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PRo3D – a tool for remote exploration and visual analysis of multi-resolution planetary terrains

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Abstract

This paper describes a viewer called PRo3D that enables planetary scientists to explore and analyze accurate reconstructions of planetary terrains. These reconstructions, derived from 3D-processing of images obtained by rovers, landers, and satellites, provide access to the corresponding planetary surfaces on Earth in a virtual space. PRo3D allows zooming through a broad range of geometric scales to study geologic structures from far away to microscopic close-up. The viewer provides various measurement tools to derive the true dimension of surface features and let scientists place annotations in 3D space. PRo3D is a component of the *FP7-PRoViDE* tool set.

1. Introduction

An interactive viewer was necessary as user front-end to explore and analyze 3D reconstructions of planetary terrains. Already existing viewers usually focus on different application domains, such as 3DROV [4], which is used for operations planning and Rover simulation. Geological analysis has different requirements. These are:

- Study 3D representations of rock outcrops by moving around efficiently to get different perspectives
- Be able to visualize and investigate data from orbital imagery down to the magnifier-scale imagery (investigate multi-resolution data sets) for global context and spatial referencing between differently located phenomena
- Measure geological structures to determine their dimensions and other geometric features
- Mark regions and features and label them.

Meeting these requirements allows scientists to gain deeper insights from the 3D reconstruction and also supports decision making during mission operation, e.g. when choosing promising locations to send the rover to.

2. Virtual Exploration

Scientists are able to virtually fly through 3D reconstructions of Martian surfaces similar to nowadays games' experience. The crucial difference to games is the high accuracy of the reconstructions. To suffice for scientific analysis geometry and textures require a much higher resolution and a geometrically and visually correct rendering.

To handle huge amounts of geospatial data in an interactive application, PRo3D applies a technique known as Levels of Detail (LoD) [1] [3]. The appropriate level is automatically chosen for separate patches of the surface depending on the distance from the viewpoint (see Figure 1). In such a way, close-by areas are rendered at a higher detail than those further away. LoDs also allow seamless zooming within a broad range of scales so that geologists can relate large-scale structures to close-up features of rock outcrops.

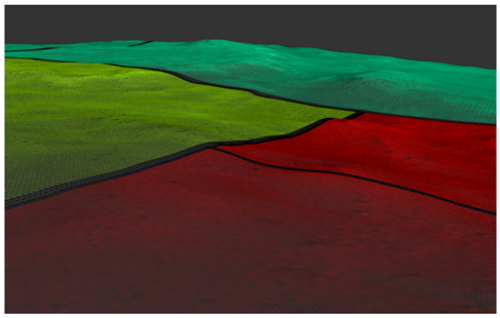

Figure 1: Color coded LODs.

3. Measurements and annotations

The viewer provides interactive tools for various types of measurements in 3D space, a feature that is essential

for analysis. The following measurement tools are currently available:

- Body-fixed coordinates of selected points on planetary surface
- Distance from viewpoint to surface point
- Linear distance between two surface points
- Distance on the surface (way length) between two points
- Length of a path on the surface, described by a user-drawn polyline
- Dip and strike to calculate the inclination and orientation of sedimentary layers [2]

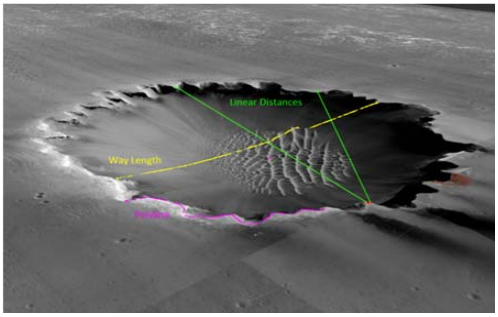

Figure 2: Demonstration of measurements types.

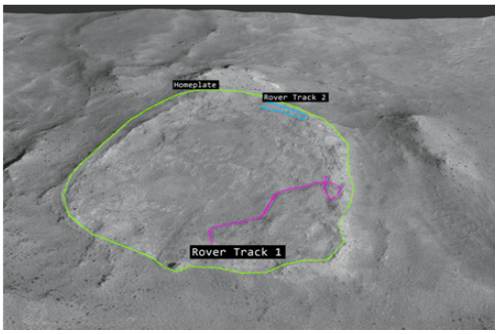

Figure 3: Annotation options (Credits: Tao and Muller, EPSC 2014)

Figure 2 shows examples of measurements. Besides measurements scientists can also place annotations in the virtual environment (Figure 3). For instance, the polyline tool allows scientists to mark and label regions of interest. These viewpoint-oriented text labels can be attached to any measurement and provide a powerful tool to annotate phenomena and insights in 3D space. All measurements can be interpreted as spatial bookmarks, which enables users to trigger a "fly-to" animation in order to locate the corresponding measurement. Intuitive viewpoint transitions offer an efficient comparison between measurements without losing the geospatial context.

4. Summary and Conclusions

We presented a tool for remote exploration and visual analysis of Martian surfaces. It immerses planetary scientist into a detailed 3D reconstruction of Martian surfaces, which is accurate enough to perform measurements and gain geological insights. Thereby it also supports decision making in ongoing and future missions.

User tests by planetary scientists have shown that the PRo3D virtual environment is an important additional method for the analysis of Martian surfaces. In future versions we will continuously improve and extend the interactive tools for measurements and annotations based on feedback from planetary scientists and the user community. Planned features further include false-color renderings of reconstructed surfaces to visualize properties such as inclination or rock materials.

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