Sustainable Space Exploration

SUBTITLE HERE

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BACKGROUND

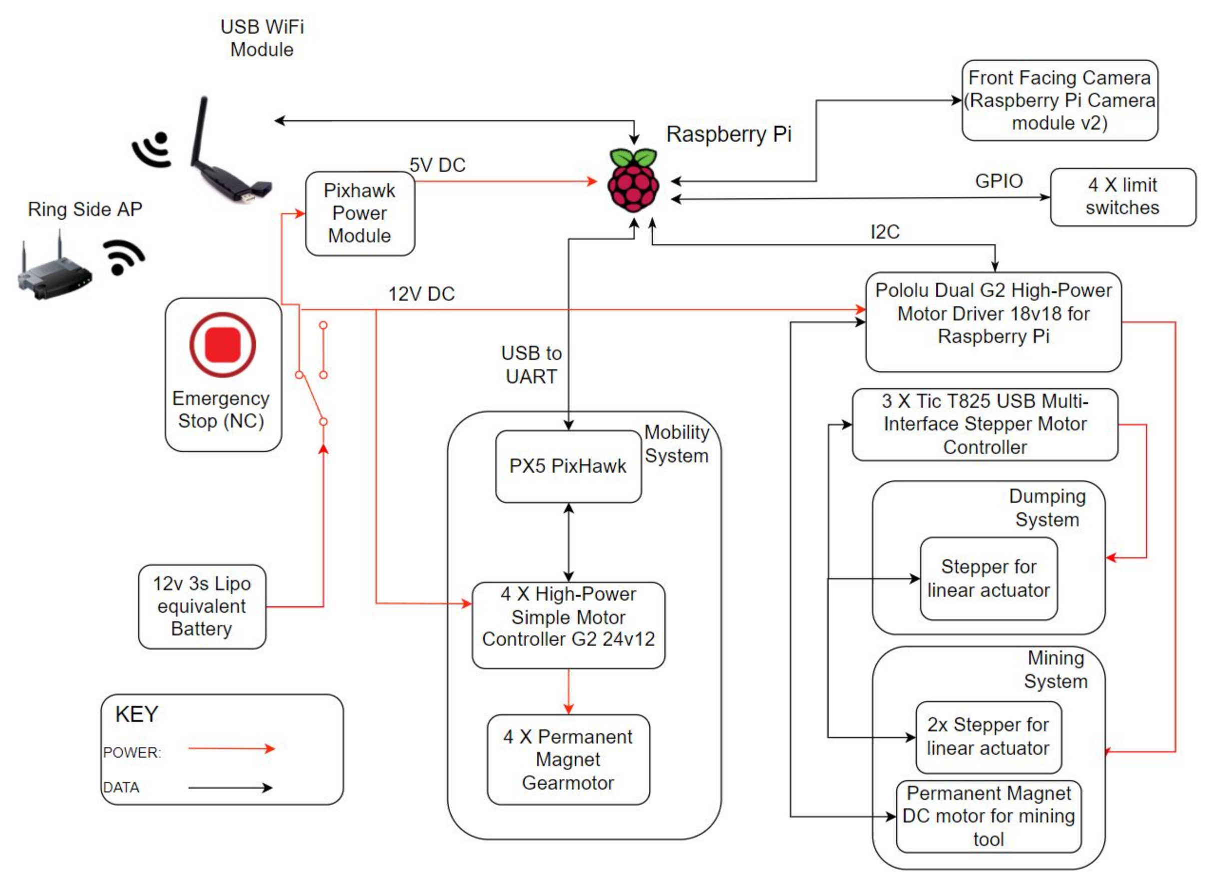
As part of the Artemis plan, NASA intends to return to the moon and establish a permanent presence. The moon is a harsh environment, and typically characterized by very unsustainable logistics. There is a significant cost both financially and environmentally to launching large rockets to go to the moon. To enable a permanent presence a more sustainable method of supplying exploration crew is needed.

