Enhancement of JMARS

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INTRODUCTION

JMARS (Java Mission-planning and Analysis for Remote Sensing) is a geospatial information system (GIS) developed by ASU's Mars Space Flight Facility to provide mission planning and data analysis tools for NASA planetary mission data to scientists, students of all ages, and to the general public [1]. It provides convenient accessing and visualization of imagery data coming from various Mars missions such as MGS TES, Odyssey THEMIS, MER Mini-TES, and MRO HiRISE. NASA's new mission, Mars Science Laboratory (MSL)/Curiosity has a number of instruments on board for measuring the abundance of chemical elements in Martian soil and rock samples. One of these instruments is APXS (Alpha Particle X-ray Spectrometer). APXS exposes the rock/soil samples to alpha particles and X-rays emitted during the radioactive decay of the element curium [2]. Another MSL instrument named ChemCam uses laser pulses to vaporize thin layers of Martian rock and soil samples up to 7 meters (23 feet) away. ChemCam instrument uses laser-induced breakdown spectroscopy (LIBS) along with a remote micro-imager (RMI) to provide chemical compositional analysis from a distance [3-4].

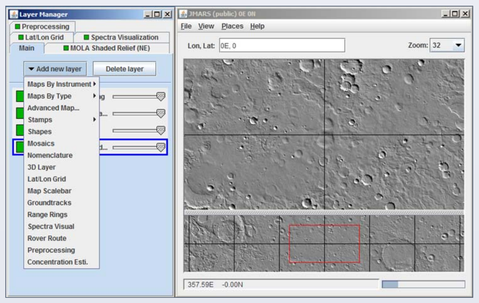

Fig.1 JMARS layer manager and viewing window

OBJECTIVES

We are developing a Java version of chemical composition analysis tools for JMARS. These tools will be specifically for analyzing the APXS and LIBS spectra of the MSL-collected Martian rock/soil samples and will allow JMARS users to download and visualize these LIBS/APXS spectra and conduct a number of analyses including signal preprocessing and correction, concentration estimation, spectrum similarity and abnormality detection in the spectrum signals. Additionally, these add-on tools will allow the JMARS users to download the Mars rover paths and visually examine the rover paths and the spectra data collection sites on the Mars map.

SYSTEM ARCHITECTURE

The architecture of JMARS is based on a client and server structure as shown in Fig. 2. Users can download the client software from the JMARS website and install it on their PCs. The client modules however have limited computational capabilities, and computationally intensive tasks occur on the JMARS servers. Each JMARS server module is a separate entity which is assigned to a specific processing task. They are installed on powerful network workstations. JMARS with the integrated add-on tools for APXS/LIBS spectrum analysis will use a similar client/server architecture. When a user chooses to use the spectral analysis tools, user requests are sent to the server which contains the signal processing engines, databases for APXS/LIBS spectra data and shape files for Mars rovers' routes and data collection sites. The requested data and results are then sent back to the JMARS client. The server side will have a multi-threaded architecture with multiple workers fulfilling these requests as seen in Fig.3.

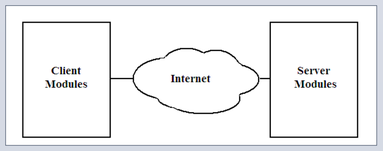

Fig.2 Client-server architecture in JMARS

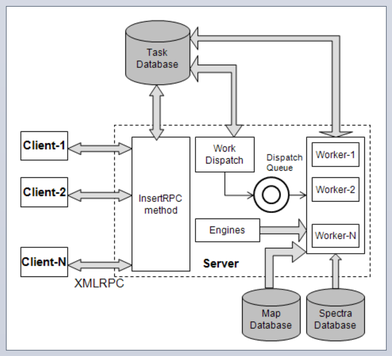

Fig.3 The server components for the JMARS add-on tools

ADD-ON TOOLS for JMARS

Range Rings Layer: This tool enables the user to plot range rings which are a set of concentric circles around any point to examine distances between the rover and the surrounding entities around the rover.

