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Extended Abstract:

Space Exploration is a costly and sometimes wasteful endeavor. Sustainable space exploration involves changing the way we explore. Living off the land, so to speak, has been the mark of exploration for time immemorial. NASA would like to change this paradigm and as part of the NASA Artemis program, is heavily investing in a sustainable presence off this planet [1]. To effect this, one of the programs they are running is the LUNABOTICS RMC, Robotic Mining Competition. The goal of this competition is to design, test, and build a robot for harvesting simulated regolith as if it were on the moon or elsewhere. Regolith is the fine dust that covers the surface of the moon and mars, and is different from soil because it lacks any organic matter. This regolith is the source of sustainable exploration. There are chemical processes to break down the regolith into its constituent chemical elements such as oxygen and hydrogen and iron. These then can be used for various tasks such as life support, rocket propellant, or structural materials.[2] To collect and process this raw material a variety of novel technologies are needed. Our focus is on the collection side of this material process chain, known as ISRU or In-Situ Resource Utilization. Our team has developed a robot and collection system and is in the process of currently building it to participate in the competition at the end of May in Florida.

Our collection system consists of a telerobotic mobile digging machine that will be driven to a target collection site. There are a myriad of challenges associated with the collection process. One of which is simply driving on the regolith, which is complex and easy for a robot to get stuck. To mitigate this problem the team has investigated various design equations for wheel and grouser arrangements and will incorporate the results from internal experiments. A second challenge is avoiding obstacles while driving. To mitigate this problem, the team has also trained a machine vision based obstacle detection system. This detection system was trained using an open source data set of labeled lunar rocks.[3] The purpose of this system is to detect obstacles

that the telerobotic vehicle may detect that a human operator may not. There is limited bandwidth on the moon, and video quality may be degraded at times. A machine learning based solution that utilizes edge computing can accomplish higher fidelity video processing than a cloud based solution in the bandwidth constrained environment.

These are not the only challenges associated with collecting regolith, but they are the team's main areas of focus. The team has only so many resources available and the list of challenges is very large. The design goal is to deliver workable hardware that can be used in the competition and as a platform for future Sonoma State University teams to work with.

Sustainability and Space Exploration are words not commonly used together. The paradigm of single use expendable rockets is nearing its end. The entire space exploration endeavor across all spectrums must realize this new reality. Teams must solve the problems associated with space exploration that have been ever present since the days of Apollo, and they must solve these problems in a sustainable manner. Part of this solution comes from the launch side, but part of the solution must also come from the payload side of the equation. Exploration efforts need to be designed from the ground up to utilize local resources to reduce the cost and ecological impact back here on Earth.

References

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