

BHARATIYA ANTARIKSH HACKATHON

2024

Innovation partner 



Team Name: CODING BRIGADES

Name of College: LDRP Institute of Technology and Research, Gandhinagar

Team Members Details:

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4. Nancy Rajesh Patel

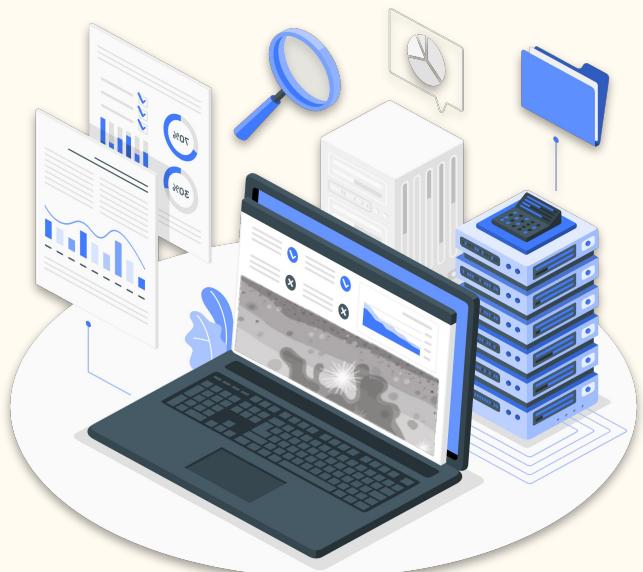


Spectral classification of Chandrayaan-2 IIRS

using AI/ML for understanding geological diversity of the Moon

Introduction

- **Spectral classification systematically categorizes hyperspectral data** based on unique spectral reflectance characteristics.
- This facilitates the analysis of the Moon's geological diversity by **mapping mineral distributions and simplifying complex hyperspectral data interpretation**.
- Our proposed solution provides **an intuitive GUI for exploration and analysis of IIRS data** through advanced AI/ML techniques.



Loopholes in the Existing Solutions

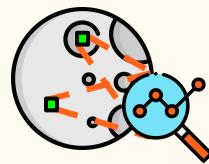
- **Absence of an intuitive GUI with spectral classification overlays** on the lunar selenographic map.
- **Lack of a tool for comparing spectra across different lunar regions** hinders global mineralogical trend analysis.
- **Time-series analysis is not incorporated, limiting the tracking of dynamic lunar processes.**
- **Limited lunar mineral spectral libraries hinder accurate classification** of surface compositions.
- **No Research and Findings Reporting system** for efficient documentation and sharing of observations.
- **No incorporation of spectral anomaly detection,** which limits the identification of unique mineralogical features.
- Linear spectral unmixing methods are constrained by their **inability to handle complex non-linear mineral interactions.***



