Optical flow based navigation for a VTOL UAV

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The last few years have witnessed an increased interest in small autonomous flying systems, endowed with hovering capabilities (VTOLs), and able to operate in cluttered environments. In both the civilian and military domains, the underlying possibility for an unmanned aerial vehicle to easily move around embarked sensors (like cameras) would give rise to new working methods in such diverse domains as surveillance (of forest fire, traffic), exploration (deported vision for soldiers, investigation of dangerous sites), or inspection of vertical infrastructures, leading to fewer casualties (military domain, surveillance) and cost reductions (inspection).

In this talk we focus on aerial robotic task involving interaction of a VTOL robotic vehicle with its environment. Navigation and control strategies in partially known or unknown environments is a central issue in the area of field robotics.

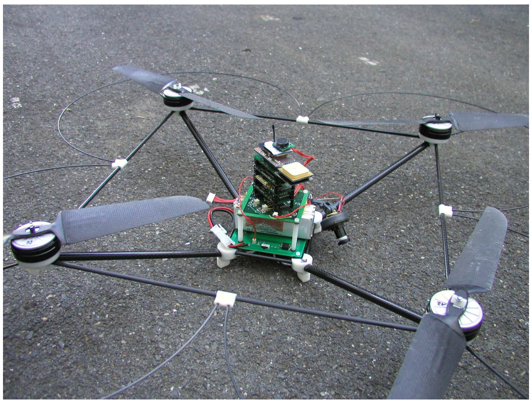

Figure 1. The quad-rotor UAV (CEA List)

The development of aerial robotic vehicles raises a number of unique problems in sensing and control. A key challenge is to develop simple controllers that robustly stabilize the system, relative to the local environment, using a minimal sensor suite. In this context, the typical sensor suite embedded on a light weight VTOL UAV consists of an Inertial Measurement Unit (IMU) for attitude estimation, and a camera providing information about the environment.
Commonly a hierarchical control strategy is employed and the attitude is considered as an actuator input dynamics for the translation dynamics of the system [1, 8]. High quality sensor output is important for the system performance and different works have shown that complementary filtering technique provides high quality estimation of the attitude [10, 5]. Once high bandwidth quality estimates of the attitude are available then the attitude control problem can be approached using any of the established control methodologies in the literature [8, 1].
Using a camera as the primary sensor for relative position leads to a visual servo control problem, a field that has been extensively developed over the last few years [8]. An alternate approach for the motion autonomy uses insight from the behaviour of flying insects and animals to develop control strategies for aerial

robots, in particular, techniques related to visual flow [4, 7, 2]. In this talk we propose a control strategy based on the measurements of the translational optical flow [3, 11] to perform robotic tasks such as performing smooth vertical landing or terrain following along with a guarantee that the vehicle will not collide with the ground during transients. Global proof of stability of the nonlinear control schemes and discussion of their robustness to noise and uncertainties will be considered. Finally we present some simulation and experimental results to demonstrate the performance of the control approach.

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