Scientific Visualization for Atmospheric Data Analysis in Collaborative Virtual Environments

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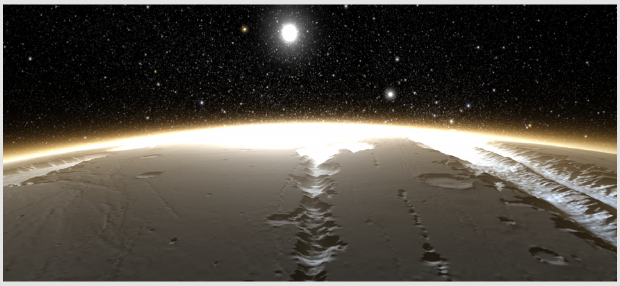
Scientific Visualization



Cinematic rendering of the Martian surface with stars and atmospheric effects

Introduction

The European research project CROSS DRIVE (Collaborative Rover Operations and Planetary Science Analysis System based on Distributed Remote and Interactive Virtual Environments) aims at developing an innovative collaborative workspace infrastructure enabling remote scientific and engineering experts to collectively analyze and interpret combined datasets using shared simulation tools. The three year project started in January 2014 and unites best European expertise in the fields of planetary research and Mars science, Virtual Reality (VR), atmospheric science and research as well as rover mission planning. The research and development focus on three use case studies:

- Landing site characterization
- Atmospheric science and analysis
- Rover target selection

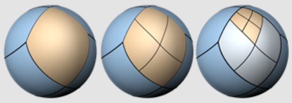
The requirement analysis and evaluation is driven by experiences from past missions and with close view on the ESA ExoMars 2016 TGO and 2018 rover mission.

Atmospheric Data Analysis

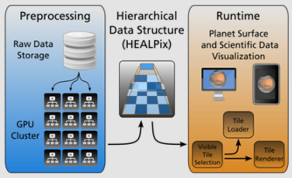
Currently the implementation for the second use case is in its final phase. Here, the requirements were generated based on the domain experts input and lead to development and integration of appropriate methods for visualization and analysis of atmospheric data. The methods range from volume rendering, interactive slicing, iso-surface techniques to interactive probing. All visualization methods are integrated in DLR's Terrain Rendering application. With this, the high resolution surface data visualization can be enriched with additional methods appropriate for atmospheric data sets. This results in an integrated virtual environment where the scientist has the possibility to interactively explore his data sets directly within the correct context.

The terrain rendering is based on the HEALPix tessellation of a sphere. This has several advantages:

- Self similar LOD patches
- No special cases on planet poles
- Area preserving during projection
- Quad tree data structure support

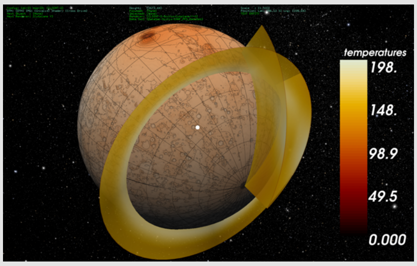


HEALPix tessellation and subdivision

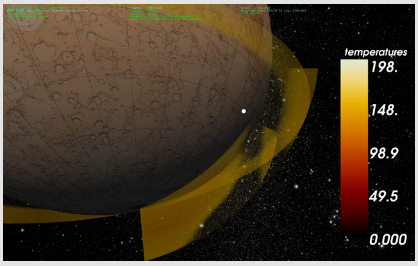


Software architecture of database, data structure and terrain rendering modules

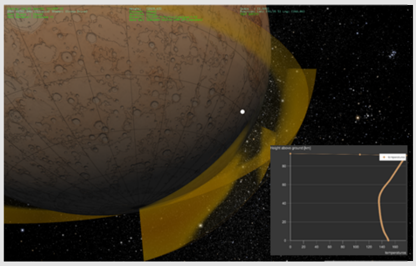
The atmospheric data sets include volumetric data of the Martian atmosphere with different scalar and vector fields, precomputed two dimensional maps and vertical profiles. In most cases the surface data as well as the atmospheric data has global coverage and is of time dependent nature. Furthermore, all interaction is synchronized between different connected application instances, allowing for collaborative sessions between distant experts. Also the application is currently used for visualization of data sets related to Mars the techniques can be used for other data sets as well. Currently the prototype is capable of handling 2 and 2.5D surface data as well as 4D atmospheric data. The visualization techniques for the volumetric data sets can handle VTK based data sets and also support different grid types as well as a time component.



