ARC Based Path Planner for Lunar Surface with Digital Elevation Model

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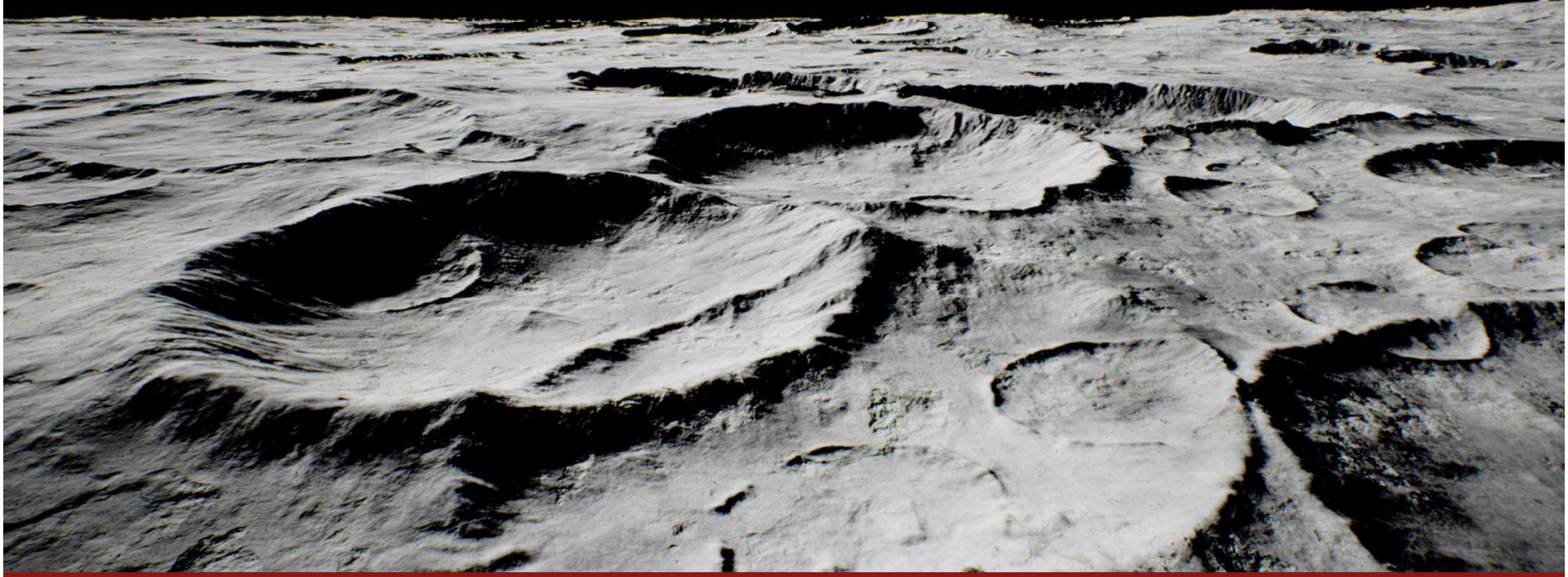
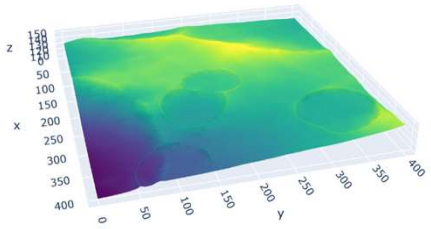


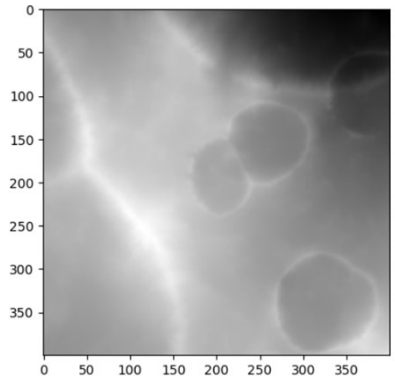
Outline/Problem Statement

- Problem: Plan a path on a lunar digital elevation model
- Background and Progress: Lunar DEM, Path Planning, ARC-Path Planner

