SMALL SATELLITE MISSIONS SYMPOSIUM (B4)
Design and Technology for Small Satellites - Part 1 (6A)

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ROBUST CONTROL AND PATH PLANNING ALGORITHMS FOR SMALL SATELLITE FORMATION FLYING MISSIONS

Abstract

Small satellites are highly suitable for formation flying missions, where multiple satellites operate together in a cluster or predefined geometry to accomplish the task of a single, conventional large satellite. In comparison to traditional large and expensive satellites, small satellites offers low development cost as it enables use and reuse of commercial off the shelf components in less time. However, collision free navigation and control of these satellites is a challenging problem. Moreover, the space debris also poses treats to these small satellites. The recent unprecedented collision of a US, commercial Iridium communications satellite and a defunct Russian satellite strongly emphasise the need for intelligent and robust control systems for satellites. Autonomous collision-free reconfiguration is a challenging task and needs to be accomplished with minimal use of on-board power. The propulsion system is one of the key subsystems that determine the cost and lifetime of the mission. Spacecraft propulsion utilising naturally available electrostatic forces is an emerging technology and is not fully proven to be suitable for a realistic mission. Advancement in this field would be a major breakthrough in propulsion technology. This motivates us to use electrostatic propulsion in combination with electric propulsion for small satellite formation flying missions. The major focus of this study is on improving the on-board intelligence for autonomous navigation and control using a fuel-efficient propulsion system. A robust control algorithm using output feedback sliding mode control is proposed for formation flying and reconfiguration. Intelligent path planning algorithm is designed using Artificial Potential Field (APF) method, which is widely used for collision avoidance of mobile robots. This paper presents how satellites in the formation can aggregate towards a goal position, similar to biological swarms (flocks of birds, schools of fish etc) and then takes up positions to form a predefined formation. Based on the knowledge of current position, the proposed fast output sampling sliding mode controller would optimise the trajectory to generate the next desired formation. Since sliding mode control guarantees robust performance, the impact of external perturbations like solar wind and internal perturbations like change in mass due to fuel consumption will have negligible impact on the performance of the satellite. In this study, initially homogeneous and heterogeneous formations of 3-10 satellites would be considered followed by distributed systems or swarms (¿ 10 satellites). It is envisaged that the results presented in this paper would enable to advance the current state-of-the-art of small satellite formation flying technology, in addition to enhancing controller performance for a realistic mission scenario.