CREATE SIMULATION OF LUNAR SURFACE USING MODEL DISTILATION

Long term: use super resolution to generate 3d ai environment for ice mining rover

Wavelength Range (nm)	What It Detects
1.5 - 1.65 µm (1500-1650 nm)	H_2O Ice Absorption
2.7 - 3.2 µm (2700-3200 nm)	Hydroxyl (OH) Presence
6 - 10 µm (6000-10000 nm)	Thermal Emission of Ice
UV (~280-350 nm)	Reflectance Differences Between Ice & Regolith

Wavelength detection for Ice mining application

- **LCROSS NASA imaging spectromer (has 3 sensors)**
- Found **water-ice spectral signatures** at lunar poles.
- Key absorption peaks: **2.8-3.2 µm (OH and H_2O bonds)**.
- Utilized satellite spectrometer
- Two infrared and ultraviolet spectrometers used for examining composition
- Two mid infrared cameras examined plume and its water contents caused by impact [determine how much water]

- **Ultraviolet 260 to 650 nanometers used for differentiating regolith and ice**

- **3000 nanometers had strongest h2o absorption**
- **6000 nanometers had confirmed water molecule**

DATASET

LDEM_83S_10MPP_ADJ.TIF - 4.8G [LOLA ELEVATION MAP 10 m/pixel]

LDSM_83S_10MPP_ADJ.TIF - 7.1G. [LOLA SLOP MAP 10 m/pixel]

LOLA

- "In a 50km polar orbit, pulsing the laser at 28 Hz creates an ~50m-wide swatch of five topographic profiles. Swaths will have 1.25km separation at the equator, with [complete polar coverage beyond +/-86 degrees latitude.]"
- south polar stereographic X/Y coordinates in meters and in the MOON_ME reference frame of the JPL DE421 ephemeris.

AI MODEL DISTILLATION

- Use error data for slope and elevation
- Use hillshade data as well to accurately map surface slope difference
- Use effective resolution data for ?

Code setup

a) Data loader node (lunar elevation data and scaled image)
   1. Pre processing
b) Feature extractor
   1. elevation
   2. crater locations,
   3. image processing

c) Utilize LOLA dataset as metadata for visual map
   1. Establish habitat location and ice (based on previous imaging)
   2. Allign properties to coordinates

d) Configure rover
   1. Alternating speeds
   2. Account for slopes, recharge time
   3.Power
   4. Thermal dissipation
   5. Mining time/storage
   6. Data rate for Machine Learning

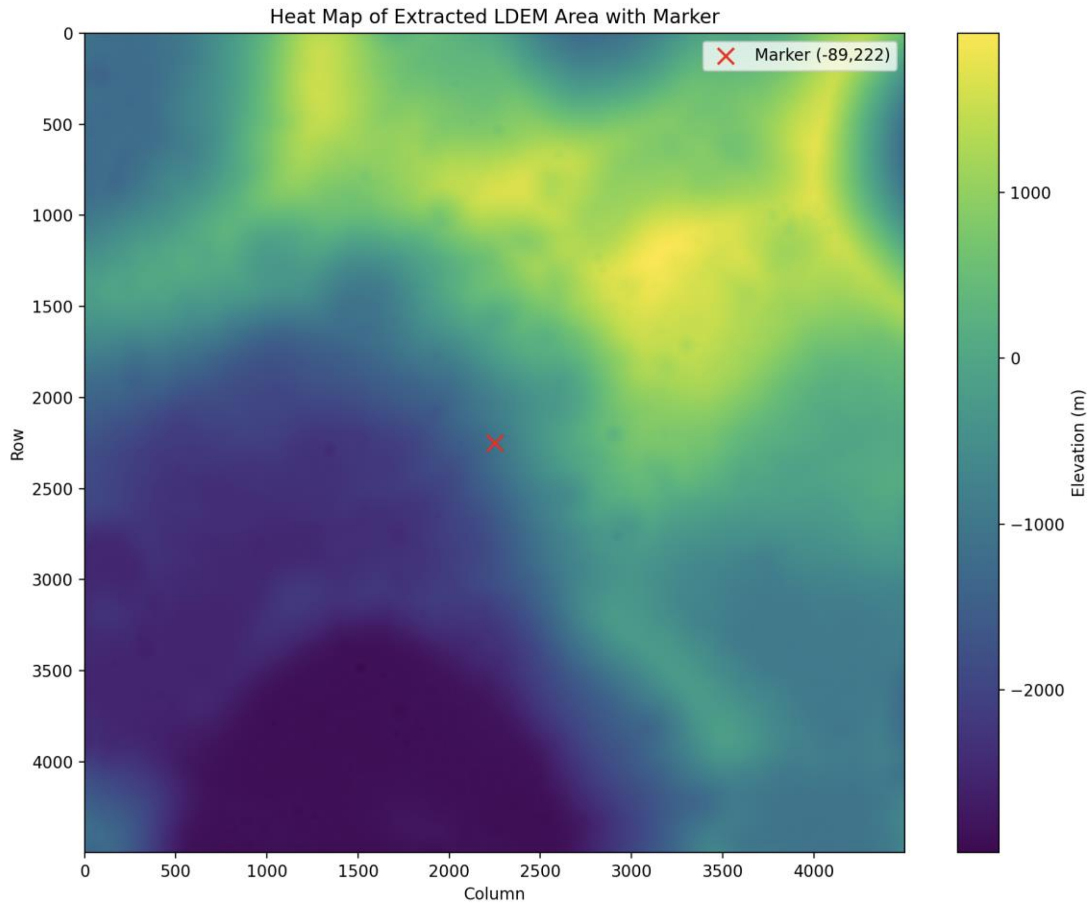
e) Implement reinforcement learning (Path optimization)

