EPSC Abstracts
Vol. 12, EPSC2018-147, 2018
European Planetary Science Congress 2018

Mars INteractive Exploration based on Reconstruction and Visual Analysis: The MINERVA Concept

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Abstract

MINERVA is a 3D GIS currently under development by JR, VRVis and EOX for a collaborative, holistic planetary science data infrastructure to allow members of different instrument teams to cooperate synergistically in virtual workspaces by sharing observation information, analysing and annotating the data. MINERVA is implementing a novel framework of interoperable and collaborative components based on an interactive 3D Viewer with GIS functionality, a database that maintains the knowledge about spatiotemporal data products, and a visual analytics platform that will help find new interconnections between the data coming from different instruments to discover new modes of scientific exploitation. MINERVA will be usable for the ExoMars Rover Mission (to be launched in 2020), which provides a heterogeneous set of scientific data captured by different instruments from the surface of the Red Planet. We will present the MINERVA concept, discuss various use cases and give selected details on representative ExoMars workflows and available & envisaged technical solutions.

1. MINERVA Scope

The ExoMars 2020 mission will provide a heterogeneous set of data from different instruments captured on the surface of Mars [1]. Imagery for science target selection, navigation, or close-up detailed visual analysis for geology, complemented by multi-spectral imagery from orbiters will be supplemented with georeferenced sensor data such as from the WISDOM ground penetrating radar instrument, looking into the Mars subsurface. The Analytic Laboratory Drawer inside the Rover body punctually observes samples acquired by a drill. A comprehensive and efficient analysis of this wealth of heterogeneous science data demands a sophisticated workflow that takes account for the heterogeneity of data and allows an overview of interconnections between different data entities.

Based on the instrument data and PDS4 archiving interfaces being established in the respective ROCC-to-Instrument ICDs[1], concepts are required for the support of a holistic analysis of all the versatile scientific data from the entire rover mission. The MINERVA goal is to provide for the first time an integrative, holistic and analytic support for planetary scientists. This will not merely make the analysis more efficient but the tight integration of heterogeneous analysis methods in real time will allow insights, which would be hard or impossible to obtain using isolated methods. A major challenge is imposed by the huge & heterogeneous data volume. New interactive visualization methods based on, e.g., semantic annotations, meta-information and data modalities will be investigated. Beside the science claim in the mission itself, MINERVA will focus on the holistic workflow and on specific ExoMars requirements and the exploitation of the scheme for future missions and terrestrial applications.

2. MINERVA Components

The MINERVA prototype (Figure 1) will consist of three tightly integrated components:

1) A data base for scientific data products that also maintains analysis results [2]
2) A 3D Visualization Engine (PRo3D) [3] to navigate through 3D Mars surface reconstructions for extensive geological/morphologic interpretation [5] using a variety of interactive measurement tools. PRo3D offers important GIS functionalities such as orthographic view, superimposed rover tracks and data locations.
3) A non-spatial visualization component [4] for in-depth investigation of data, to discover relations, properties and coherencies otherwise hidden.

[1] ROCC…Rover Operations Control Centre; ICD…Interface Control Document

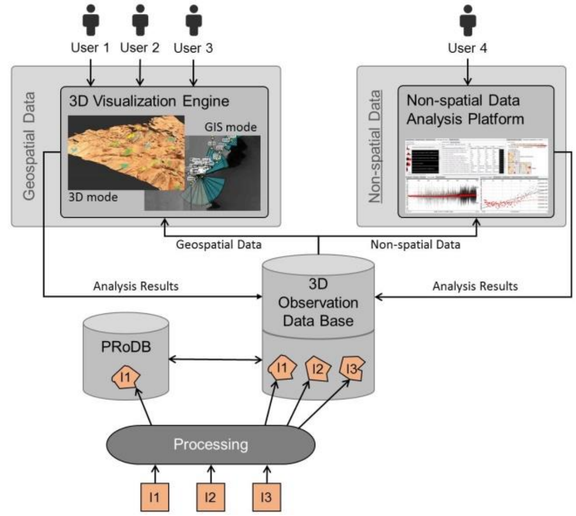

Figure 1: The Instrument Teams (I1…I3) use generic (PDS4) importer tools to ingest mission data into the 3D Observation Data Base. It is available to PRo3D with integrated GIS functionality, and the Non-spatial Data Analysis Platform. Users can share locations & observations and launch visual analysis of different instrument data at the same time.

3. MINERVA Use Cases

MINERVA will offer the users the opportunity to visualize, analyze, and annotate the mission data in a spatiotemporal context and in the context of other meta-information from the scientific measurements[2]:

- Support scientists in geo-referencing of scientific products (e.g. spectra) for the characterization of regions and the identification of their boundaries.
- To enable holistic overviews and correlations of product cues from multiple heterogeneous instruments. The scientists will be able to enrich the database by the output of interactive or semi-automatic tools for scientific assessment.
- Measure / annotate on 3D surfaces on PRo3D. Measurements/annotations are available in a data base and can be accessed by other users in PRo3D.
- Multi user handling to give different users different rights for loading and manipulating "session profiles" to support teams of scientists to exchange data e.g. on the same outcrops.
- Search for spatial and temporal correlations in laboratory instruments data (spectrometers etc.).
- Get spatial overview of products' locations having certain characteristics (e.g., a spectrum with a certain shape) and/or particular meta-information, e.g. rover orientations, focal length.
- Gain an overview of distribution of products by time / rover orientation / etc.
- Simultaneous inspection of ensembles of spectra / images. This may include a characterization of the overall dispersion, a pairwise comparison of particular products, and the clustering of products by their characteristics (e.g., the shape of their spectrum)
- Bidirectional relation of product locations to corresponding product characteristics, e.g., identify spectral bands with high values / strong variation / etc. within a region; identify potentially non-contiguous regions where objects have certain characteristics; inspect interpolated spectra between samples.

[2] The list is only a subset from many more. Further instrument collaboration use cases are being discussed with ExoMars instrument teams in workshops and direct communication.

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Acknowledgements

MINERVA is receiving funding from the Austrian Space Applications Programme (ASAP14) funded by BMVIT. JR, VRVis and EOX co-finance the activity.