Lunar Digital Elevation Model

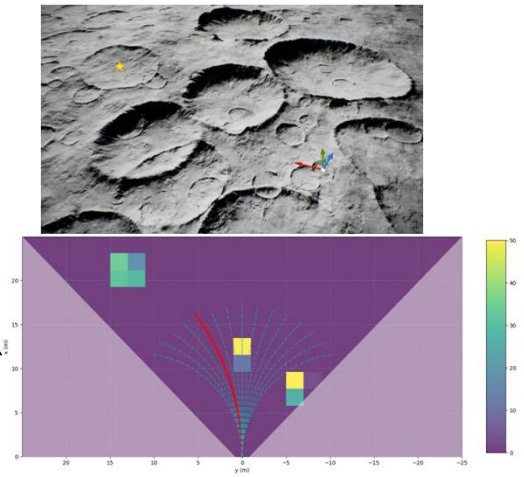
- DEMs provide an initialization for Gaussian Splat or NeRF that improves performance
- Allow us to model the terrain of the moon in a quantitative way
- 1 meter resolution





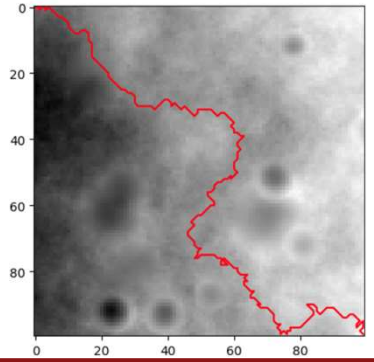
The Unreal AirSim Environment

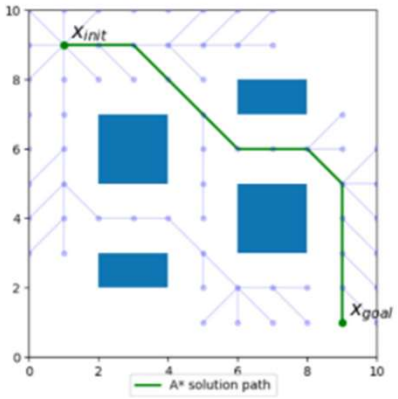
- There are three coordinate frames to consider:
- The Unreal Engine Coordinate Frame, essentially just the DEM, (0,0) is top left
- The AirSim Coordinate Frame
- The local coordinate frame
- Additional Notes:
- Many craters too big for the car to exit
- Small slopes can throw off the trajectory
- 1 meter DEM resolution



A* Path Planning

- Classical graph based planner using a heuristic cost function between points
- Guaranteed to find the shortest path
- A* combines the actual cost from the start with a heuristic estimate to the goal
- In Lunar Path Planning, there are two main considerations for the cost function: the slope of the terrain and the distance from the goal
- We can write our cost as weighted combination of these goals.

