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RELATIVE NAVIGATION OF SATELLITE SWARMS

Abstract

Satellite swarms have received great interest in the past decade, motivated by providing global internet connectivity to Earth, exploring asteroid belts, space-based IoT and ultra-long wavelength radio astronomy. For example, OLFAR (Orbiting low-frequency satellite array) is a project which aims to launch 50 or more cubesats for space-based radio astronomy, to be deployed far away from Earth. In such large swarms comprising of tens of satellites, localization of each individual satellite using Earth-based stations may not always be possible due to various practical constraints.

Firstly, due to distant deployment locations, resource constrained cubesats may not be actively available for Earth-based communications. Secondly, due to the sheer number of satellites and limited availability of the ground-station, accurate localization and time correction would be a challenge. Finally, in some missions, the satellite swarm maybe completely disconnected from Earth-based GPS satellites and other communication systems, for e.g., the preferred deployment location for the OLFAR mission is on the far-side of the Moon.

One of the fundamental challenges of such GPS-denied (and Earth-communication limited) satellite swarms, is the relative navigation of the satellites. Localization of the satellites, and synchronization of their respective onboard clocks is vital for coherent data collection, inter-satellite communication and for collision avoidance. How can the satellites cooperatively localize their relative positions and synchronize their clocks relatively, without an external reference?

In this paper, we will review state of the art in terrestrial relative navigation, which can be readily applied to satellite swarms. We discuss the benefits and limitations of employing such techniques, and explore the feasibility of these methods for space-based systems. We will use OLFAR as a use case to evaluate the various methods.

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