

Scientific Visualization for Space Science Data Analysis in Collaborative Virtual Environments



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Scientific Visualization



The Gale crater on Mars (5.4° S, 137.8° E). Shaded DTM data on a yellow-red color scale

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.

Architecture

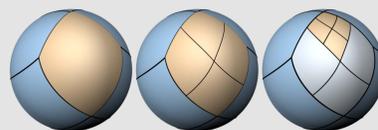
The visualization of terrain data on a planetary scale is a challenging task. During rendering high framerates have to be achieved, even if the data sets reach several terra-bytes in size. Our rendering system is based on a LOD approach and a HEALPix tessellation of a sphere. This has several advantages:

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

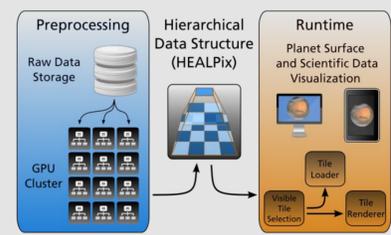
The development of our prototype is driven by the following main objectives:

- Fully scalable architecture
- Asynchronous rendering, loading of additional data and communication
- Easy adaption to different interaction and display devices
- Presentation of unchanged scientific data

The geo-referenced raw data is pre-processed into several LOD-friendly database files. The data itself is completely unchanged.

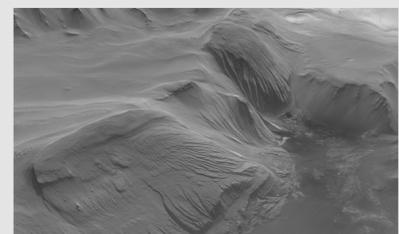


HEALPix tessellation and subdivision

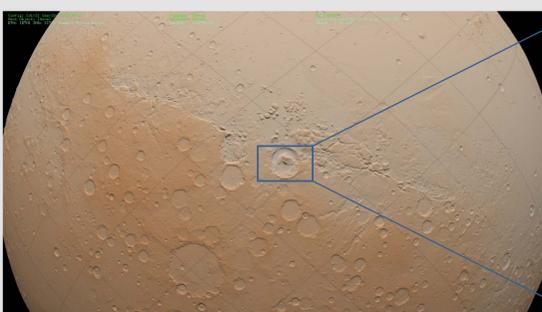


Software architecture of database, data structure and terrain rendering modules

The LOD structure is constantly updated. If the renderer requests a higher resolution LOD, the necessary data is uploaded from main memory to the GPU. In case a requested LOD of a specific tile is not yet available in main memory, it is loaded in a background thread from disk or network. If available we present at least one data sample for each pixel on the output device(s). LOD updates can be delayed to subsequent frames in case the current frame budget is exceeded.



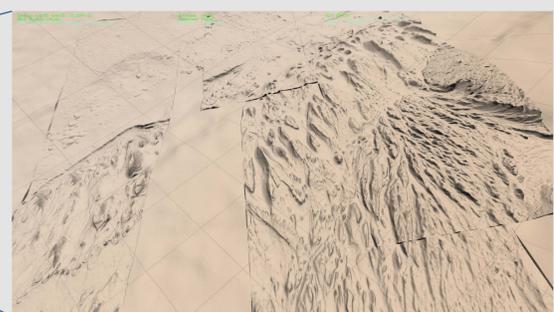
Real time high resolution terrain rendering



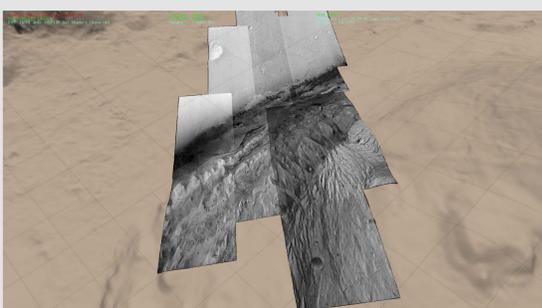
Terrain Visualization on planetary scale



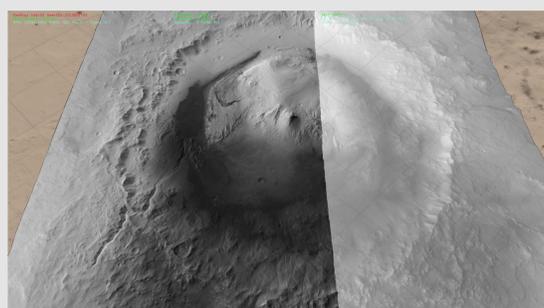
Zoom to area of interest (250 km wide)



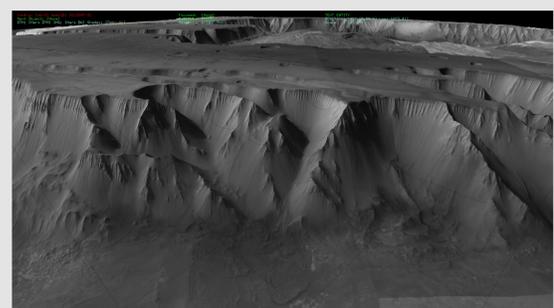
Detailed inspection (25 cm / pixel)



Gale crater DTM overlaid with imagery data (HIRISE)



Gale crater DTM overlaid with imagery data (HRSC)



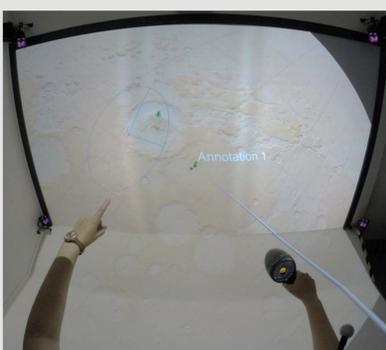
Valles Marineris imagery data (HRSC)

Collaborative Virtual Environment

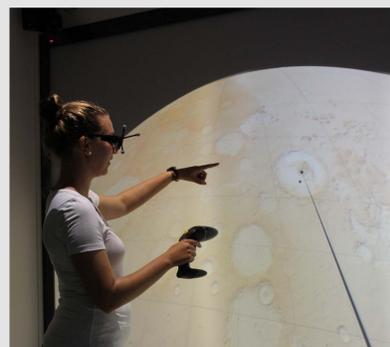
Immersive virtual environments can create the illusion of being "teleported" to the planet one is exploring and, for example, give the scientist the possibility to travel along the terrain to explore various terrain features. With this, the scientist are able to undertake a virtual, collaborative field 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 GIS tools controlled with intuitive interaction techniques.

All GIS tools 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. It is a C++ framework for the development of VR applications and provides:

- Platform abstraction
- Clustering
- Interfaces to a wide range of interaction devices.



CROSS DRIVE prototype running in DLR's 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.
- Additional scientific data (e.g., sub-surface and time dependent atmospheric data)
- Virtual rover models
- Real-time shadow generation
- Atmospheric scattering.

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 d'Aeronomie Spatiale de Belgique, Belgium
- National University Corporation Tohoku University, Japan



Gale crater and interactive GIS tools (landmark, polyline)



Gale crater and interactive GIS tools (profile line, landing ellipse)