Team Name : Lunar Nodes

Team Leader Name : Gonugunta Pavana Lakshmi

Problem Statement : Generation Of High-Resolution Lunar Digital Elevation Model from Lunar Images Using Photoclinometry (Shape from Shading).

Team Members

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Brief about the Idea:

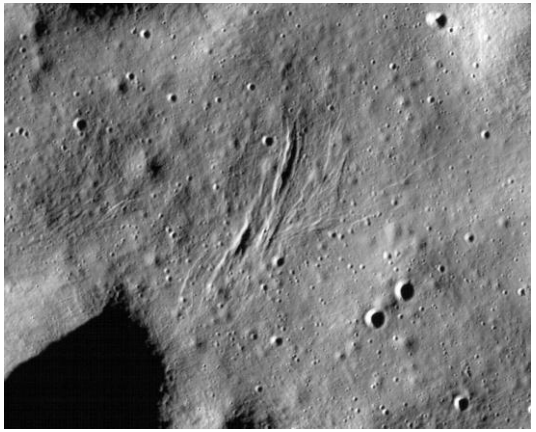
Title : High-Resolution Lunar DEM Generation Using Photoclinometry

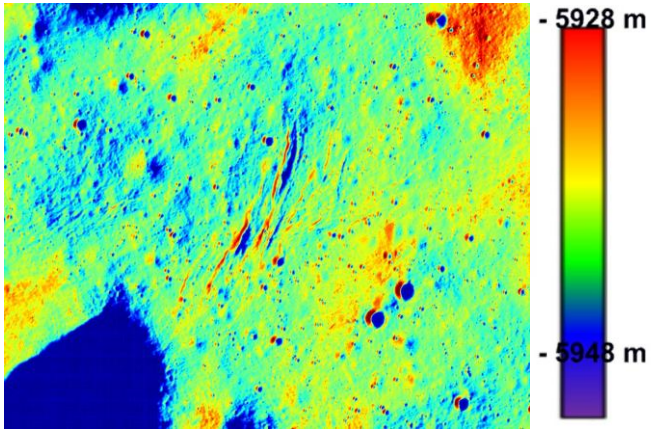
Idea Brief : This project aims to generate a high-resolution Digital Elevation Model (DEM) of the lunar surface using **photoclinometry** (Shape-from-Shading), which extracts topographic information from mono lunar images. It utilizes data from missions like **Chandrayaan** (TMC, OHRC), **NASA** (LRO NAC/WAC), and **JAXA** (Selene). The generated DEM will be evaluated against reference DEMs (stereo-photogrammetry/laser altimetry) to ensure accuracy in height and terrain feature representation, enabling improved lunar surface analysis in areas lacking stereo imagery.

Our Approach includes:

- Create a disparity map from mono images with illumination metadata.
- Refine disparity at sub-pixel levels for enhanced accuracy.
- Transform disparity maps into an absolute DEM.

Expected Outcome:
High-resolution lunar DEM for scientific and exploration applications.





Opportunity should be able to explain the following:

1. How different is it from any of the other existing ideas?

Most existing lunar DEMs are generated using stereo images or laser altimetry (LIDAR), which are:

- Not available for all regions, limited in resolution, expensive to acquire.
- Our solution uses Photoclinometry to create elevation maps from single mono images, even in areas without stereo or LIDAR coverage.
- This approach allows higher resolution terrain mapping using existing datasets like Chandrayaan and NASA images.

