AA228 Final Project Update
Autonomous Decision-Making for Lunar Regolith Sample Collection under Energy and Environmental Uncertainty

Project Re-Introduction

As future lunar missions transition to sustained surface operations, autonomous rovers will play a pivotal role in identifying and gathering valuable regolith resources that can support in-situ construction. Our project focuses on designing a decision-making framework that allows a rover to search an uncertain lunar environment, manage limited energy, and collect high-value samples without continuous human supervision. We therefore frame this task as a sequential decision-making problem under uncertainty, aiming to capture the key challenges of limited sensing, unpredictable terrain, and tradeoffs between exploration, energy use, and scientific gain.

Work Completed and Next Steps:

So far, our progress has focused on refining the problem scope, selecting suitable algorithms, and beginning implementation of the simulation environment. Our work is being developed in Python, and we plan to use a model-free Q-learning approach to learn an approximate optimal policy for the rover's decision-making problem.

We have implemented an initial class structure for the grid world that allows us to randomly generate M x N gridworlds with randomly placed obstacles. We have not decided on set numerical rewards/punishments for the lunar environment, but we can generate the environment.

Our next steps are to implement the actor dynamics, which will be modeled as simple Cartesian movement about the plane with some stochasticity built into the actor's movement. Furthermore, the actor will have incomplete knowledge of the environment around itself, only seeing as far as we allow its sensors to. We intend to penalize longer missions as well to ensure that the rover does not spend too much time exploring without committing to its current resources collected, and encourage efficient sample collection.

At this stage, additional features such as a detailed power budget or cost comparisons remain uncertain given the project timeline.

Martin Yitao bpalalto@stanford.edu / Jason Gunn jwgunn@stanford.edu / Loïc Poisson lpoisson@stanford.edu