ABSTRACT

Motion Planning for Multi-Spacecraft Interferometric Imaging Systems

by

Islam I Hussein

Co-Chairs: Anthony M. Bloch and Daniel J. Scheeres

The use of multiple spacecraft formations to form interferometric images offer many advantages, including replacement of large monolithic telescopes, superior angular resolution and the possibility of reconfiguration for different imaging goals. These capabilities are all relevant to various NASA missions under the Origins program. This work focuses on designing space-based formations for improved image quality using the fundamental concept of the modulation transfer function (MTF). A derivation is given of the MTF for sparse aperture interferometric imaging systems under some stated assumptions. The MTF is then used to design free-flying and rigid observatories.

In a free-flying formation, the spacecraft are viewed as a set of N rigid bodies evolving on a manifold M designed to achieve improved focusing properties. This leads to a study of the formation on the special Euclidean group SE(3) and its subgroups (SO(3) and $\mathbb{R}^3$) subject to some motion constraints. Various constrained optimal control problems are formulated to achieve minimum fuel expenditure while meeting imaging specifications such as high image quality and improved angular resolution. Necessary conditions are derived, which provide further insight into the properties of an optimal formation. Finally, the study is reduced to a class of two-spacecraft spiraling maneuvers, for which the global optimal solution is obtained. In a rigid formation, on the other hand, the relative position between a spacecraft pair is fixed in magnitude. An Earth-orbiting observatory that satisfies the necessary conditions, with the potential to be implemented in future Origins missions, is proposed and studied.