Simulation

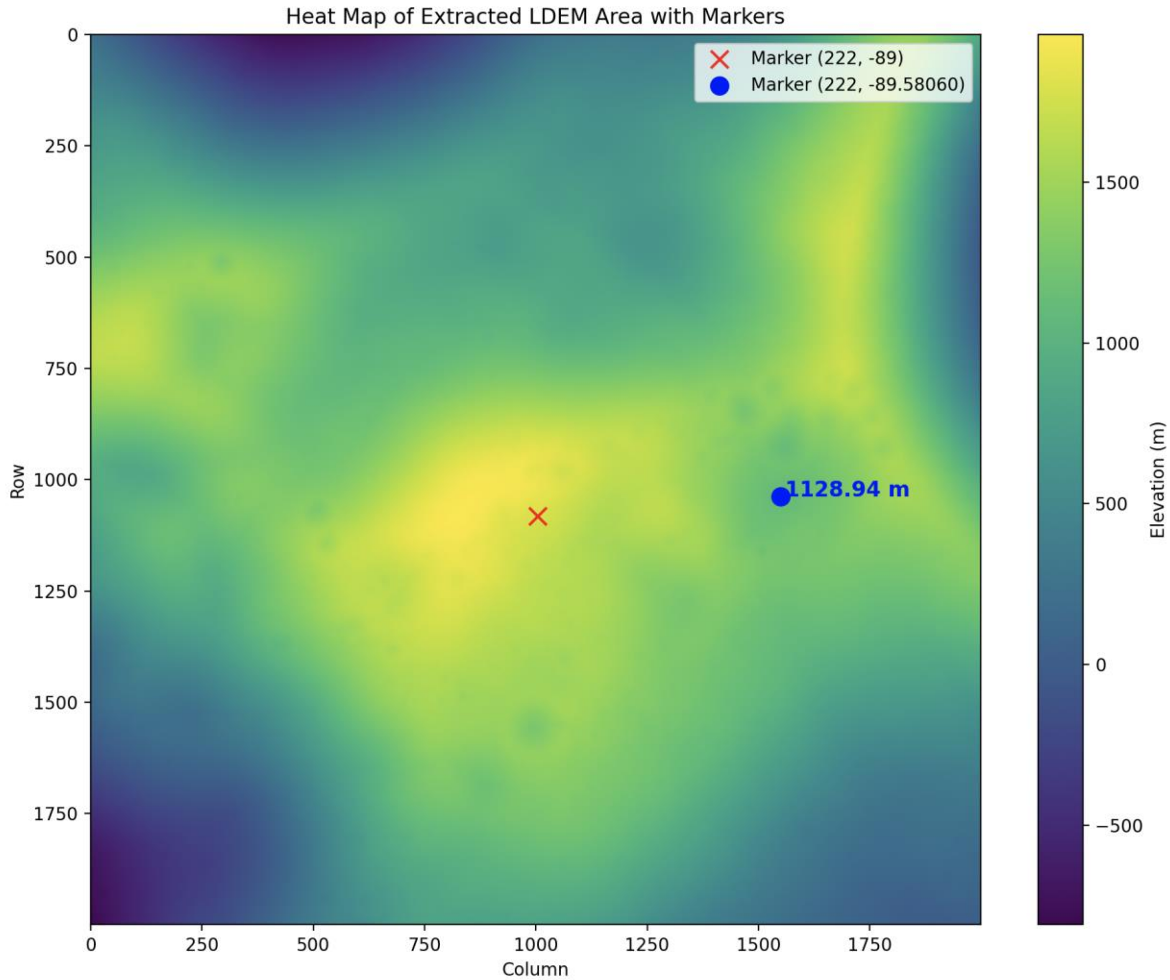
A) High res scaled image by using super res, fitted with meta data from LOLA elevations
B) Topical 3d view with contours pertaining to elevation and slope data
C) Use LCROSS spectrometer data to generate wavelength data in icey regions
D) Rover will take time to mine and store ice
E) Multiple runs will be recorded
    a. Set multiple realistic parameters (i.e solar recharching, maintenance)
    b. Machine learning model will learn as more runs are recorded