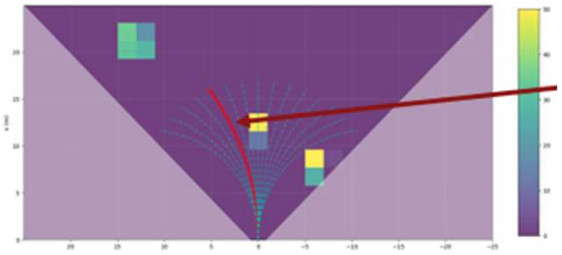




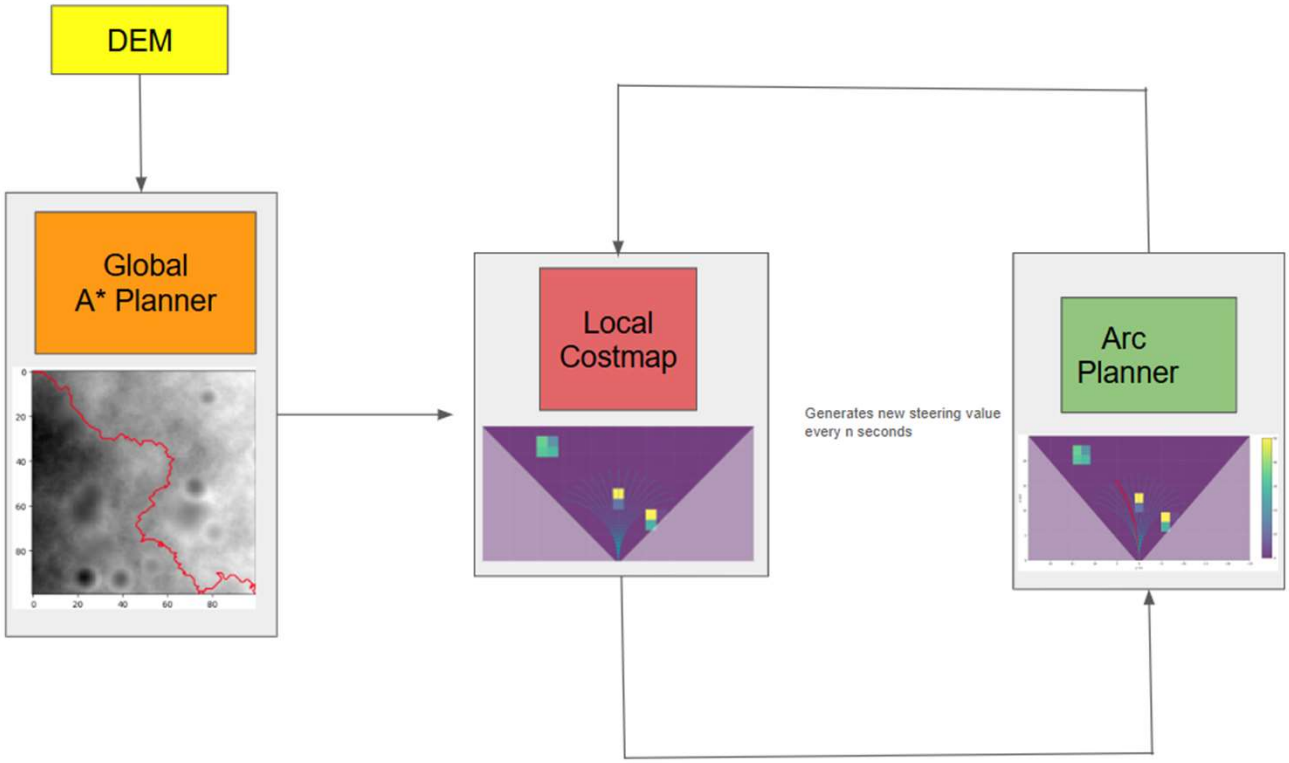
[1] Mildenhall et al., *Communications of the ACM* 2021. [2] Mildenhall, 3DV 2024

Arc-based Path Planner

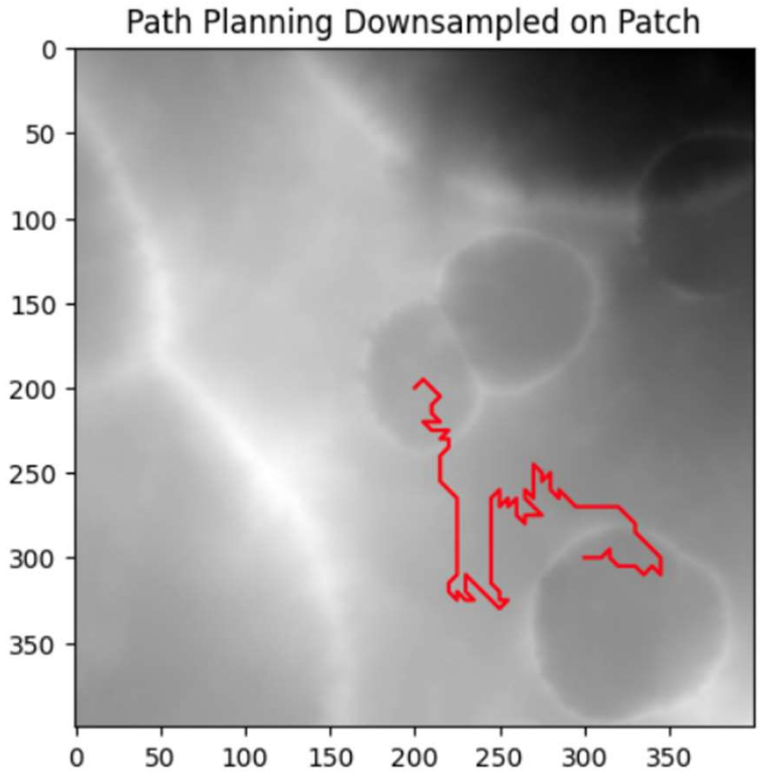
- Create a local costmap based on the DEM values
- a square in a 15 block radius
- Costs are the gradients at each point
- Sample 15 arc from a range of constant steering angular velocities
- Find which one of these arcs has lowest cost



