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PARTICLE SWARM OPTIMIZATION BASED TRACKING WINDOW PLANNING FOR CISLUNAR ORBITERS PERFORMING AUTONOMOUS RADIOMETRIC NAVIGATION

Abstract

Recent years show that there is a growing interest in lunar missions. Especially small satellite missions will play a key role due to piggyback launch opportunities and availability of data relay satellites around the Moon. In general, ground-based radiometric tracking is the working horse for establishing the necessary navigation solution. However, ground-based tracking could be expensive while the development of these small satellites is expected to be at low-cost. In addition, there will be constraints of such as limited on-board power available for data transfer. For such cases, autonomous navigation could provide a possible solution.

Up to now, there have been various autonomous orbit determination (OD) methodologies and one of them is called Linked Autonomous Interplanetary Satellite Orbit Navigation (LiAISON) using satellite-to-satellite observations to estimate not only relative, but also absolute spacecraft states. The OD performance of the method depends on various factors: observation type, accuracy, precision, and, most importantly, relative geometry between spacecraft. Basically, it is crucial to know when to collect the most useful observations to optimize the outcome of the navigation filter. Even though it is better to equally distribute measurements over the full orbit, in some cases it is not possible to track each spacecraft all the time due to various problems. In some cases, the tracking window could be nothing but the telemetry window if payload data has been transferred along with the ranging code, or if telemetry data has been used for the OD purposes. In these cases, the problem turns into finding the best tracking/telemetry window.

This study proposes a new particle swarm optimization (PSO) based tracking window planning for cislunar orbiters performing autonomous radiometric OD. It has been shown that PSO provides a near-optimal solution for the tracking windows considering constraints arising from spacecraft itself or from the design choice. Basically, PSO provides the near-optimal tracking windows by minimizing the overall OD error. The proposed algorithm can be used in advance on the ground to plan tracking/telemetry windows. This algorithm including the PSO implementation could be useful for the complex formation design such as network topologies consisting of more than two spacecraft. In addition to the proposed method, there will be a discussion on the on-board implementation, decision making and how to plan tracking windows on-board for the redundancy. The results presented could contribute to mature the design of satellite formations performing autonomous OD and to obtain cost-effective solutions for mission planning.