ENVIRONMENT

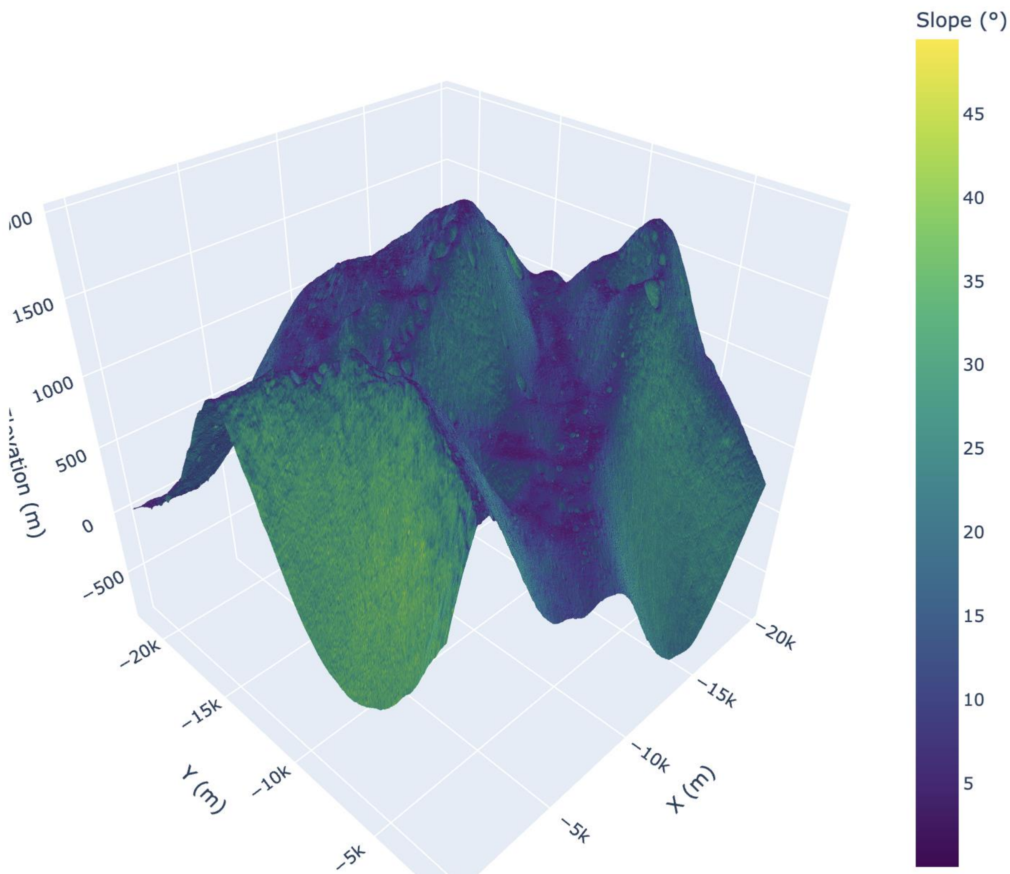
Upper Left (94d39'37.40"W, 89d20'47.52"S)
Lower Left (137d34'29.69"W, 89d 2' 4.48"S)
Upper Right (171d10'25.06"E, 89d56'46.57"S)
Lower Right (179d20'13.89"E, 89d17'14.31"S)
Center (139d58'36.07"W, 89d30' 0.10"S)


