Development of a Modular End-Effector System and Mapping for Autonomous Robotic Maintenance and Repair of Resilient Extraterrestrial Habitats

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Abstract

As the future of mankind lies in space exploration, a system to support exploratory astronauts while on extraterrestrial surfaces is an important aspect of space exploration that should be considered. The NASA funded research project to establish the resilient extraterrestrial habitats institute (RETHi) has three main goals: developing resilient habitats that can adapt to threats, developing intelligent awareness networks that can detect and diagnose issues, and constructing autonomous robots that can inspect, maintain, and repair issues in the habitats independently or in collaboration with humans. Due to the variety of anticipated tasks that the robots must carry out, specific end-effectors for the robot to use for specific types of tasks are being developed. Therefore, a modular end-effector system, that will be compatible with the space robots, is being designed. Various end-effectors, such as grippers, along with a modular camera system, can be affixed to the system. Using resources offered at the Purdue Bechtel Innovation Design Center, such as 3D printers and CNC machines, prototypes of the designs are being developed. A Fetch mobile manipulation robot is being used to simulate the robots in space for testing purposes of the end-effector system and the autonomous localization, mapping, and navigation software. A successful robot will be able to autonomously navigate to a repair site, choose the appropriate end-effectors and tools needed, and complete the repair or maintenance task.

Keywords: RETHi, space, extraterrestrial habitats, NASA, repair, robots, autonomous

Development of a Modular End-Effector System - PC6-01 Mount

The NASA funded research project to establish the resilient extraterrestrial habitats institute (RETHi) is a step towards furthering space exploration. One of the primary goals of this project is attempting to establish a support system for exploratory astronauts while on extraterrestrial surfaces. To do this, autonomous robots that can inspect, maintain, and repair issues in the extraterrestrial habitats, independently or in collaboration with humans, are being developed. Due to the variety of anticipated tasks that such robots must carry out, specific end-effectors for the robot to use for specific types of tasks are being developed. Therefore, a modular end-effector system, that will be compatible with the space robots, was being designed.

One such tool changer compatible with the modular end effectors is the pneumatic gripper. Due to the implausibility of carrying around a pressurized air tank, a vacuum pump was instead utilized. In the process of connecting pneumatic hoses together, it became apparent the need for a connector mount to hold multiple hoses together. This mount was to hold the pneumatic hoses in place and to also support airflow between the hose between ends of the mount. In order to prevent air loss and thus a loss in air pressure, the 3D printed prototype made from porous material was discarded.

In order to replace this prototyped part, the resources offered at the Purdue Bechtel Innovation Design Center (BIDC), such as CNC machines, horizontal bandsaws, manual mills, and various hand tools, were utilized in order to manufacture the mount out of a nonporous material such as aluminum. The PC6-01 pneumatic tube fittings were to screw into this mount securely. However, due to their unique nature of having tapered threads, hand taps to create threads in this mount were unavailable at BIDC. Tapered hand taps of the right specifications

were purchased and used to create tight fitting tapered threads to perfectly fit the PC6-01 pneumatic hose fittings. The final product was affixed to the Fetch robot and yielded successful results during a test fitting.

Following this project, a supplementary frame to be affixed on the Fetch robot was also constructed. Using machines and resources offered at BIDC, aluminum and steel beams were cut and drilled into. The modified parts were assembled into a frame that is used to support the gripper tool changer and many others.

RETHi is an ongoing and continuously improving project that is always striving towards innovation. The project has many improvements left to be made and many updates to be supported. A successful RETHi robot will be able to autonomously navigate to a repair site, choose the appropriate end-effectors and tools needed, and complete the repair or maintenance task. If properly executed, this project has monumental potential in redesigning space exploration and promoting the future of space travel.