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A Study of Robotic Spacewalking in the Laboratory

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Introduction

The NASA Johnson Orbit Center's Robotics Technology Branch is developing robotic technologies to aid astronauts in space. Robonaut, for example, is a humanoid robot with dexterity comparable to that of a suited astronaut. Robonaut has two dexterous arms and hands, a three-degree-of-freedom movable waist, and a two-degree-of-freedom neck that serves as a camera and sensor platform for the moment. Robonaut, unlike previous space manipulator systems, is designed to operate within existing passageways and with the same equipment as spacewalking humans. Robonaut is envisioned as collaborating with astronauts on several duties, including regular maintenance, putting up and tearing down work sites, aiding crew members when outside of the ship, and serving in a fast response role, both autonomously and via teleoperation.

The first and second portions of the Japanese experiment module, KIBO, of the international space station (logistic module and pressurized module) were launched by the space shuttle in March and May 2008, respectively, and were later joined to the international space station. In 2009, the rest of KIBO (the exposed facility) will be launched. KIBO is the first human space orbiting facility built entirely in Japan. Japan's manned space programs will benefit from its deployment. In September 2007, the Japan Aerospace Exploration Agency (JAXA) launched KAGUYA, a moon-orbiting satellite, to monitor the lunar surface and take scientific observations. The KAGUYA project's success prompted talk of KAGUYA follow-on missions, such as a lunar surface exploration mission with a moon exploration rover. The development of a manned moon outpost will be prompted by robotic and subsequently manned moon exploration. We believe that manned space operations will grow shortly as a result of these efforts. However, most space robots that have been deployed in orbit are crane-type robots with restricted capabilities. They are capable of transporting large cargoes, such as international space station modules. They are unable to carry out the jobs that astronauts do. As a result, new types of space robots are required to lessen astronaut effort.

The first collection of geological extraterrestrial planetary samples, other than meteorites, was returned to scientists on Earth by the Apollo Lunar missions. Modern equipment, methodologies, and technologies are still being used by scientists all around the world to analyze rocks and soil samples acquired by the Apollo 11 through 17 missions. With the limitations of the in-situ analysis and remote observations, the discipline of planetary science has been able to progress in ways previously unimaginable. The design and manufacture of the

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tools used by astronauts for sample collection, like every other part of the Apollo mission, had to fulfill high planetary protection criteria while also adhering to strict environmental and operability limitations. Many of those gadgets were redesigned in response to comments from the astronauts who used them. Geological and geo-microbiological sampling will be critical in future planetary exploration missions to enhance our understanding of the solar system's history and to create viable technologies for in-situ resource use and 3D printing. Since the 1960s, design and manufacturing technology, as well as chemical and biological hazard containment techniques and analytical instruments, have advanced. While it is critical to draw on the lessons acquired during the Apollo program, there is also a significant potential for creative design solutions. The European Space Agency's (ESA) Neutral Buoyancy Facility (NBF), based at the European Astronaut Centre (EAC) in Cologne, has extensive experience performing zero-gravity simulations for ISS (International Space Station) Extra-Vehicular Activities (EVA) and has recently begun simulations of Lunar surface operations, simulating reduced gravity and mobility constraints, to prepare future human and robotics surface operations. Prototyping and testing novel geological sampling equipment that might be employed in future human surface Lunar missions is one of the key aims in this field. The tools are being developed in collaboration with the PANGAEA project's team of planetary geologists and will be field-tested during the PANGAEA space analogue test campaigns. In the v acuum of space, spacesuits have proved their capacity to do spacewalks. Even if the pressure within the suit is decreased to the absolute minimum required giving adequate life support, this pressure causes the suit to stiffen. It severely restricts the astronaut's mobility and compels him or her to use greater-than-normal force to complete even the most basic actions. The European Space Agency's Neutral Buoyancy Facility is a huge immersion tank at the European Astronaut Centre that is used to educate ESA astronauts on spacewalk operations for the international space station in Europe. The ESA astronauts are submerged in neutral buoyancy (weightlessness simulation) and equipped with equipment and instruments that replicate the ISS extra vehicular activities working environment. In the EVA spacesuit training in Houston, they studied and practice how to use the EVA operations guidelines for efficient and safe spacewalks, as well as how to improve their performance. The NBF's immersive capacity also allows for careful tweaking of the astronaut's body, spacesuit, and tools/equipment to slightly negative buoyancy, providing a suitable setting for partial gravity simulation.

The planned mission's objective is to showcase astrobot's essential operations and critical technology. Because the mission's beginning circumstances are so severe, we focus on the following capabilities that the robot needs. The ability to move around the space structure utilizing the infrastructure that has been created for astronaut activity, The capacity to manipulate astronaut-specific equipment or gear.

Most operations, such as replacing the ORU or inspecting, need the locomotive capabilities of robots. Astronauts travel inside and outside the pressurized module, as well as around the space station and ship, thus Astrobots must, too. The majority of space robots walk by grasping handrails and moving inchworm-like, step-by-step (inchworm method). This inchworm strategy, on the other hand, has the drawback of taking too long to walk. Another way of locomotion for the robot is flight. Although this technology allows robots to move freely and swiftly, it necessitates the usage of propellants, which severely limits the usable life of a robot. The Astrobot must handle the same equipment and tools as astronauts do (grab, receive, give over, operate). All of those duties may need not just an extended arm, but also the manipulation arms. The astrobot only has a deployable arm and a rudimentary hand to connect the hooks or grip the handrail due to a lack of resources; future robots

may have more robust arms and sophisticated robot hands. Even if the astrobot's hand becomes more dexterous in future missions, developing a flawless multi-purpose robot hand that can accept both enormous and small, light payloads remains unachievable. Depending on the job, it is more realistic to swap out various task-oriented robot hands. To complete assignments, the robotic hand must have appropriate gripping force and dexterity.
This condition is not met by most robot hands designed for commercial on-ground applications. Because of the actuators' ability to drive fingers, they have relatively limited grabbing strength. The finger joints of most hands include rotational actuators; however, human hands are too tiny to accommodate adequately strong actuators. Gripper-type robot hands are the most strong, but they aren't dexterous enough to perform numerous jobs. The Stanford-JPL hand4) and the Utah/MIT hand5), both created in the 1980s, had huge actuators inside the robot's body to boost grabbing power, however depending on the scenario and payload, the actuators rendered the hand useless. This strategy also makes mechanics and maintenance more difficult.