Heat Map of Extracted LDEM Area with Marker
Marker (-89,222)
Row
Column
Elevation (m)
0
500
1000
1500
2000
2500
3000
3500
4000
1000
0
−1000
−2000

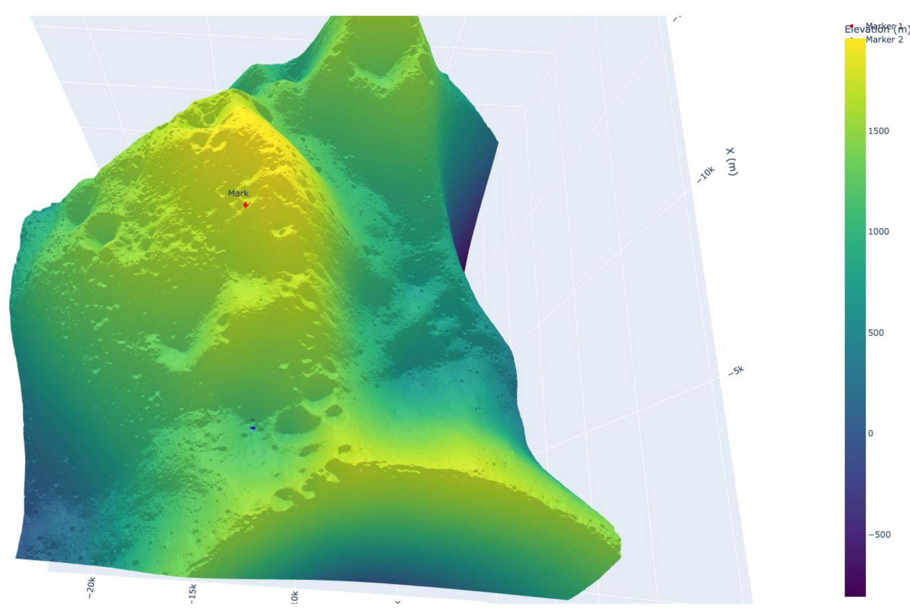
i.
ii.



Combined Plot of elevation and slope



3D Elevation Surface with Markers



- Resolution at 10 m/px
- For rover transportation simulation want a higher resolution

Solution: Super Resolution

- Train ai model with DEM files converted into csv

```
[Project Setup Node]
      │
      ▼
[Data Preprocessing Node] ──► [Model Architecture Node]
      │                              │
      ▼                              ▼
   [Training Loop Node] ◄──── [Integration/Debug Node] (feedback loop)
      │
      ▼
[Inference & Visualization Node]
```

https://www.nasa.gov/general/what-is-lcross-the-lunar-crater-observation-and-sensing-satellite/

https://planetarydata.jpl.nasa.gov/img/data/lcross/LCRO_0001/DATA/20091009113022_IMPACT/MIR1/CAL/

LOLA DATA

https://astrogeology.usgs.gov/search/map/moon_lro_lola_dem_118m

ELEVATION

https://science.nasa.gov/mission/lro/lola/

LARGE DATASET (includes slope and roughness)

https://pgda.gsfc.nasa.gov/products/90

Temperature and Slope, as well as MAP CSV

https://quickmap.lroc.asu.edu/?prjExtent=-3004075.862069%2C-1737400%2C3004075.862069%2C1737400&selectedFeature=3489%2C8&queryOpts=N4IgLghgRiBcIBMKRAXyA&shadowsType=all&layers=NrBsFYBoAZIRnpEBmZcAsjYIHYFcAbAyAbwF8BdC0yioA&proj=10