Autonomous, Objective-Based Trajectory Planning for Asteroid Orbiters

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Abstract

Conventional trajectory design techniques for space exploration missions rely strongly upon Kepler’s analytical description of orbital motion about a single spherical body or upon special classes of trajectories that are well-studied for the case of two such bodies. However, these techniques do not generalize well to the case of asteroids and comets – small bodies of high scientific value – due to the strongly unintuitive and non-periodic orbital motion produced by their irregular gravity fields. To overcome these limitations, an alternate approach to trajectory design is explored that employs techniques from robotics, non-linear control, and AI path planning. Sampling-based planning is conducted via heuristic search of a control domain that represents a set of single-impulse spacecraft maneuvers, efficiently identifying actions that produce high performance in terms of science objectives and safety constraints. Implementation of this design scheme in a receding-horizon manner with a cost-to-go heuristic ultimately produces low-frequency control sequences and resulting complex motion that enable ambitious close-proximity science operations while mitigating substantial estimation errors characteristic of small body missions.

Bio

After receiving his Bachelor’s degree in Aerospace Engineering from Texas A&M University in 2011, David began his graduate studies in orbit mechanics under the guidance of Professor Dan Scheeres at the University of Colorado, where he is now a PhD Candidate. Since 2012, he has received support from NASA’s Space Technology Research Fellowship to develop automated mission design techniques for asteroid and comet missions. During an internship in 2014, he served on a small orbit determination team at NASA JPL to support ESA’s comet-rendezvous mission Rosetta through critical phases including close observation and lander deployment.