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A MOTION CAPTURE SYSTEM FOR DYNAMIC BEHAVIOR MEASUREMENT OF DEPLOYING PANELS AND HINGE STIFFNESS OPTIMIZATION IN DELIGHT MISSION

Abstract

JAXA is developing the technologies to construct huge space structures such as Space Solar Power Systems (SSPS). Our current research goal is to build a 30m-class square planar antenna as a building block for larger space structures. We propose a sequential construction method for building a 30m-class planar antenna by deploying lightweight panels row by row using two key technologies: deployment/connection mechanisms and lightweight planar antennas. We have planned a DELIGHT (DEployable LIGHTweight planar antenna technology demonstration) mission to verify these technologies. In the DELIGHT mission, eight 1 meter square panels with deployment/connection mechanisms will be deployed in two rows from HTV-X, the new unmanned spacecraft now being developed by JAXA, and dynamic behavior during deployment will be measured using cameras to obtain data for correlating with a dynamics model.

To measure dynamic behavior, we developed a vision-based motion capture system that includes three cameras installed so that the visual field covers the envelope of motion of the panels and three types of fiducials installed on the panels for selective use based on posture and distance from the cameras. We constructed a visual field simulator with models of the cameras and panels with fiducials and determined how to arrange the fiducials on the panels by evaluating their visibility on the simulator.

In addition, we optimized the hinge stiffness parameters between the panels, which determine deployment behavior for better measurements. We integrated a panel dynamics simulator into the visual field simulator and enabled the evaluation of the measurement performance of the motion capture with respect to the hinge stiffness values. The conditions under which motion can be measured depend on the visual fields of cameras, distance between the cameras and panels, occlusion by the panels in the foreground, viewing angle of the cameras, and number and geometry of visible markers. Optimal hinge stiffness values that satisfy the above conditions as much as possible were obtained using Bayesian optimization with inequality constraints. We obtained the optimal stiffness values which achieve less than 1 % frame loss of the motion capture system by searching less than 1/1000 of the total number of searches.

This paper shows the details of the developed motion capture system and the ground test results through which the deployment angle measurement accuracy of 2 deg at 30 Hz were verified, along with the integrated visual field simulator and the optimization method.