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OPNAV-ONLY STATION KEEPING ON NRHO USING STOCHASTIC PREDICTIVE CONTROL

Abstract

In this work, we develop an autonomous spacecraft navigation and control solution for station keeping on near rectilinear halo orbits that do not rely on communication with Earth. Spacecraft autonomy is becoming a critical need, both from a mission safety standpoint in case of communication failure with Earth, as well as a scalability standpoint as the number of deployed spacecraft increases dramatically in the coming years. Autonomy is of particular importance in deep space, where communication (and thus, navigation) relies on NASA's Deep Space Network (DSN), which will need to be rationed, or where links to DSN can fail (see, e.g., the recent CAPSTONE mission). As spacecraft activity builds on the near rectilinear halo orbit (NRHO) that the Lunar Orbital Platform - Gateway (LOP-G) will fly, autonomous navigation and station-keeping control methods that do not rely on DSN are required. We have developed an autonomous navigation and control solution using horizon-based optical navigation (OpNav) measurements of the Moon, a state estimator based on a nonlinear Bayesian filter, and a stochastic targeting-based station-keeping (SK) control algorithm. Whereas most NRHO station-keeping algorithms choose to thrust near apolune due to the sensitivity of the dynamics around perilune, the stochastic control algorithm optimizes the thrust firings to occur at periods of highest confidence in the state estimate, and such that a measure of predicted uncertainty is minimized, while also avoiding the sensitive region around perilune. We will present the results of a closed-loop simulation with an ephemeris-based high-fidelity dynamics simulator, a synthetic rendering engine that visualizes the Moon with epoch-accurate lighting, and our navigation and control software.