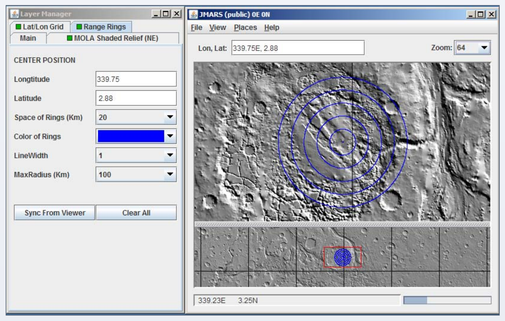

Fig.4 Range Rings add-on tool for JMARS

Rover Route Layer: This tool allows visualizing the rover path and the spectra (APXS/LIBS) data collection sites on the map. This information will be read from files in shape file format.

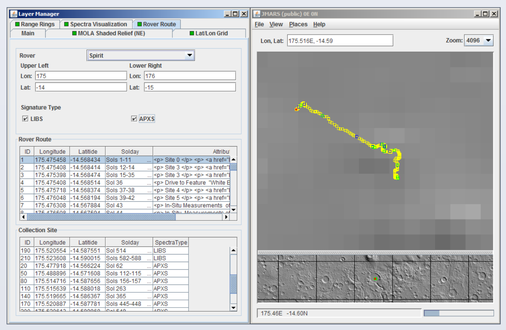

Fig.5 Rover Route add-on tool for JMARS

Spectra Visualization Layer: This tool is for visualizing LIBS or APXS spectra at rover data collection sites and displaying auxiliary information that come with the data such as APXS's "the temperature correction gain multiplier" and "linear term".

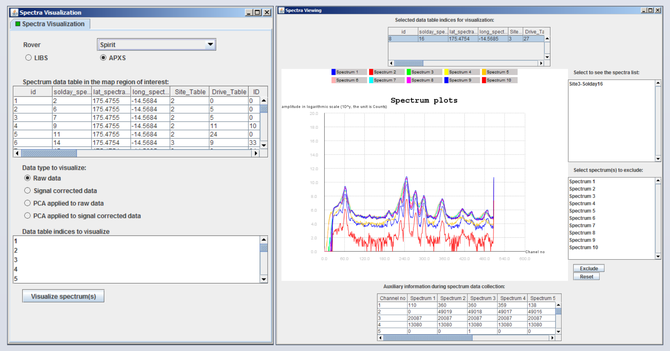

Fig.6 Spectra Visualization add-on tool for JMARS

Preprocessing and Concentration Estimation Layers: Preprocessing add-on tool will enable to apply signal preprocessing algorithms such MSC (multiplicative scatter correction) and dimension reduction to LIBS and APXS spectra. Concentration Estimation layer will consist of a number of techniques for chemical composition analysis. One of these techniques is PLS (Partial Least Squares), another is a linear spectral unmixing method, NCLS (Non-negatively constrained least squares) [5]. Other concentration estimation tools such as peak-area based concentration estimation (for APXS) is also considered to be included in this tool.