2. How will it be able to solve the problem?

Our Approach solve the problem by:

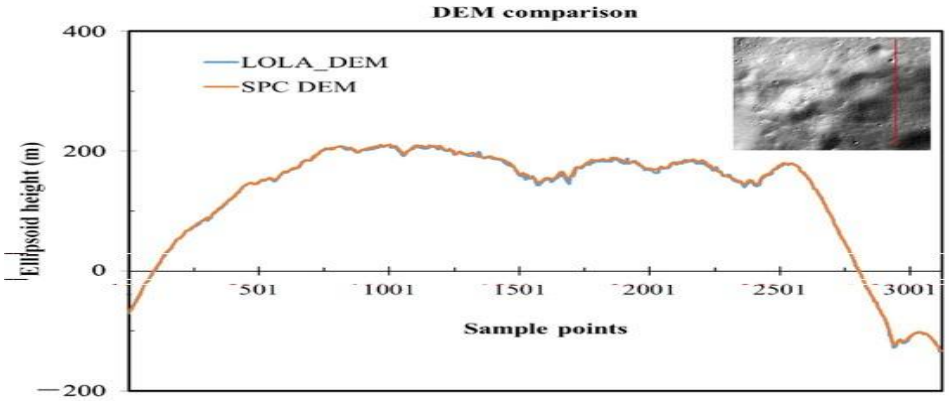
- Using brightness and lighting to estimate surface slopes.
- Creating and improving elevation maps with computer vision.
- Generating a DEM from a single lunar image and providing accurate terrain data for better planning and exploration—especially where no stereo or LIDAR data is available.

3. USP of the proposed solution

Mono-Image Only - No need for stereo pairs or LIDAR.

High Resolution - Captures fine terrain features in rough or narrow regions.

Cost-Effective - Uses existing satellite data & open-source tools.



List of features offered by the solution

- **Mono-Image Based 3D Terrain Modeling:**

Generates DEMs using single-view lunar images — no stereo required.

- **Photoclinometry-Driven Elevation Estimation:**

Uses light and shadow patterns to derive terrain elevation.

- **Pixel-Level Disparity Mapping:**

Captures fine terrain variates for high-resolution elevation models.

- **Multi-Mission Data Support:**

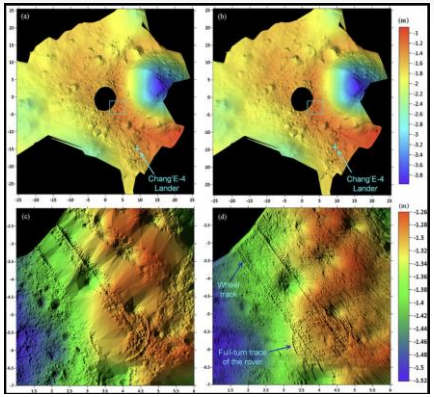
Works with ISRO (TMC, OHRC), NASA (LRO), and JAXA (Selene) datasets.

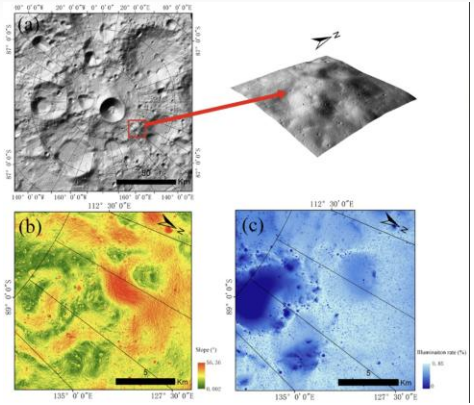
- **Visualization Capabilities:**

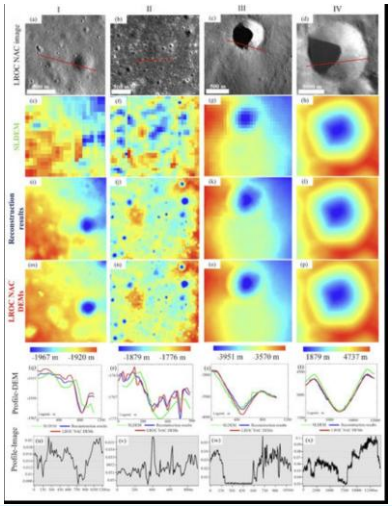
Provides 2D elevation heatmaps and 3D terrain models for analysis.

