Spectral Classification of Chandrayaan-2 IIRS Data Using AI/ML

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Introduction

- The Chandrayaan-2 mission provides high-resolution hyperspectral data of the Moon.
- IIRS (Imaging Infrared Spectrometer) data offers insights into lunar geology.
- This project leverages AI/ML to classify spectral data and identify minerals.

Objectives

- Create a visualization tool to classify IIRS data based on acquisition parameters.
- Apply AI/ML algorithms for grouping spectral classes.
- Understand the advantages and limitations of AI/ML for spectral classification.

Expected Outcomes

- Understanding hyperspectral data analysis.
- Develop a GUI for identifying areas of interest with observational parameters.
- Spectral classification for mineral identification and geological context analysis.

Dataset Required

- IIRS data from Indian Space Science Data Center:
  https://idp.issdc.gov.in/
- Supportive data for validation:
  https://ode.rsl.wustl.edu/moon/

- Python/MATLAB

Steps to Achieve Objectives

1. Data Acquisition and Preparation
2. Data Visualization and Filtering (GUI Development)
3. Data Preprocessing
4. AI/ML Model Development
5. Model Validation and Interpretation
6. Evaluation

1. Data Acquisition and Preparation

- Download IIRS and supportive data.
- Organize data and familiarize with formats and metadata.
- Convert data to suitable formats if necessary.

2. Data Visualization and Filtering

- GUI Design: Tkinter, PyQt, Flask, or Django.
- Visualization: Matplotlib, Cartopy.
- Features: Select date range, overlay IIRS strips on lunar globe, display observation parameters, filter data.
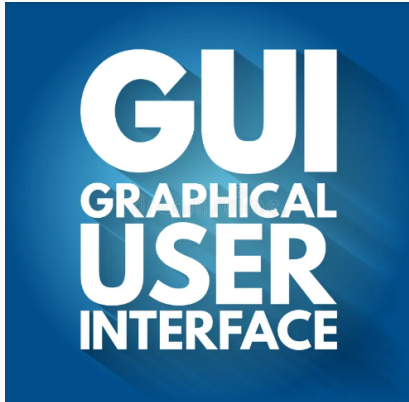
3. Data Preprocessing

- Geometry-Based Classification: Group data with similar geometry.
- Region Selection: Select well-covered lunar region with mentor guidance.
- Noise Removal: Apply techniques like Savitzky-Golay filtering, wavelet denoising.

4. AI/ML Model Development

- Feature Engineering: Extract relevant spectral features.
- Model Selection: Experiment with unsupervised and supervised algorithms.
    - Unsupervised: K-means clustering, Gaussian mixture models (GMMs).
    - Supervised: Support vector machines (SVMs), Random Forests, Neural Networks.
- Evaluate model performance using metrics like accuracy, precision, recall, and F1 score.

5. Model Validation and Interpretation

- Compare results with published findings.
- Link spectral classes to specific lunar minerals.
- Analyze spatial distribution of minerals for geological insights.

6. Evaluation

- User Experience: Ease of use and satisfaction with GUI.
- Classification Accuracy: Validate against ground truth data.
- Relevance: Compare results using multiple AI/ML algorithms.

GUI Enhancement Ideas

- Interactive 3D Visualization: Use Plotly or PyVista.
- Customizable Filtering: Advanced options beyond basic geometry.
- Data Comparison: Integrate tools for comparing IIRS data with supportive datasets.

AI/ML Model Innovation Ideas

- Transfer Learning: Use pre-trained models for lunar spectral classification.
- Ensemble Models: Combine multiple AI/ML algorithms for better performance.
- Explainable AI: Use SHAP values, LIME to understand model predictions.

Advanced Data Analysis Ideas

- Time-Series Analysis: Analyze temporal changes in spectral signatures.
- Spatial Clustering: Identify regions with similar spectral characteristics.
- Anomaly Detection: Detect unusual spectral signatures indicating rare minerals.

Additional Considerations

- Data Augmentation: Create synthetic samples to improve model robustness.
- Collaborative Filtering: Suggest relevant IIRS data or tools based on user preferences.
- Cloud Computing: Use cloud platforms for efficient analysis.

Conclusion

- AI/ML can significantly enhance the spectral classification of Chandrayaan-2 IIRS data.

- The project aims to provide a comprehensive tool for lunar geological analysis.

- Collaboration and innovative approaches will drive the success of this project.