Proposed Novel Features



Time-series
Spectral Analysis



Lunar Regions-wise
Analysis



Research and Findings
Reporting

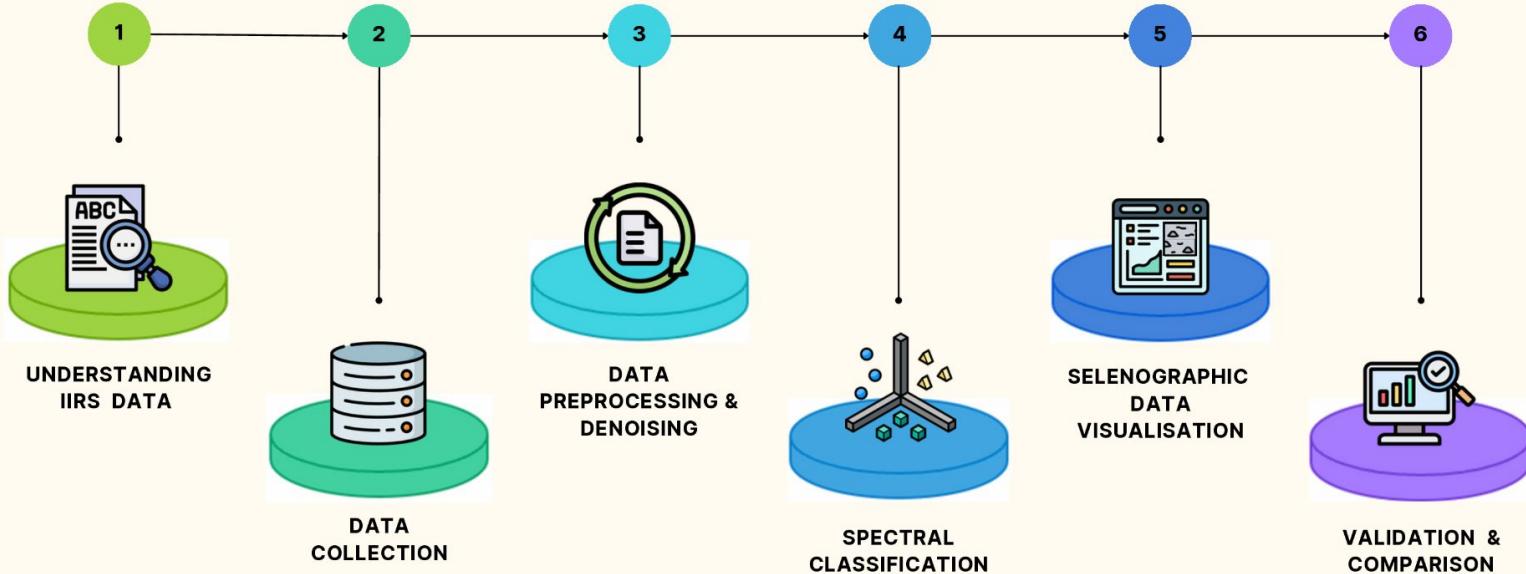


Automated Spectral
Classification Validation



Spectral Anomaly
detection

Process Flow Diagram



Understanding IIRS Data

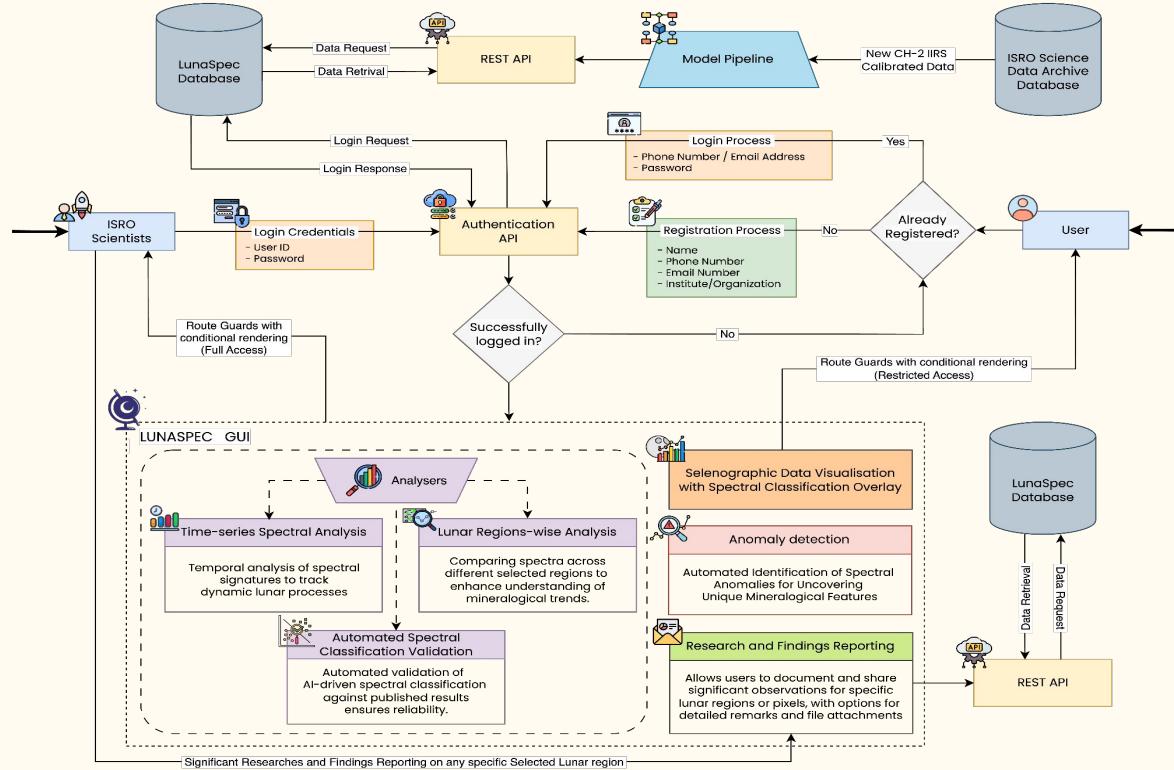
- The dataset comprises a total of **3,172 folders containing IIRS data**, each containing four subfolders—data, browse, geometry, and miscellaneous—with distinct start times, end times, sizes, and altitudes.
- The **browse subfolder contains summarized science data and thumbnail images (png format)** for quick visual reference and easy inspection.
- The data directory contains IIRS's primary science data, including **.qub files (radiance images) and .hdr files with details for each of the 256 bands**.
- The geometry directory includes files providing **spatial and geometric context (csv format)** to the data, containing longitude, latitude, pixel size and scan line.
- The miscellaneous directory contains metadata, including **orbit, attitude, sun angles, and liberation angles, for radiance to reflectance conversion**.
- Radiance to Reflectance Conversion Formula:**