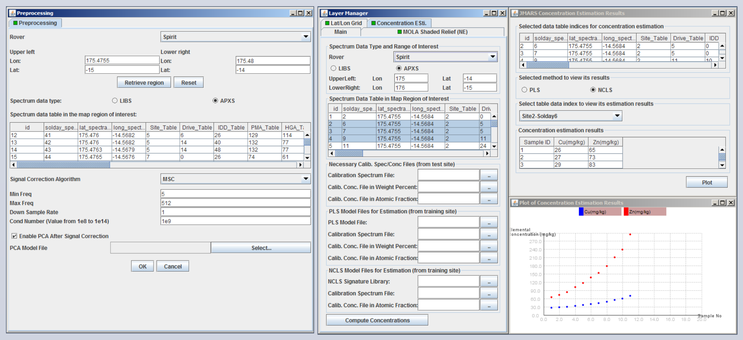

Fig.7 Preprocessing and Concentration Estimation add-on tools for JMARS

Similarity and Abnormality Analysis Layers: Similarity Analysis tool will enable a user to identify the spectrums which have resemblances to a user-selected reference spectrum in a quantitative manner. Spectral Angle Mapper (SAM) will be used as the similarity measure [5]. The Abnormality Analysis tool will allow a user to identify the spectra (LIBS or APXS) that have different spectral shapes than the majority of the spectra that are collected by the two instruments. The results of this analysis can be utilized to determine the rock/soil samples of different characteristics/origin in chemical composition and/or identify some issues in the data collection to help to label those spectra as outliers. The RXD (Reed and Yu Detector) technique [6] will be used for abnormality analysis in this tool.

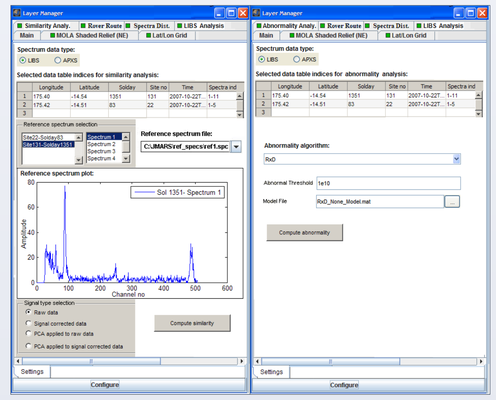

Fig.8 Similarity and Abnormality Analysis add-on tools for JMARS (pending)

Training Layers: These layers will be used train mathematical models to conduct concentration estimation and similarity/abnormality analyses. The training will be for generating PCA (Principal Component Analysis) models to reduce the dimension of the LIBS or APXS spectra, PLS models to identify the chemical compositions and RXD models to detect the abnormal spectra.

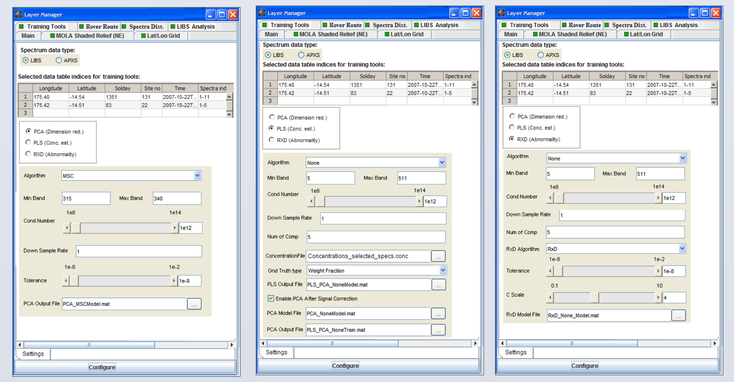

Fig.9 Training add-on tool for JMARS (pending)

Conclusions

We are still in the design and development stage of the JMARS add-on tools for APXS/LIBS spectra analysis. This poster aims to introduce our high level system architecture briefly and present some of the preliminary results from the ongoing development.

References

[1] JMARS official website, https://jmars.mars.asu.edu/

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[3] Mars Science Laboratory/Curiosity fact sheet, http://www.jpl.nasa.gov/news/fact_sheets/mars-science-laboratory.pdf

[4] The ChemCam Instrument Suite on the Mars Science Laboratory Rover Curiosity: Remote Sensing by Laser-Induced Plasmas, http://www.geochemsoc.org/publications/geochemicalnews/gn145jun11/chemcaminstrumentsuite

[5] C. Kwan, B. Ayhan, G. Chen, C. Chang, J. Wang, and B. Ji, "A Novel Approach for Spectral Unmixing, Classification, and Concentration Estimation of Chemical and Biological Agents," IEEE Trans. Geoscience and Remote Sensing, vol. 44, no. 2, Feb. 2006.

[6] Hyperspectral Imaging, Techniques for Spectral Detection and Classification, Kluwer Academic, Chein-I Chang.

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