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APPLICATION OF SMART SENSORS AND ACTUATORS FOR SPARSE APERTURE

Abstract

Imaging satellites with large aperture space mirrors at a higher altitude would provide greater resolution and a large field of view. Developing cost-effective large aperture space mirrors in the size of 10-30 meters is a challenging task due to many reasons. A sparse aperture system has long been considered as a viable approach for large aperture in space. A sparse aperture system consists of multiple satellites in orbit with smaller apertures. The light collected with each aperture is coherently combined to provide the imaging resolution equivalent to a single large aperture system. The concept is attractive because it allows the use of small satellites. However, it has many technical challenges, such as having these satellites maneuvering accurately in satellite formation, metrology system to measure errors in satellite formation in few nanometers and correct them to achieve coherent combination. In order to achieve this accuracy smart sensors and actuators are needed. To demonstrate sparse aperture concept, a testbed has been developed at the Naval Postgraduate School (NPS). This paper will present the results of this research.

In NPS sparse aperture testbed, a white light source reflected off an USAF resolution test target is collimated by a parabola and sent to three sparse spherical mirror arrays on separate 6 axis motion stages to simulate on-orbit motion. In order to measure the motion of the sparse aperture in nano-meters range, a laser metrology system consisting of nine (9) single-axis displacement interferometer was employed. The laser interferometer probes the displacements of three corners of each spherical collector mirror. Light from collector mirrors is optically relayed to the combiner platform, where each beam is reflected off a flat mirror mounted on a PZT tip/tilt/piston stage to correct the aberration caused by satellite formation motion. Transformation matrix is developed, which represents the relationship between the collector mirror motions measured by the laser metrology system and required correction by the piston/tip/tilt stages. The coherently combined light is then reflected to CCD imaging camera. The test bed demonstrated the sparse aperture concept that sparse mirrors were moving in satellite formation and images from them were combined coherently and stable.