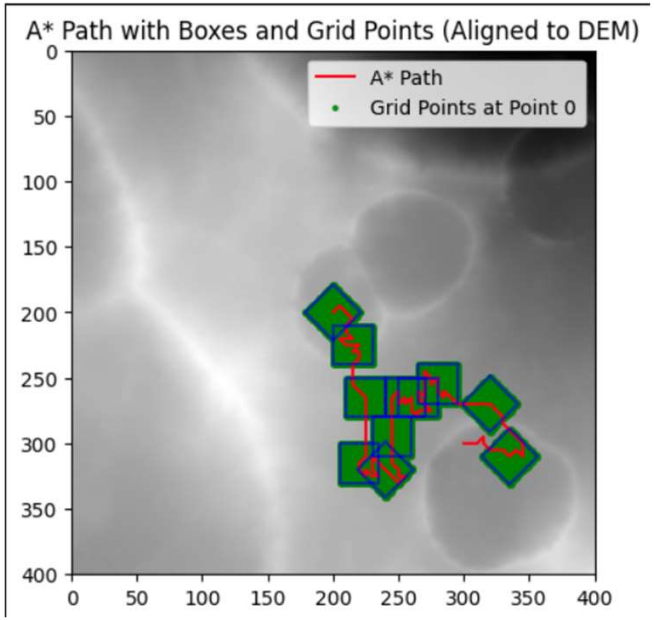
Full Pipeline

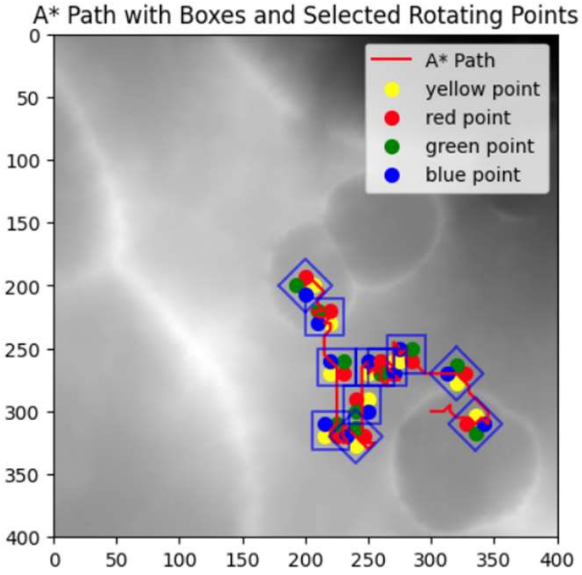


Results


Path Planning Downsampled on Patch
0
50
100
150
200
250
300
350
0
50
100
150
200
250
300
350

Results


A* Path with Boxes and Grid Points (Aligned to DEM)
A* Path
Grid Points at Point 0
0
50
100
150
200
250
300
350
400


A* Path with Boxes and Selected Rotating Points
A* Path
yellow point
red point
green point
blue point
0
50
100
150
200
250
300
350
400

Current Challenges and Future Works

- ARC Planner does not seem to be working properly yet.
- Need to ensure that my design choices for the algorithms work, ie rounding arc indices to their nearest local grid point instead of interpolation
- Need to Further tune Cost functions for A* and ARC Planner
- Very difficult to tell if DEM values actually align with the Unreal Environment, especially when the car moves