How to control MAVs in cluttered environments?

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Flying in the vicinity of obstacles while avoiding collisions is a real challenge for micro aerial vehicles (MAV), which have tremendous weight constrains and cannot carry heavy sensors or processors. When compared to classical ranging techniques such as ultrasound, laser, or radar, visual sensors constitute a very promising alternative because cameras can cover a wide field of view without complicated scanning mechanisms or bulky antennas. However, modern cameras feature an overwhelming number of pixels, which requires interfacing to powerful processors to be read and processed in real-time. On the other hand, many insects like flies or bees are capable of impressive flight maneuvers in the vicinity of objects with an amazingly low number of pixels [5], relying mainly on optic flow [3][6].

At EPFL, we got inspired by these flying insects to construct a series of MAVs whose only mission was to remain aloft when facing various kinds of obstacles such as walls, trees, the water surface, or various kinds of terrain. In order to achieve this, we equipped our flying robots with ultra low resolution sensors measuring optic flow in several divergent directions [6][7]. We developed a control strategy called optiPilot [1], which maps these optic-flow signals into roll and pitch commands in a very

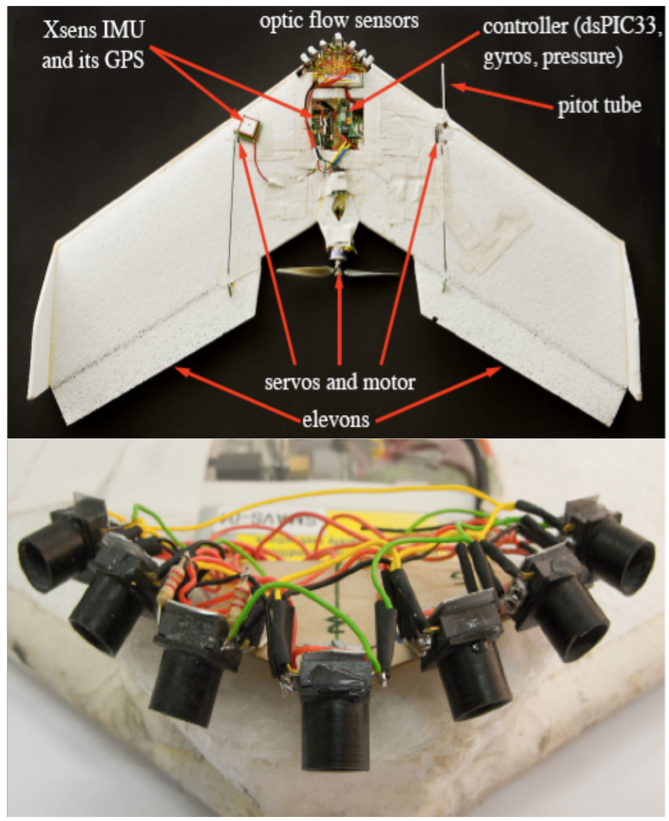

Figure 1 – A swinglet™ equipped with optic-flow sensors. Top: The 400-gram flying-wing is equipped with seven optic flow sensors looking in divergent directions to ensure collision avoidance and flight stability. The IMU+GPS are used to monitor and characterize the airplane behavior, but not for controlling it. Bottom: closer view of the vision system including seven optical mouse sensors with custom-made optics.

efficient way to provide flight stabilization and collision avoidance. After testing this approach on ultra-light indoor MAVs [6][8][9], we recently demonstrated it in natural outdoor settings using a series of optical mouse sensors as optic-flow detectors (figure 1).

In this talk, we will describe the optiPilot strategy before introducing the recent results obtained with it [1][2]: automatic take-off and landing, terrain following, obstacle avoidance, and GPS-steered path following. We will conclude with some thoughts about how this technology can be turned into a commercial product.

References

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