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DESIGN AND EXPERIMENTAL RESULTS OF A DUAL-ARM PLANAR AIR-BEARING PLATFORM FOR ISAM MISSIONS

Abstract

Experimental validation platforms are critical for developing Space Robotic Manipulators (SRMs) which require advanced control algorithms to execute precise tasks. The development of these algorithms is crucial for the feasibility of In-Orbit Servicing, Assembly, and Manufacturing (ISAM) missions. This work discusses the design, development, and testing of a new dual-arm robotic air-bearing platform to be used for such work.

Air-bearing platforms are proven to be a cost-efficient, reliable, and accurate solution for simulated microgravity environments with at least three degrees of freedom. While numerous air-bearing platforms have been built in recent decades, we present a platform that hosts multiple robotic manipulators to explore and validate SRM capabilities. The test platform is qualified with the following experiments, with initial results discussed in the paper:

1. Demonstration of the effectiveness of disturbance-free robotic arm path planning algorithms by considering the induced base motion from robotic arm movements.
2. Performing simulated repair, assembly and manufacturing tasks on the Client Space Object (CSO) such as installing Orbital Replaceable Units and deployment and assembly of dummy solar panels.
3. Docking with a CSO using a robotic manipulator with a docking-port end effector.

Mechanically, the platform is levitated by four air bearings and actuated by four cold-gas thrusters and one reaction wheel. The platform allows two robotic arms to be mounted, while the current configuration has two 3-degree-of-freedom robotic arms installed that perform planar motion. An Optitrack V120 Trio system is used to determine the platform's current pose.

A Jetson Orin NX is selected as the on-board computer, allowing in-situ testing of various machine-learning-based algorithms for different purposes including state estimation, control and localisation. At the embedded level, an Arduino Mega 2560 is used to serve as the microcontroller of onboard actuators with real-time control.

This work is part of a broader project at The University of Sydney developing technology for ISAM missions in collaboration with leading Australian space companies. This paper contributes to the long-term sustainability of ISAM missions by detailing a testbed for algorithm development that will ultimately improve the safety and autonomy of in-orbit services.