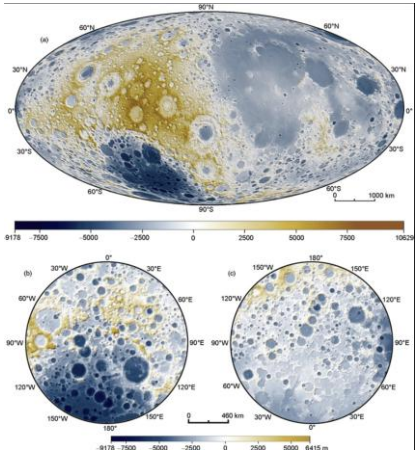
- **Lightweight, Scalable & Cost-Efficient:**

Uses open-source tools and public datasets — no hardware dependency.

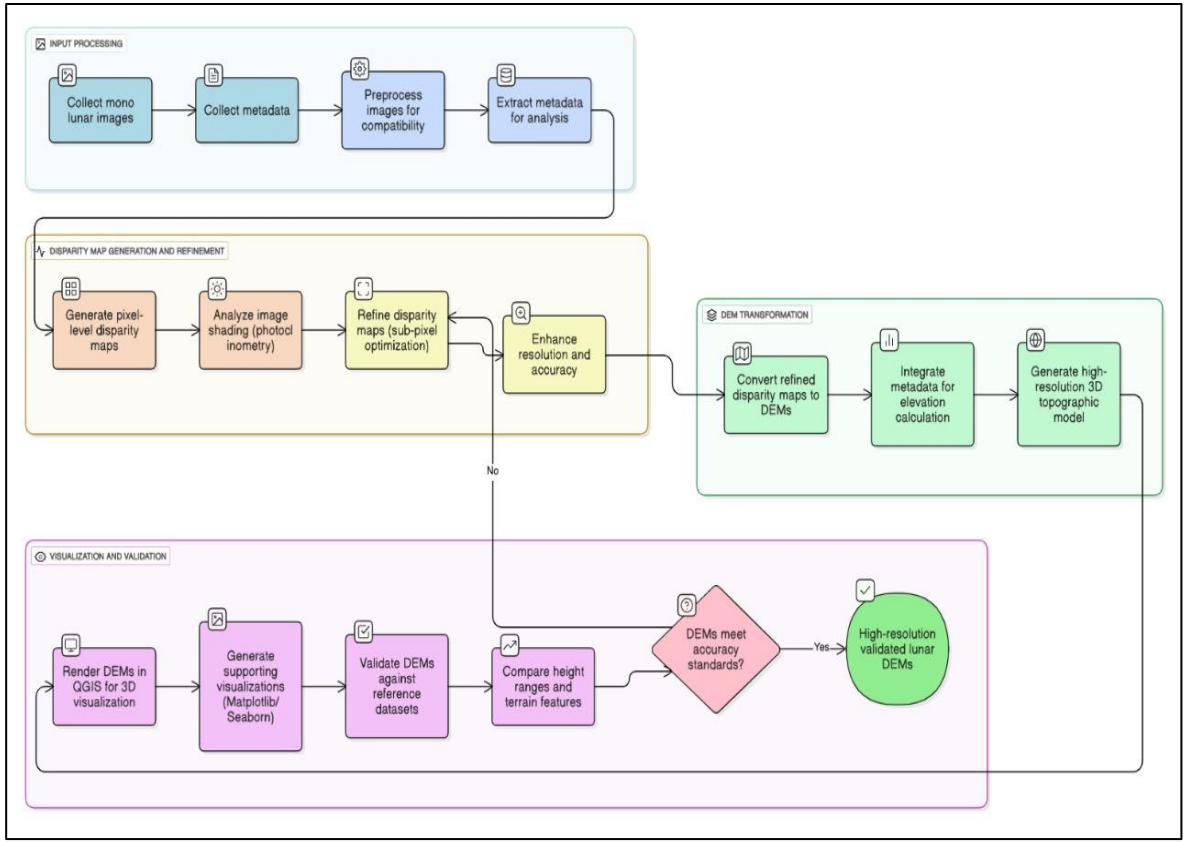








Process flow diagram



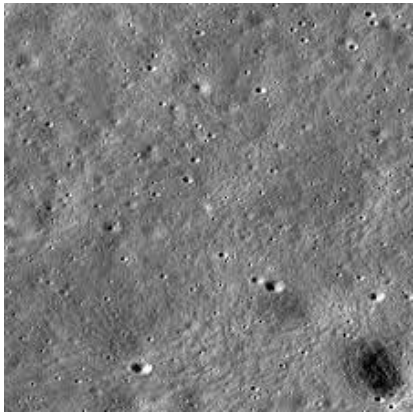
1. Input Processing
- Collect mono lunar images and extract relevant metadata.
- Preprocess images for compatibility and analysis.

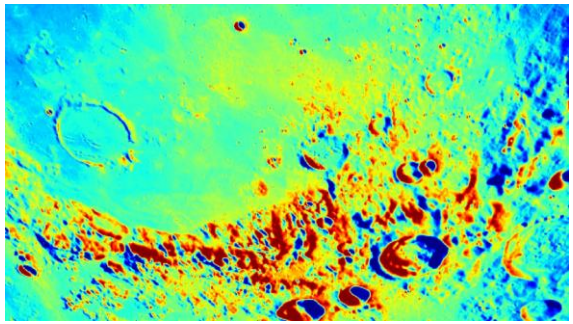
2. Disparity Map Generation & Refinement
