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Author: Mr. Ravi Nallapu
University of Arizona, United States

Prof. Jekanthan Thangavelautham
University of Arizona, United States
Prof. Erik Asphaug
University of Arizona, United States

TOWARDS END TO END DESIGN OF SPACECRAFT SWARMS FOR SMALL-BODY RECONNAISSANCE

Abstract

Understanding the physics of small bodies such as asteroids, comets, and planetary moons will help us understand the formation of the solar system, and also provide us with resources for a future space economy. Due to these reasons, missions to small bodies are actively being pursued. However, the surfaces of small bodies contain unpredictable and interesting features such as craters, dust, and granular matter, which need to be observed carefully before a lander mission is even considered. This presents the need for a surveillance spacecraft to observe the surface of small bodies where these features exist. However, there are more than 2-million small-bodies in the solar system and sending a large dedicated spacecraft to each body is intractable. A better solution is needed

While traditionally, the small body exploration has been performed by a large monolithic spacecraft, a group of small, low-cost spacecraft can enhance the observational value of the mission and reduce cost. The challenges experienced for large spacecraft include getting into orbit around a small-body and making the right maneuvers to perform reconnaissance. In contrast, it should be noted an individual small spacecraft is quite limited by propulsion, attitude-control, communications and mission life, however a large number working cooperatively can make up for individual limitations.

In this work we propose the development of Integrated Design Engineering Automation of Swarms (IDEAS) software. IDEAS is a machine-learning based end to end automated design and control tool for conceptual design of spacecraft swarms. Using IDEAS we have been developing swarms of small-spacecraft to tackle some of the challenges of planetary mission design.

In particular we have found that swarms of flyby spacecraft maybe configured to optimize area-coverage mapping of a small-body. It may even be possible to obtain nearly 100% area coverage of small-body under desired lighting conditions. Furthermore, we have extended that approach to perform co-orbit missions to small moons in planetary systems. In this work we also look at how swarms of spacecraft can cooperatively enhance their communications capability by locking their antennas into a phase array. Through this configuration, the spacecraft are cooperatively transmit data to ground station at higher data rates. All of these capabilities are possible thanks to the dynamic reconfigurability of a swarm of spacecraft.