Manipulation Concepts for Human-Robot Cooperative Lunar Exploration

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Abstract. Any robotic mission extraterrestrial surface needs a flexible mechanism to perform \textit{in-situ} analysis and use onboard instruments. Manipulators serve this function by placing instruments onto rocks thus enabling science experimental results sent to earth. An objective for permanent human settlement on Moon remains a formidable task for space agencies around the world. Human-rover coordination is necessary to efficiently accomplish tasks for construction of lunar outposts, maintenance of habitats and other infrastructure. Generally, it is more efficient if many of the human tasks can be accomplished using lunar robots as it is cost-efficient and does not impose safety issues. In order to efficiently replace a human astronaut for the said reasons, “light-weight” robotic manipulators are necessary with high degree of manipulation capabilities like humans.

This paper illustrates various robots for astronaut replacements as well as supplementary systems. The DLR Light Weight Robot III (LWR) enables complex manipulation capabilities to handle different tasks from selecting, handling lunar samples to setting up habitat construction. The system has a high dynamic performance with a load-to-weight ratio of 1:1 [Figure 1]. The LWR is anthropomorphically designed, kinematic redundant with 7 Degrees of Freedom (DOF) similar to a human hand [Figure 2]. Unlike a conventional 5-DOF manipulator such as the Instrument Deployment Device (IDD) used on the Mars Exploration Rovers, the LWRs can be used for other operations on Moon, in addition to normal operations such instrument placement on rocks, tool deployment etc. The LWR can also be mounted on a mobile platform such as rovers for lunar surface traverse operations. These LWRs can be effectively incorporated in humanoids known as \textit{Robonaut} for wide range of dynamic and manipulation capability within a particular workspace. It possesses integrated sensors and “vision” sensing like humans. New alternative designs are discussed to replacement of the LWR hands with tools such as instruments, drillers etc. for lunar applications.

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REFERENCES


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Aravind S. Seeni is pursuing Master of Science in Space Studies at the International Space University (ISU) in Strasbourg, France. His undergraduate study is on Aeronautical Engineering and has interest in Space engineering and science. During his master studies at ISU, he developed particular interest on system studies of robotic vehicles. He worked as an intern investigating several subsystems of rovers and other robotic systems at the German Aerospace Center (DLR) for a moon mission.