- Generate and refine disparity maps using photoclinometry.
- Enhance resolution and accuracy with sub-pixel optimization.

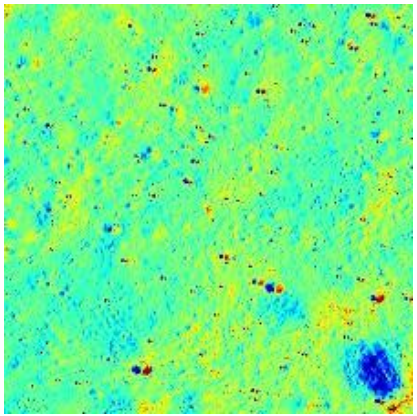
3. DEM Transformation
- Convert refined maps into elevation models (DEMs).
- Integrate metadata to generate 3D topographic models.

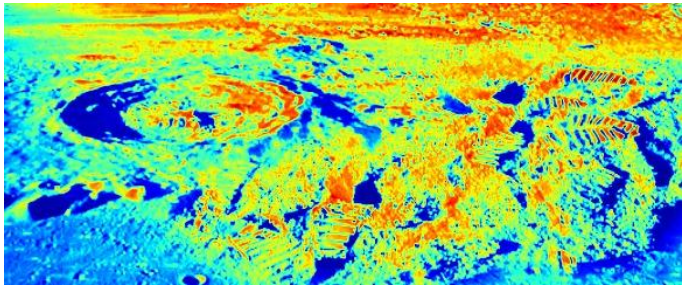
4. Visualization & Validation
- Visualize DEMs and validate with reference datasets.
- Finalize only if height and terrain accuracy standards are met.

