IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures - Dynamics and Microdynamics (3)

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GROUND-BASED HIGH-DOF AI AND ROBOTICS DEMONSTRATOR FOR IN-ORBITS SPACE OPTICAL TELESCOPE ASSEMBLY

Abstract

Astronomists and cosmologists demand larger (mirror diameter $> 10m$) space optical telescopes to investigate more distant events happened during the very early period of the universe, for example formations of the earliest starts. The deployable telescope design like James Webb Space Telescope which has a $6.5m$ diameter primary mirror has already reached the capacity limits of the existing launch vehicles. Therefore, the space industry has been considering using robotic technologies to build future larger space optical telescopes in orbits from smaller mirror segments.

One of the design paradigms is to use a high-DOF manipulator on a pseudo-fixed or free-flying platform to build the optical telescope in orbits. This approach requires high precision and accuracy in the robotic manipulation GNC system which has several challenges yet to be addressed: 1. Orbital environmental parameters, such as lighting can affect sensing and perception; 2. Disturbances and uncertainties caused by orbital dynamics, occlusion and sensor noise can affect accuracy and precision of the manipulation and capturing system.

To investigate these problems for in-orbits manipulation, the UK national hub on future AI and robotics for space (FAIR-SPACE) at Surrey Space Centre (SSC) has being developing a ground-based hardware-in-the-loop (HIL) robotic demonstrator to simulate in-orbits manipulation. The key elements of the demonstrator are two 6-DOF manipulators and two RGB-D cameras. One of the manipulators with a $>$ 3-DOF gripping mechanism represents the assembly manipulator on a spacecraft that the orbital dynamics, kinematics, and environmental disturbances and uncertainties are propagated in a computer. The other 6-DOF manipulator with a torque/force sensor is used as a gravity offload mechanism to carry the space telescope mirror segment. The relative motions between the service/manipulation arm and the mirror segment are computed and then executed by the second arm. The two RGB-D cameras provide visual feedback of the end-effector and use machine learning to estimate the pose and position of the mirror segments respectively. The demonstrator aims to do verification and validation of the manipulator assembly approach for future large space optical telescope against ground truth and benchmarks.

This paper introduces the design of the demonstrator and operation of the gravity offload manipulator, explains the modelling method of orbital disturbances and uncertainties and how to apply them to the demonstrator, and finally presents the potential demonstrations and experiments will be carried out.