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Author: Mr. Samuel Fedeler
Colorado Center for Astrodynamics Research, University of Colorado, United States,
samuel.fedeler@colorado.edu

LUNAR OBSERVER EFFICACY FOR NRHO TARGET TRACKING

Abstract

Maintaining tracks on space objects in the cislunar regime is a critical problem as more objects populate the region. An optimally convergent decision-making methodology was previously developed for sensor tasking using Monte Carlo Tree Search [Fedeler, 2020]. This abstract proposes the utilization of Monte Carlo Tree Search to evaluate the observational capacities of several lunar surface observers. Observers shall track targets in Near Rectilinear Halo Orbits (NRHOs) nearing the planned trajectory for the NASA Gateway. Lunar surface observers are beneficial in that they offer a solution to a key problem for cislunar observation using terrestrial optical observers. Specifically, it is challenging to observe cislunar targets when the moon is illuminated because it greatly increases the noise floor in imagery. Lunar observers avoid this dilemma and offer a variety of viewing geometries for targets in Halo orbits.

This study will apply analytic sensor models to accurately simulate detection probabilities for optical observers using the methods of [Coder, 2016]. Initial analysis will be performed considering the effectiveness of a variety of optical sensors in order to determine target accessibility throughout the lunar synodic period. Lunar observers will be placed at the lunar north and south poles, in regions that would offer both access to NRHOs and lines of communication with Earth.

Targets are treated as cannonball models of randomly swept surface areas and albedos, with randomized initial phasing about reference orbits. Studies are performed using the circular restricted three-body problem, and in order to properly evaluate observers, it is assumed that these dynamics sufficiently approximate the time evolution of target state uncertainties. Two simulations will be considered, each using 100 targets; in the first, targets shall follow periodic orbits over a synodic period. In the second, targets will perform stationkeeping maneuvers, leading to a challenging state estimation problem. For the first case, an unscented Kalman filter is deemed a sufficient estimator, but in the second case, the unscented Optimal Control-Based Estimator shall be applied [Lubey, 2014].

Results shall be evaluated in several ways. Estimation performance and target accessibility metrics shall be used. A key result will evaluate necessary observation cadences, and a minimum necessary observation frequency will be determined, below which filter divergence occurs. These results will support future missions considering the installation of lunar observers and offer a solution to the problem of space domain awareness in an increasingly dense environment.