Automatic Mineral Detection on Lunar Surface

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Data collection

DATASET:

Lunar Chandrayaan-I M3 hyperspectral data (Level 2 calliberated)

PURE MINERAL SPECTRA:

RELAB and PDS spectral data from Mineral and Rock Sample Database obtained from Centre For Terrestrial and Planetary Exploration (C-TAPE)

MINERALS:

Orthopyroxene, Clinopyroxene, Olivine, Plagioclase, Spinel, Ilmenite, and their mixtures

Literature Analysis

VISION BASED METAL SPECTRAL ANALYSIS USING MULTI-LABEL CLASSIFICATION

Eranga Ukwatta et al.(2009) DOI: https://doi.org/10.1109/CRV.2009.42

- Using computer vision and machine learning techniques on (LIBS) spectra, they presented an in situ fully automatic method for detecting constituent elements in a sample specimen.
- Casted the metal detection problem as a multi-label classification and thus enabling detection of elemental composition of the specimen.
- The paper makes use of a multi-label classification approach to metal spectroscopy which enables multi-element analysis. Another similarity is, accurate elemental analysis is not required but rather a qualitative analysis.

MULTI-LABEL CLASSIFICATION FOR DRILL-CORE HYPERSPECTRAL MINERAL MAPPING

I. C. Contreras et al.(2020) DOI: https://doi.org/10.5194/isprs-archives-XLIII-B3-2020-383-2020

- A multi-label classification concept is introduced for the mineral mapping task in drill-core hyperspectral data analysis.
- The quantitative and qualitative analysis of the obtained results shows that the multi-label classification approach provides meaningful and descriptive mineral maps and outperforms the single-label RF classification for the mineral mapping task.
- We are both working on hyperspectral data related to minerals using multi-label classification in the process.

More Literature

Intelligent Identification for Rock-Mineral Microscopic Images Using Ensemble Machine Learning Algorithms

Ye Zhang Et al.(2019) doi:10.3390/s19183914

Lunar terrain and mineral's abundance automatic analysis

Qinghua Su Et al.(2013)
DOI: 10.1016/j.ijleo.2013.08.022

A Survey on Machine Learning in Chemical Spectral Analysis

Dongfang Yu Et al.(2020)
DOI:10.32604/jihpp.2020.010466

What we did so far

✓ Spectral Extraction

- Extracting the spectral information from the pure mineral spectra from the database

✓ Data preprocessing

- transforming raw data into an understandable format
- Resolving issues found in the data

✓ Feature Engineering

- selecting and transforming the most relevant variables from raw data when creating a predictive model using machine learning or statistical modeling.

✓ Experiment

- Did a sample experiment using the ML algorithms on the dataset and compared the results obtained

Steps taken:

Data preprocessing:

- Data cleaning- Handling of missing data, duplicated data and noisy data
- Data transformation- continuum removal

Feature Engineering:

- Viewing geometry : 30 degree
- Selection of required wavelengths
- Feature selection: PCL technique

Experimentation:

- Splitting of training and testing data: 80/20 rule
- ML algorithms used: SVM, ML-KNN, and RF
- Compared F1-score and accuracy score

