

Trajectory design for asteroid surface mapping missions with flybys of spacecraft swarms

Ravi teja Nallapu

Abstract

Asteroids are being actively studied with multiple motivations, which include hazard monitoring, potential resource for interplanetary missions, and insights on the evolution of the Solar system. With the asteroids being actively pursued by the science and engineering communities, missions to asteroids are highly desirable.

However, the dynamics of spacecraft motion around asteroids are quite complicated. The source of these complications can be attributed to three factors: Firstly, the asteroids are irregularly shaped objects, so the gravity potential is complicated. This makes the motion of the spacecraft non-Keplerian. Secondly, the magnitude of gravity is small, which means that the spacecraft has to be close to the asteroid to be under the influence of the asteroid's gravity field. The third complication arises from the trajectory perturbation arising due to the solar radiation pressure. With the complications laid out, any trajectory of any mission needs to accommodate these concerns.

While existing literature has focused heavily on asteroid rendezvous, surface operations, and escape trajectories, limited literature exists on proximity operations around asteroids. This work discusses the spacecraft trajectory design near the vicinity of asteroids which include orbits and flybys. The work proceeds by analyzing the equations of spacecraft motion around the asteroid to obtain stable trajectories. Among these stable trajectories, an optimal trajectory can be selected to meet the mission objectives. This is demonstrated by designing optimal trajectories to an asteroid for a surface mapping mission.

This work lays a systematic foundation to the trajectory design problem around asteroids, and shows potential to be easily scaled to design optimal trajectories for a constellation of spacecrafts. Future versions of this work aim to address the coupled attitude and trajectory control of such a constellation for an optimized objective performance.