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Associating Planetary Instruments' Data by 3D GIS and Visual Analysis: The MINERVA Framework

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Abstract

Planetary surface missions have emerged into complex robotic sensor frameworks collecting valuable yet heterogeneous data along the mission timeframe and spatially distributed across the probe's working range. MINERVA provides a 3D data base, an interactive 3D viewer with GIS functionality and a visual analytics platform that helps find correlations between data coming from different instruments to discover new modes of scientific exploitation. It facilitates the access and collaborative interpretation of planetary science data, including instrument products, analyses, and annotations. It allows members of different instrument teams to cooperate in virtual workspaces by sharing observations and analyzing and annotating data in a collaborative fashion. We report on latest MINERVA developments and draw the path to its usage within forthcoming robotic missions including ExoMars.

1. MINERVA Scope

ExoMars 2020 will provide a rich set of data from different instruments captured on the surface of Mars [1]. A comprehensive and efficient analysis of this wealth of heterogeneous science data demands a sophisticated workflow that takes account for the heterogeneity of the data and allows an overview of interconnections between different data entities. We identified three gaps in current tool chains: (1) Showing products from all instruments of a rover mission and potential derived products in their common spatiotemporal context. (2) Effective collaboration, where members of different instrument teams can share their analyses and their annotations in their common spatiotemporal context. (3) Analyzing & associating metadata beyond instrument products themselves, such as temperature, exposure duration, or solar elevation as typically available in metadata files associated with a product, without efficient means to put them into a common context.

MINERVA (Mars INteractive Exploration based on Reconstruction and Visual Analysis) offers 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, and also by discovering new modes of scientific exploitation through visual analytics. MINERVA represents a novel framework of interoperable and collaborative components based on an interactive 3D Viewer with 3D-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.

2. MINERVA Components

The MINERVA prototype consists of three tightly integrated components:

1) A data base for scientific data products that also maintains analysis results [2] and complies with open standards e.g. WFS [6]
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 c 'Christian Koeberl' <christian.koeberl@univie.ac.at> llaborative/interactive 3D-GIS functionalities such as an 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.

3. MINERVA Test Cases

In a first fully fledged-up test the framework ingested the full MSL missions' data set within 2137 Sols for

5 instruments (Mastcam, Front Hazcam, MAHLI, APSX, Chemcam), summing up to 137.000 product entries and a data amount of about 200 Gigabytes. Usability within PRo3D (Figure 1) and Visplore (Figure 2) was proven by testing search queries, as well as display of data dependencies within Visplore.

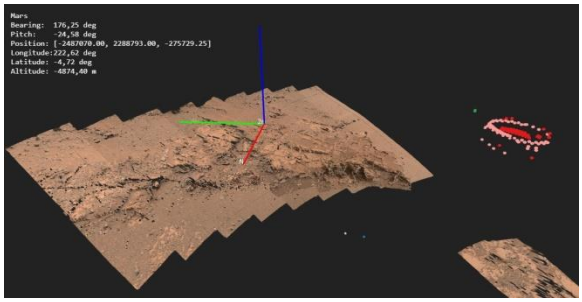

Figure 1: MSL product locations as dots of Mastcams (red), Navcams (blue), and ChemCam (green) in spatial context with the Garden City outcrop reconstruction. 3D data was derived from Mastcam images of the Sols 925, 926, and 929. Data Credits: NASA/CalTech/MSSS/ASU

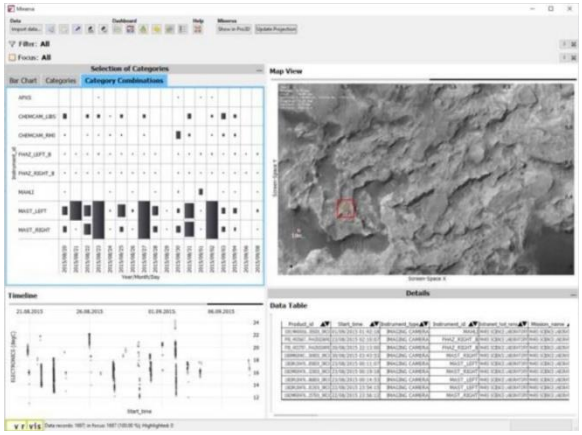

Figure 2: Selection of products in the visual analytics component Visplore. Some products are simultaneously displayed in PRo3D (see Figure 1).

4. Conclusion

MINERVA offers the users the opportunity to visualize, analyze, explore and annotate robotic surface mission data in a spatiotemporal context and in the context of other meta-information from scientific measurements. Several use cases have been identified so far in discussions with planetary scientists:

- Geo-referencing of scientific products (e.g. spectra) for the characterization of regions and the identification of their boundaries
- Holistic overviews and correlations of product cues from multiple instruments and triggering further interactive or semi-automatic tools for scientific assessment
- Measure / annotate on 3D surfaces including storage in the data base for later access
- Search for spatial and temporal correlations in laboratory instruments' data (spectrometers etc.)
- Spatial overview of products' locations having certain characteristics (e.g., spectrum with a certain shape) and/or particular meta-information, e.g. rover orientations, focal length, temperatures
- Overview of products' distribution by time / rover orientation / sun angle etc.
- Simultaneous inspection of ensembles of spectra / images including characterization of overall dispersion, pairwise comparison of products, clustering of products by their characteristics
- Bidirectional relation of product locations to corresponding product characteristics, e.g., identify spectral bands with high values / strong variation / etc. within a region.

References

[1] Vago, et al (2017). Habitability on early Mars and the search for biosignatures with the ExoMars Rover. Astrobiology, 17(6-7), 471-510.

[2] Meissl, S., & Triebnig, G. (2010). Land Monitoring Network Services based on international geospatial standards: SOSI and geoland2/SDI Projects. International Journal of Digital Earth, 3(S1), 70-84.

[3] Barnes et al (2017, March). Application of PRo3D to Quantitative Analysis of Stereo-Imagery Collected During the Mars Utah Rover Field Investigation (MURFI) Analogue Rover Trials. In Lunar and Planetary Science Conference (Vol. 48).

[4] Piringer et al (2009). A multi-threading architecture to support interactive visual exploration. IEEE Transactions on Visualization and Computer Graphics, 15(6), 1113-1120.

[5] Balme et al (2017). Surface-based 3D measurements of small aeolian bedforms on Mars and implications for estimating ExoMars rover traversability hazards. Planetary and Space Science.

[6] OpenGeospatialConsortium. WFS - web feature service. Accessed: 2019-04-26

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