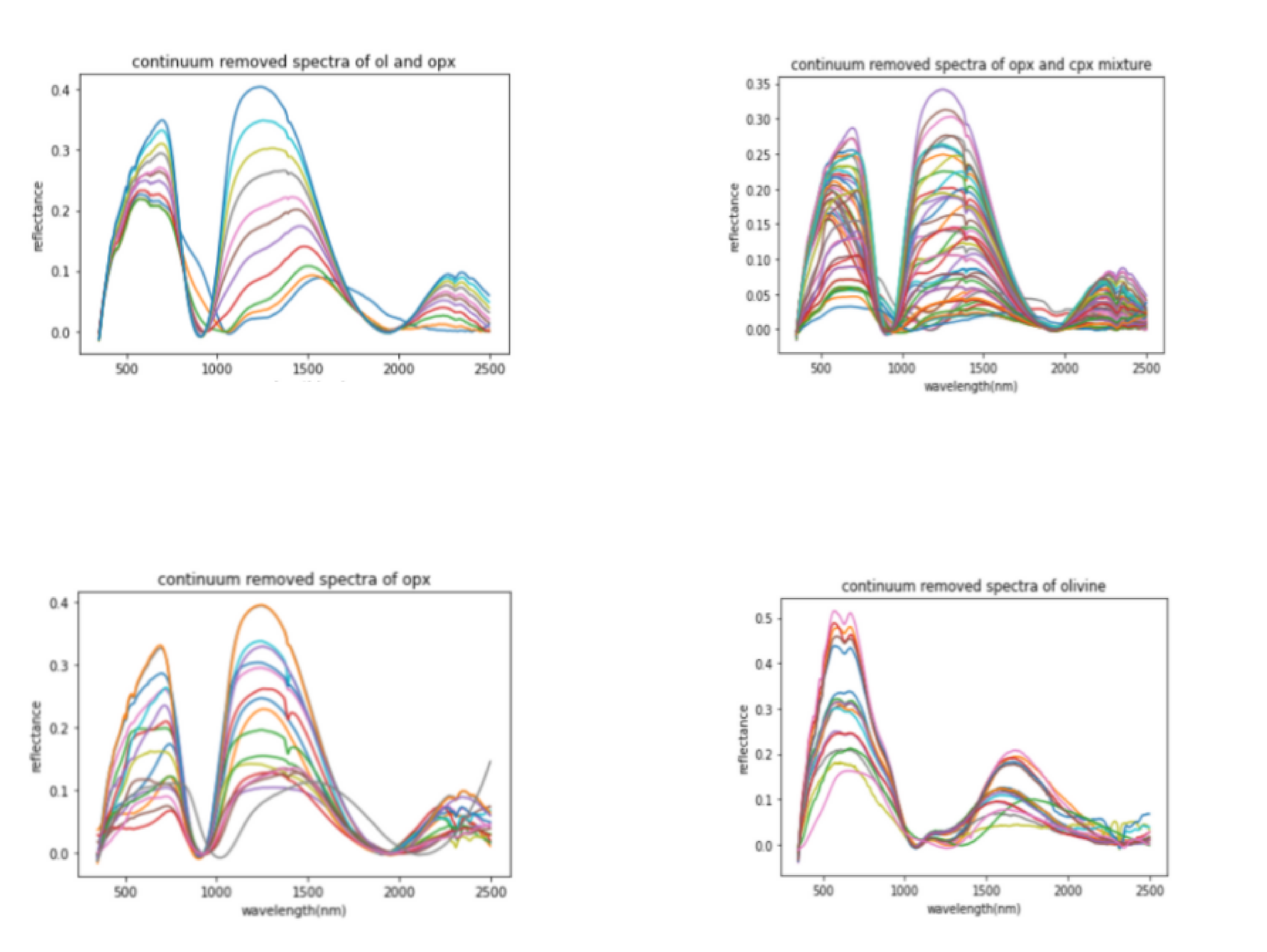
Continuum Removal

Normalizes reflectance spectra in order to allow comparison of individual absorption features from a common baseline.

Allows comparison of spectra that are acquired by different instruments or under different light conditions.

Spectra of :

- mixture of orthopyroxene and olivine.
- mixture of orthopyroxene and clinopyroxene.
- orthopyroxene.
- olivine.



Experimental Observations:

Minerals under study:

- Olivine
- Orthopyroxene
- Clinopyroxene

ML algorithms under study:

- SVM
- ML-KNN
- Random Forest

Classes	SVM	ML - KNN	Random Forest
F1-score of: Olivine Orthopyroxene Clinopyroxene	0.80 1.00 0.98	0.89 0.97 0.86	0.36 0.86 0.69
Score	0.8823529411764706	0.8095238095238095	0.8571428571428571

Experimental Results

- All the three machine learning algorithms gave satisfactory results and thus proved machine learning techniques can be used to solve the mineral detection problems.
- K-fold cross validation showed the training and testing data split by the 80/20 rule gives good results
- Among the three ML algorithms, SVM is found to have the best result for this experiment.

Thank you! :)