3D Tracking and Mapping using Cooperative UAVs

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I. Overview

In applications such as search and rescue [1], surveillance/picture compilation [9] and planetary exploration [8], where a high degree of maneuverability/vehicle speed and large area coverage ability is required, the use of multiple autonomous airborne vehicles has gained a great amount of interest. In these tasks, the vehicle is often required to operate over unknown terrain, where navigation grade terrain maps are unavailable and where GPS signals may be denied. Un-aided Inertial Navigation Systems (INS) could be used, however the high-cost, weight and power requirements of the necessary unit plus the limited operational time due to the eventual growth in system errors is prohibitive to many projects. Instead, a low-cost INS can be used on each UAV where the INS errors are corrected using a terrain sensor on each UAV that performs online generation of a map of the previously unknown environment; the now well known paradigm of Simultaneous Localisation And Mapping (SLAM).

There have been several demonstrations of SLAM for airborne vehicles [5], [4], [6], [3], [2], [7]. Our interest is in using a single, monocular vision camera and inertial sensors to perform SLAM over a large-scale area. This task is complicated by several factors. The fast-moving dynamic motion of the platform means that the vehicle's pose must be tracked in six degrees of freedom (the vehicle makes large rolling and pitching motions) and features may only be within the field of view of the camera for a short period of time. The available baseline for stereo cameras is very small on an aerial vehicle; we are therefore required to use a monocular camera which has several associated difficulties in feature extraction, data association and feature position initialisation. The vehicle operates over large areas which creates issues with filtering and data fusion consistency; real-time smoothing algorithms must be implemented to ensure accuracy in the localisation and mapping estimates. Finally, multi-UAV data fusion algorithms are required in order to share terrain information across several UAVs operating as a team over their environment.

In this presentation we show results from our continual development towards a cooperative airborne SLAM system. Previous work has focussed on the use of sparse point features [5], [2] in the generated map, where as in the current work we are developing methods for generating dense 3D terrain maps with more rich and useful information for UAV mapping missions. Secondly, we concentrate on the use of real-time smoothing algorithms in order to provide consistent, robust and reliable localisation and mapping estimates. Thirdly we focus on multi-UAV data fusion and control algorithms for a team of cooperating UAVs in a SLAM mapping mission. We present both simulation and real-system results from a team of Brumby Mk III UAVs operating over a remote, arid area of the Australian outback.

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