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Robotic Manipulation Testbeds with HPSC

Abstract

Interoperability and scalability of robotic manipulators will be key to develop and sustain a lunar surface and cislunar ecosystem. From in-space servicing, assembly, and manufacturing (ISAM) to logistics, maintenance, and science operations, robotic manipulation is a critical NASA capability need and the demand for high-performance spaceflight computing will only rise as robotic tasks become more autonomous. With increased complexity, testbeds for research, feasibility studies, and technology demonstrations will be essential. **The Dexterous Robotics Team at NASA Johnson Space Center has established multiple robotic manipulation testbeds taking a supervised autonomous remote operations approach and plans to infuse High-Performance Spaceflight Computing (HPSC) to emulate the flight environment and close the gap between space technology development and flight operations.**

Integrated Mobile Evaluation Testbed for Robotic Operations (iMETRO) - JSC

The iMETRO facility located at Johnson Space Center is a new testbed for robotic manipulation research centered around human spaceflight. It features multiple robotic manipulation assets, mockups of various crew interfaces used in the planned Moon to Mars Architecture, and a remote operations capability.

Currently, the testbed runs state-of-the-art Robot Operating System (ROS) 2 software to perform supervised autonomous robotic manipulation tasks that require onboard perception and motion planning as well as real-time command and control of robotic hardware.

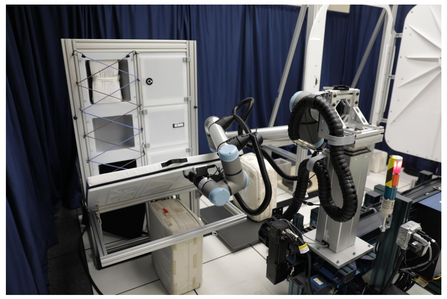

Figure 1: iMETRO robotic asset autonomously lifting a mockup of a lunar habitat bench seat to access a cargo transfer bag (CTB).

One robotic asset consists of a UR10e manipulator mounted to a telescoping lift and linear rail system. All three actuation systems are integrated to perform complex robotic tasks and must execute motion in a precise and coordinated manner. **Integrating HPSC evaluation boards with this robotic asset to act as the onboard computer will provide an opportunity to benchmark the coordinated and simultaneous real-time control of multiple actuation systems.**

Lunar Assembly and Service by Autonomous Robotics (LASAR) - MSFC

The LASAR Early Career Initiative project funded by NASA Space Technology Mission Directorate (STMD) aims to perform autonomous laser beam welding on structural joints designed by Langley Research Center (LaRC) using a robotic manipulator within Marshall Spaceflight Center's (MSFC) V20 thermal vacuum chamber.

The 6 degree of freedom robotic manipulator is developed by Motiv Space Systems and is planned to be delivered in November of 2024. It will operate at temperatures between 0 and 40 degrees Celcius at vacuum and will include a laser beam welding tool and monocular camera at the end effector.

The robotic autonomy software will be written by PickNik Robotics in collaboration with NASA Johnson Space Center's (JSC) Dexterous Robotics Team. It will feature a Robot Operating System (ROS) 2 interface to command the manipulator and PickNik Robotic's MoveIt Pro software as the operator interface. The system will be able to perceive its environment, plan a motion/path according to a calculated trajectory, and precisely follow the planned trajectory autonomously to perform the welding/assembly objective

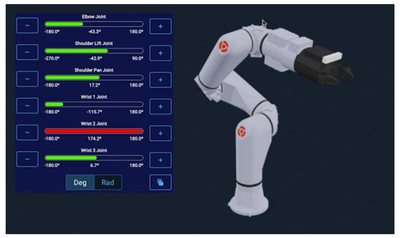

Figure 2: Motiv Space System's xLink robotic manipulator inside PickNik Robotic's MoveIt Pro software. (Source: https://picknik.ai/pro/scan-pick-and-place)

LASAR and MSFC's robotic manipulation testbed in TVAC will be the first deployment of the HPSC evaluation boards targeting robotic manipulation. The project plans to cross compile ROS 2 software for the RISC-V architecture and develop RS-485 drivers to communicate to the robotic manipulator. Pass-through wires will be used to allow for the HPSC evaluation board to operate outside of the TVAC chamber.

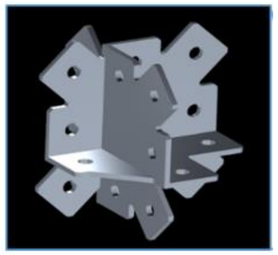

Figure 3: Artist's depiction of an autonomous robotic laser manufacturing platform on the Lunar surface (left panel); LASAR will demonstrate laser welding to join slotted "Snowflake" joints developed by NASA Langley Research Center (right panel).

Electric Dexterous Manipulator Testbed (eDMT) - JSC

The eDMT is a robotic platform configured to simulate International Space Station (ISS) Special Purpose Dexterous Manipulator (SPDM) actions. It allows engineers to perform robotic operations on Earth that emulate the SPDM end effector and arm motions prior to mission execution on ISS.

Operations for it include testing a payload's robotic interfaces and establishing acceptable visual cues. It also tests clearance monitoring for robotic operations and evaluates whether a payload will perform as expected on-orbit.

Integrating HPSC evaluation boards with the eDMT will allow for accurate testing of payloads and robotic interfaces currently used on ISS with flight forward compute hardware and with medium payloads up to 70 kilograms and large payloads up to 165 kilograms.

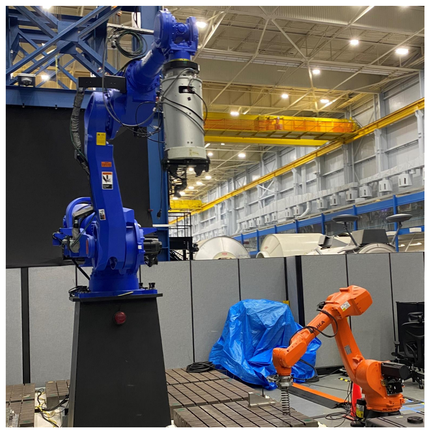

Figure 4: Medium and large payload robotic manipulators (Blue Yaskawa Motoman ES165 and Orange Kuka KR70). The large payload manipulator features the Orbital Replacement Unit/Tool Change-out Mechanism (OTCM) end effector used on the SPDM on ISS.

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