Paper ID: 2983
student

SPACE EXPLORATION SYMPOSIUM (A3)
Space Based Astronomy (4)

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# OPTIMAL INTERFEROMETRIC MANEUVERS FOR DISTRIBUTED TELESCOPES

**Abstract**

The scientific community has proposed several interferometry missions like Stellar Imager (NASA) and Darwin (ESA) to expand our knowledge about the universe and search for distant Earth-like planets. Synthetic-imaging space-based interferometers, consisting of multiple telescope apertures flying in controlled formation in order to combine received information from each of the flotilla members are nowadays the subject of interesting research. These interferometric procedures can overcome the present angular resolution limits. Obtention of images with high angular resolution, low ambiguity and high intensity is always traded with fuel consumption; this trade is the main interest of this research.

The design of interferometric maneuvers and optimal interferometric controllers must balance image performance and energy consumption, which are the key aspects of any space-based observation mission. Different kind of coordinated spirals have been designed and tested onboard the ISS using SPHERES, a formation flight facility designed by the Space Systems Laboratory (MIT). The facility consists of three self contained nanosatellites. It enables testing and validation of formation flight algorithms in a representative microgravity environment.

The first objective is optimization and implementation of coordinated spiral maneuvers with emphasis on their interferometric interest (minimum fuel consumption when filling completely the image-frequency plane). These tests permit the comparison of fuel consumption in real space conditions between different algorithms like *Stop and Stare* and *Drift Through* maneuvers. Analysis of these results confirm the capability of designing and implementing coordinated maneuvers between more than two spacecraft and ascertain the theoretical high interest of *Drift Through* maneuvers in terms of fuel consumption.

The second goal of this research is the resolution of an optimal control problem within the LQ framework, to determine the optimal imaging reconfiguration of a formation flight system. Its objective is to balance the quality of the celestial observation and the usage of fuel without being restricted to a specific trajectory. Two new optimal controllers have been designed: an *Optimal Incremental Controller* and a *Position Redefining Controller*. The first controller achieves less than 0.01 $W/m^2$ (mean square image quality error) for more than 4 reconfigurations and has a monotonically decreasing error. On the other hand, fuel savings of more than 50% are achieved with errors of image metrics of less than 5% when using the second designed controller. This leads towards improvements in mission lifetime and flexibility of any distributed space-based observation system.