where,

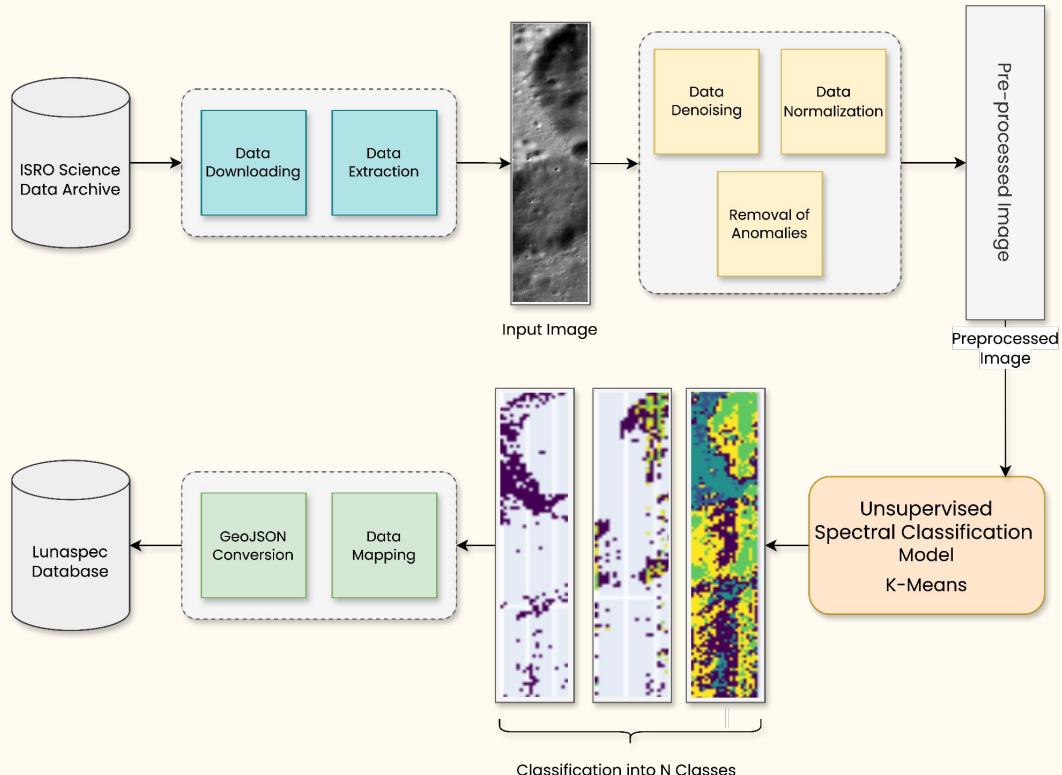
$$\rho_{ap} = \frac{L(\lambda)}{\cos(i) \times \frac{F_0(\lambda)}{\pi}} \times \left(\frac{1}{d_{AU}} \right)^2$$