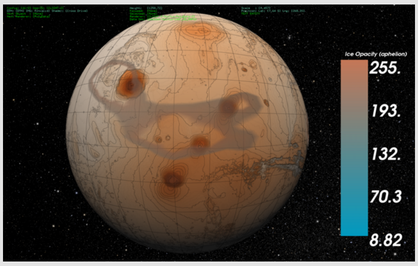
Cut planes to visualize 3D Temperature fields



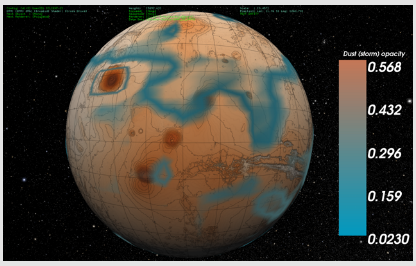
Customized transparency of transfer-function



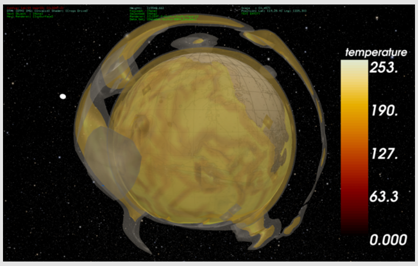
Cut planes and 2D-Diagram overlay



Visualization of 2D Maps on the surface



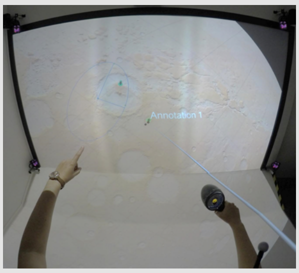
Visualization of 2D Maps on the surface



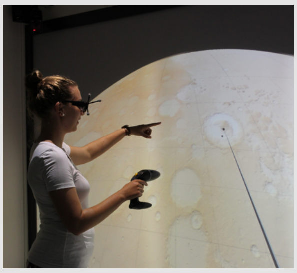
Visualization of 3D Temperature Fields using iso-surfaces

Collaborative Virtual Environment

Immersive virtual environments can create the illusion of being “teleported” to the planet one is exploring and, for example, give the scientist the possibility to travel along the terrain to explore various terrain features or see the planet as context for atmospheric data visualization. With this, the scientist are able to undertake a virtual, collaborative field trip to distant planets. Furthermore, atmospheric and sub-surface datasets can be analyzed in the dimensions of time and space. During the discussion process the scientists can make use of simple interaction concepts to manipulate the way the different data sets are visualized. This includes, creating all supported visualization methods on own data sets, changing iso-values and cut plane positions and manipulation of transfer functions. All methods and the scenario itself are fully synchronized. Several application instances can be linked via a network connection following a server-client approach. The application development of the presented visualization system is supported by the ViSTA VR-toolkit.



CROSS DRIVE prototype running in DLRs Virtual Reality Lab



Scientist during the discussion on landing site characterization.

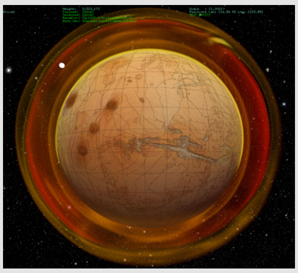
Future Development

In the remaining time we will target:

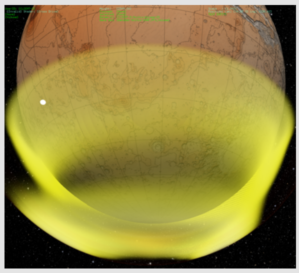
- Real-time video avatars as virtual representation of scientists
- Extend and improve our system.
- Virtual rover models
- Real-time shadow generation
- Integration of Martian moons

The CROSS DRIVE partners are:

- German Aerospace Center (DLR)
- University of Salford, UK
- Advanced Logistics Technology Engineering Center, Italy
- Thales Alenia Space Italia, Italy
- Istituto Nazionale di Astrofisica, Italy
- Institut dAeronomie Spatiale de Belgique, Belgium
- National University Corporation Tohoku University, Japan



GPU based direct volume rendering



GPU based direct volume rendering

Deutsches Zentrum für Luft- und Raumfahrt

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