To enable this sustainable development, NASA has invested in an annual competition known as the Robotic Mining Challenge (RMC), which aims to develop technology that will enable a sustainable presence on the moon. The focus of the competition is In-Situ Resource Utilization (ISRU). ISRU is a technology that can utilize lunar Regolith, which is the blend of soil and rocks on the lunar surface. ISRU can transform the regolith into critical supplies such as breathable air, drinkable water, and even rocket fuel. ISRU is a complex process, and multiple systems are needed to enable it. The RMC is focused on collection and delivery of the raw regolith.

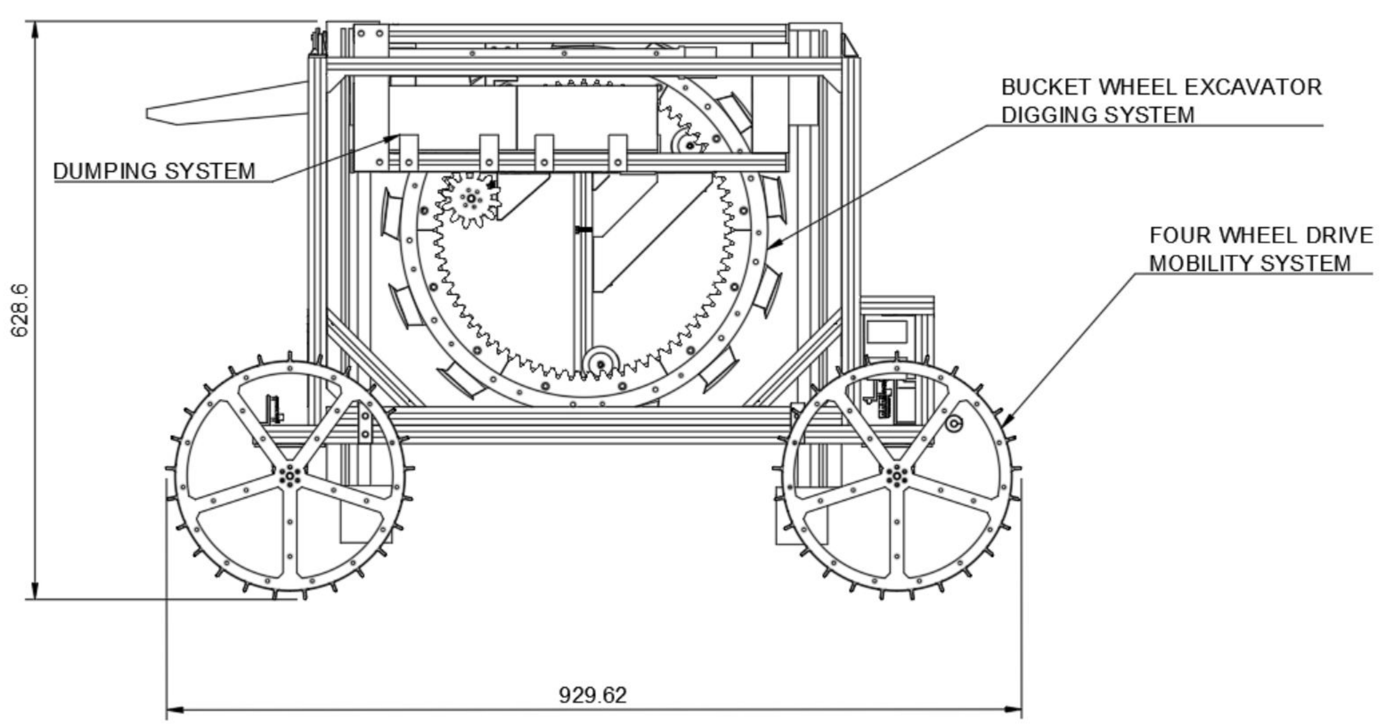
Abstract

Our RMC robot assists NASA in mining and collecting regolith on the lunar surface by collecting, transporting, and depositing regolith safely and allowing access to the regolith for future applications. This is Sonoma State's first year competing in the RMC, and through the process will meet the competition's standards. Allowing sustainability to drive the process of building the robot, NASA makes efforts for each team to abide by their guidelines. Through iterations of system overviews, methodology, and tests it will help address the technological challenges of collecting regolith as well as train a future workforce for NASA and other organizations.

