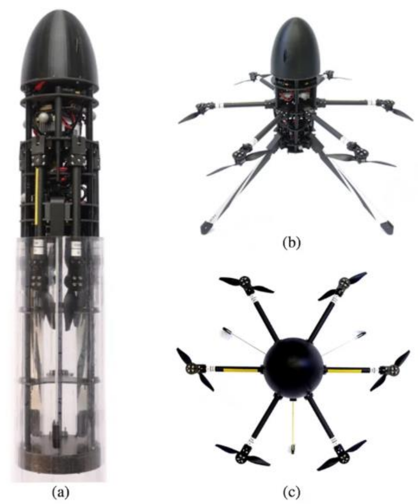
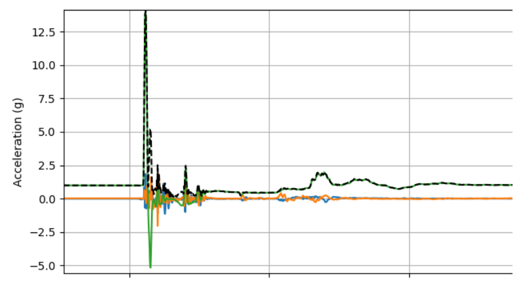
The development of efficient and convenient quadrotors for search and rescue missions has been at the forefront of research in both academic and industrial sectors for the past decades. Such devices are typically small enough to be carried by an operator and quickly deployed near the objective of their mission. However, the traditional rigid body of these UAVs will usually require the operator to clear an area on the ground before safely initiating the takeoff, limiting the potential speed of their intervention in emergency situations. The Streamlined Quick Unfolding Investigative Drone (**SQUID**) offers a solution to this problem by featuring fully foldable arms (to attach propellers) and legs (to land). The folded configuration can then be loaded in a launcher and fired in the sky, actively deploying and stabilizing in flight.



Some difficulties to overcome in the design of such a drone are the ability to respect the tight volume constraints while including the required payload to complete the mission, as well as successfully transitioning from ballistic to flight phase, given that the high accelerations experienced during a launch render some sensors temporarily unreliable. With these challenges in mind, the objectives of my project were twofold :

1. Downsize a previous version of the UAV from a 153mm diameter to a 98mm diameter while keeping most of the capabilities as well as adding actuation on the deployment of the arms.
2. Investigate alternative positioning methods to apply during the launch, namely Visual-Inertial Odometry (VIO) and gyroscope data integration.

Once the downsizing was complete, some VIO positioning tests were carried out using the OpenVINS framework and different camera configurations. It was shown that in absence of accelerometer saturation and with proper initialization, both stereo and monocular cameras, placed either downfacing or sidefacing, can provide a stable position estimate within a few centimeters of the ground truth. However, in real launch situations, the saturation of the accelerometer causes a bad initialization and unusable position data.



Most commercial accelerometer accelerometers will typically saturate at 16g, when the actual acceleration during launch is as high as 23g (extracted from video). Nevertheless, extended testing has shown that, due to the short duration of the saturation (~0.2s), a Kalman filter does a good job at providing a correct position estimate. Furthermore, a temporary attitude estimation using only the gyroscope data for launch is also usable.

Finaly, it was also shown that, despite gaining little height during launch, a delayed deployment of the arms does not prevent successful ballistic to flight transition, and can help protect the propellers if obstacles are within the trajectory.