- ρ_{ap} is the apparent surface reflectance
- λ is wavelength
- $L(\lambda)$ is the calibrated radiance measured by IIRS (Level 1 radiance product)
- i is the solar zenith angle
- $F_0(\lambda)$ is the solar irradiance at one Astronomical Unit (AU)
- d_{AU} is the distance from surface to the sun in AU.

Proposed Architecture



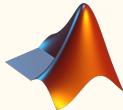
Model Pipeline



Tool & Technology



Python



Matlab



GDAL



Seaborn



Matplotlib



NextJS



NodeJS



GeoPandas



PyTorch



SciPy

SWOT Analysis



Strength

- Integration of **advanced AI/ML technologies**
- **Comprehensive Spectral analysis (time series, regional mapping, anomaly detection)**
- Intuitive **GUI** for user-friendly exploration
- Detailed and Collaborative Research and Findings Reporting System
- **AI-driven Model validation**
- Tailored access with conditional rendering for **two distinct user groups: general Users and ISRO scientists**



Opportunities

- Valuable scientific contributions
- Guidance for future lunar missions
- Potential for collaboration and funding
- Advancements in AI/ML technique



Weaknesses

- **Data quality and volume:** Large, high-resolution spectral data requiring substantial storage and processing resources
- **Dependency on external tools:** Reliance on external libraries and frameworks may pose compatibility and maintenance challenges



Threats

- **Data Security:** Risks related to securing large volumes of sensitive or proprietary data