System Overview



The robot will be divided into several main subsystems, notably the mobility system, the mining system, the dumping system, and the network system.The dumping system and mining system represent the core mission systems, and will both share a common moving platform in the center of the robot. The mining system uses a bucket wheel excavator that performs the task of mining the regolith. The dumping system will collect the mined material and once full, the robot will drive to a collection bin and dump the mined material. The robot will also be equipped with a camera for situational awareness that will stream video to the telerobotic control station with the team controlling the robot. An overview of the robot with major dimensions is shown below.



Testing

Since logistics to the lunar surface is so complicated, making the best use of available resources is key. To that end we have focused on SWaP-C optimization, (Size, Weight and Power + Cost) We have created a test plan to measure our impact on the lunar environment and want to make the best use of limited resources.

Power Draw Test:

Validates that the robot has uses a limited amount of power, since power generation on the lunar surface is limited.

Result:

Robot used 5.25 Wh during a 15 minute operation time, so we are efficient with our use of power.

Average Bandwidth Test:

Validates that the system bandwidth while using camera and control system does not exceed the available bandwidth on the lunar surface

Result:

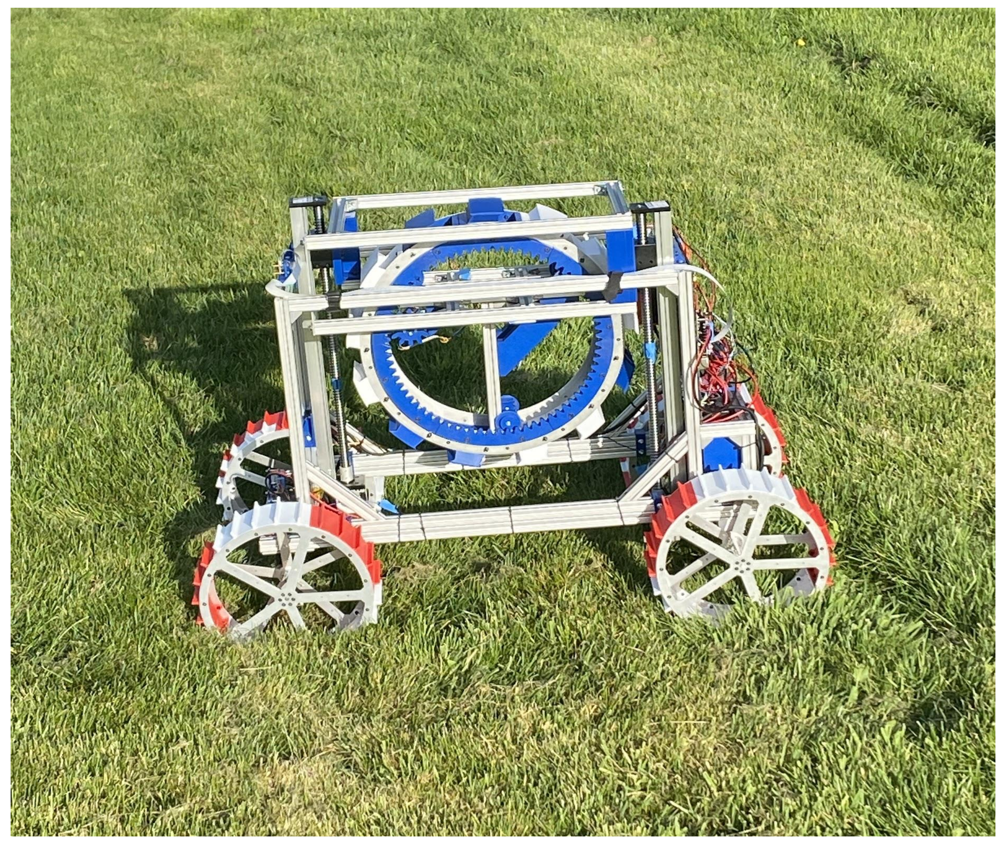
Our robot uses an average of 3.76 Mbps, which is below the 5Mbps limit available on commercial lunar landers.

Mobility Test:

Validates that the robot is capable of moving to a mining location in a reasonable time across difficult terrain.

Result:

Our Robot was able to clear over 7 meters in less than 90 seconds, which satisfies our mobility need.