Wireframes/Mock diagrams of the proposed solution

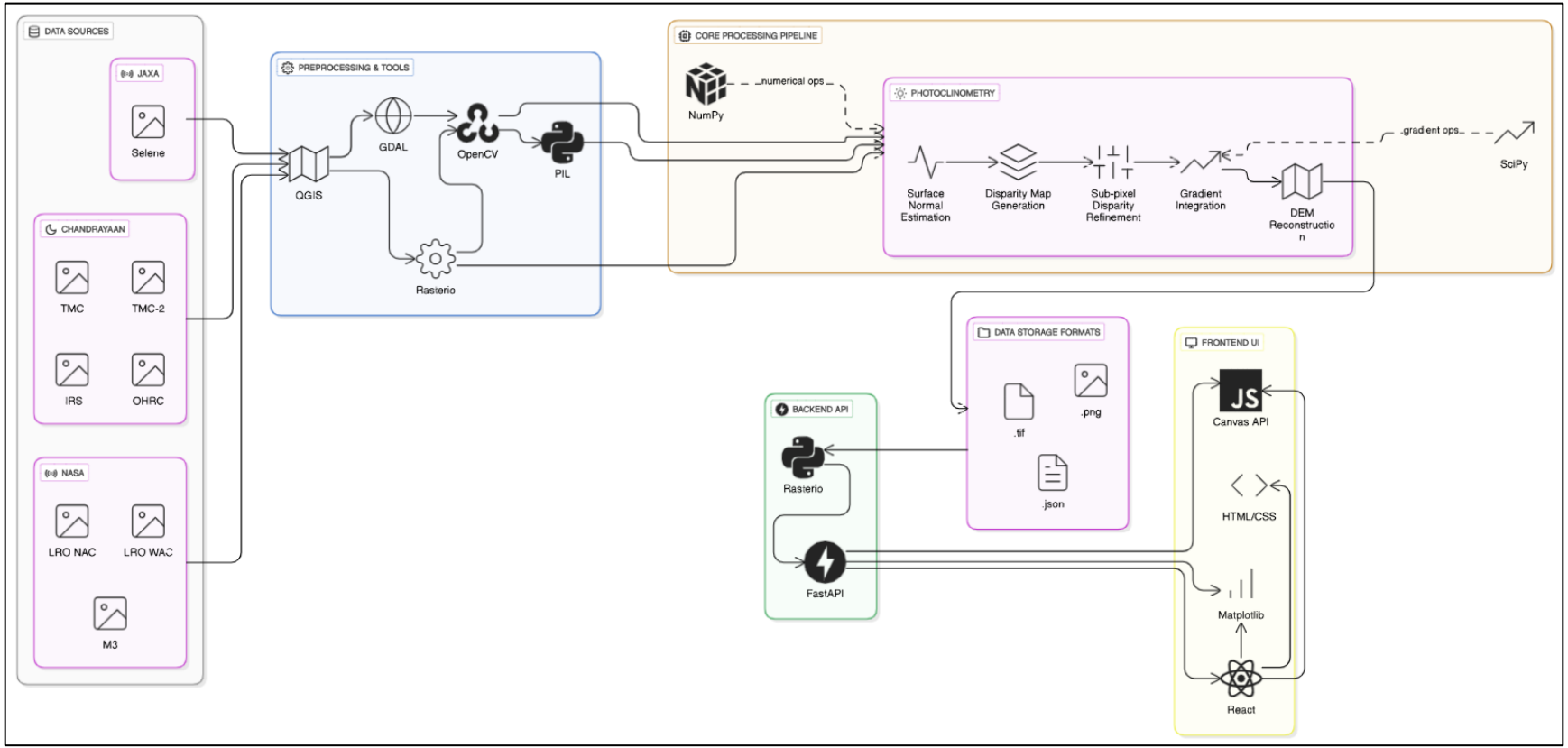








Architecture diagram



Technologies

Frontend

React js

JavaScript

HTML & CSS

Backend

Python

FastAPI

Geospatial Tools

QGIS – DEM inspection

GDAL – Geospatial data conversion

Tools & Libraries (Python)

- NumPy
- OpenCV
- Rasterio
- SciPy
- Matplotlib

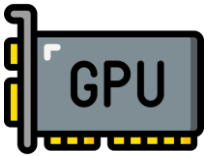
Data Storage Formats

Estimated implementation cost:

₹0 – Utilizes existing datasets and open-source tools, requiring no additional hardware or mission resources.

Free Public Datasets

- Uses open lunar imagery from Chandrayaan (ISRO), LRO (NASA), and SELENE (JAXA).
- No licensing or data purchase needed.



Standard Hardware

- Runs on a regular laptop or desktop.
- No special GPU or cloud infrastructure required.

No Paid APIs

- All processing is local.
- No third-party or cloud API charges.

Open-Source Tools

- Powered by free libraries: Python, OpenCV, GDAL, QGIS, FastAPI.
- Zero software cost.

Scalable & Modular

- Solution is lightweight, easy to expand.
- Cost-effective.

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