Use Cases



Monitoring lunar surface temporal variations



Targeted exploration



Facilitating collaborative research

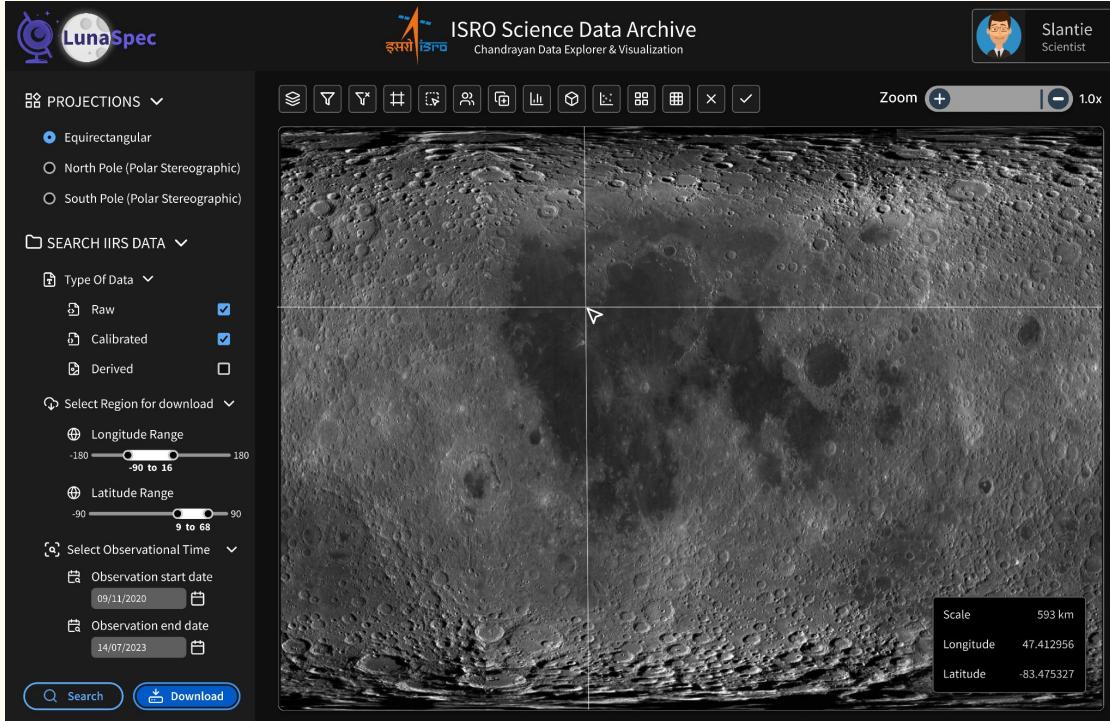


Identifying unusual features



Model accuracy assessment

Proposed UI



The image displays a proposed User Interface (UI) for a scientific data archive. The interface is divided into several sections:

- LunaSpec:** A sidebar on the left containing a logo and navigation links for "PROJECTIONS" (Equirectangular, North Pole, South Pole), "SEARCH IIRS DATA" (Type Of Data: Raw, Calibrated, Derived; Select Region for download: Longitude Range -180 to 180, Latitude Range -90 to 68; Select Observational Time: Observation start date 09/11/2020, Observation end date 14/07/2023), and "Search" and "Download" buttons.
- ISRO Science Data Archive:** The main central area featuring a grayscale map of the Moon's surface. The map includes a vertical scale bar and a horizontal coordinate grid. A legend at the top right shows various symbols for terrain features like craters, mountains, and plains.
- Slantie Scientist:** A small profile icon of a person in a lab coat in the top right corner.
- Information Panel:** A bottom right panel displaying geographical coordinates: Scale 593 km, Longitude 47.412956, and Latitude -83.475327.

Landing Page

Proposed UI

The screenshot displays the LunaSpec interface for Chandrayaan Data Explorer & Visualization. On the left, there's a sidebar with projection settings (Equirectangular selected), search filters for IIRS data (Raw and Calibrated checked), region selection (Longitude Range from -90 to 16, Latitude Range from -90 to 68), observational time (start: 09/11/2020, end: 14/07/2023), and search/download buttons.

The main area shows a grayscale image of the Moon's surface with a yellow box highlighting a specific region. A callout window titled "Spectral Classes Histogram" shows the distribution of pixels across four classes:

Class	Number of Pixels
0	1.2
1	0.5
2	0.8
3	0.2
4	0.1

At the bottom right of the image, there are scale and coordinate details: Scale 600 km, Longitude 77.519531, and Latitude 27.681427.

Spectral Classification on selected Lunar Region

Proposed UI

LunaSpec

PROJECTIONS ▾

- Equirectangular
- North Pole (Polar Stereographic)
- South Pole (Polar Stereographic)

SEARCH IIRS DATA ▾

Type Of Data ▾

- Raw
- Calibrated
- Derived

Select Region for download ▾

Longitude Range: -180 to 180

Latitude Range: -90 to 68

Select Observational Time ▾

Observation start date: 09/11/2020

Observation end date: 14/07/2023

Search **Download**

ISRO Science Data Archive
Chandrayan Data Explorer & Visualization

Slantie Scientist

Zoom + | - 4.7x

Spectral Classes Histogram

Class	Number of Pixels
0	1.2
1	0.5
2	0.8
3	0.2
4	0.1

Scale: 600 km
Longitude: 77.519531
Latitude: 27.681427

Research and Findings Reporting

Proposed UI

LunaSpec

PROJECTIONS ▾
 Equirectangular
 North Pole (Polar Stereographic)
 South Pole (Polar Stereographic)

SEARCH IIRS DATA ▾
 Type Of Data ▾
 Raw
 Calibrated
 Derived
 Select Region for download ▾
 Longitude Range
 Latitude Range
 Select Observational Time ▾
 Observation start date
 Observation end date

ISRO Science Data Archive
Chandrayaan Data Explorer & Visualization

Slantie Scientist

Zoom 1.0x

Radiance vs Wavelength Chart

Plot 1 (Blue Line)
Plot 2 (Red Line)

Wavelength (nm)

Scale 467 km
Longitude 89.123456
Latitude 56.789012

Lunar Regions-wise Analysis

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THANK YOU