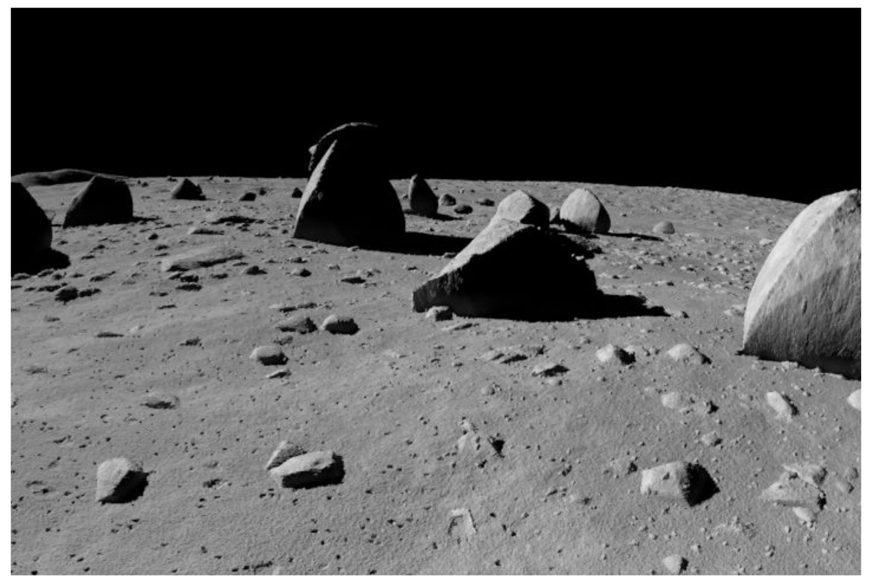


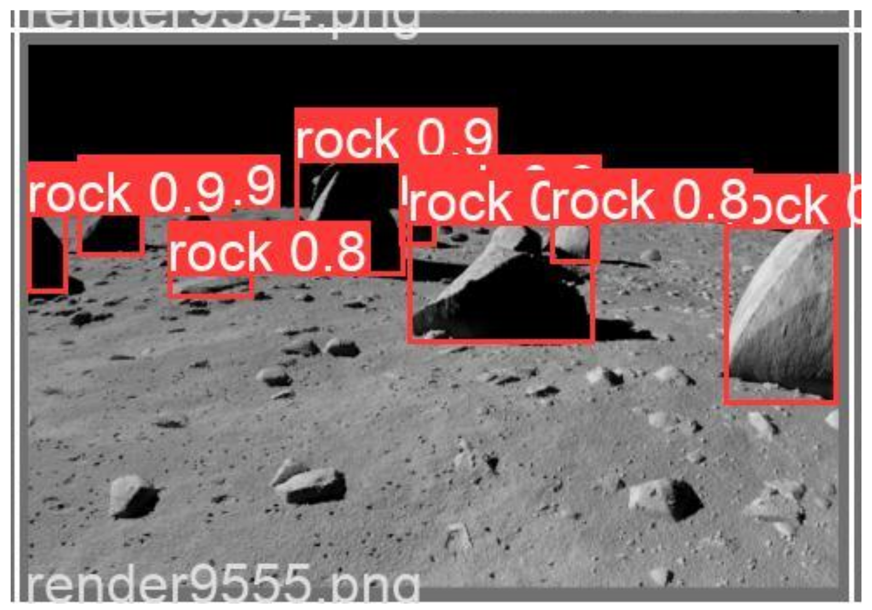
Conclusion

Our delivered robot helps enable a sustainable future on the moon by investigating key technologies that NASA and exploration crew can use to enable access local resources and live off the land.

Future Work

Future work would involve efforts to further reduce astronaut and exploration crew workload. Driving remotely operated vehicles in a telerobotic fashion is challenging due to lack of situational awareness. We believe that higher levels of automation or assistance tools would reduce operator workload. To that end we have investigated a Machine Learning based Advanced Driver Assistance System (ADAS) that can identify rocks and display them on the operator's screen. Results so far are not conclusive, but early results are promising. Shown below is a simulated view of the lunar surface before and after having an early version of our detection system applied.





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