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Multiple ways to visualize planetary image data

S. Elgner, S. Adeli, K. Gwinner, C. Hüttig, R. Jaumann, E. Kersten, U. Köhler, K.-D. Matz, A. Nass, J. Oberst, S. Pieth, F. Preusker, T. Roatsch, D. Tirsch, M. Wählisch, M. Weiland, K. Willner, and the DLR-Berlin Adlershof 3D show group

Institute of Planetary Research, German Aerospace Center (DLR), Berlin, Germany (stephan.elgner@dlr.de)

Abstract

At the DLR Institute of Planetary Research, we have many different ways of visualizing planetary image data. From the creation of scientific cartographic products over perspective 3D views to immersive virtual reality environments we apply many different visualization techniques to gain a better understanding of a planet's surface. Processing the data to obtain the best visual and contextual representations for scientific and engineering uses as well as for public outreach is part of our daily routine. We present some of the progress we have made in the field of data visualization during the last decade benefitting from modern techniques.

1. Introduction

Remote sensing data from planetary (e.g. Mars Express, Cassini, Messenger), Moon (LRO), asteroid (Dawn) or comet (Rosetta) missions are among the most exciting image data sets available.

By using stereo-photogrammetric methods image mosaics and digital terrain models for several celestial bodies, e.g. Mars [1], Moon [2], and Vesta [3], have been created to establish topographic data bases for scientific or engineering needs. These data sets, sometimes along with complementary data from other sources, e.g. laser altimetry data, serve as input for the visualization techniques we apply.

2. Mapping

An accessible and versatile way to present extensive image data sets is the use of cartographic products, i.e. topographic and thematic maps (Fig. 1). Geographic information systems (GIS) allow combining data and obtaining derivative information easily. Using Web Map Services (WMS) we can browse the data in a convenient way. Perspective views, often available as anaglyphic 3D stereoscopic images, help to perceive the 3rd dimension and are a staple in public outreach work [4][5].

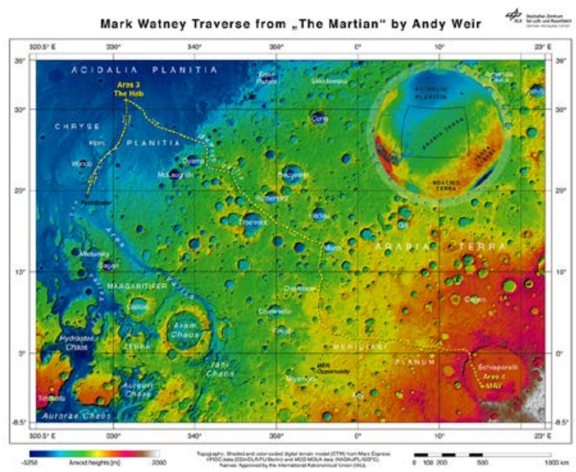

Fig. 1: Topographic map illustrating the protagonist's route from the book "The Martian" [6].

3. 3D Visualization

3.1 Meshes

Another approach is the use of triangulated meshes, which can be visualized with readily available software tools or inside web browsers utilizing WebGL technology. This is especially important for some irregular bodies, e.g. comet 67P/Churyumov-Gerasimenko or the Martian moon Phobos, which cannot be adequately represented in two-dimensional map forms. With the help of 3D printing hardware we can have an easy look at all the facets of a body while experiencing its shape with our own hands.

3.2 Animations

Computer generated imagery in the form of video sequences is an important factor in our public outreach efforts. While earlier examples mostly serve as cinematic overviews showing prominent surface features (Fig. 3) we now also embed more detailed information about the body or the mission to serve educational purposes. By using popular video streaming and social media platforms we can reach millions of viewers [7].

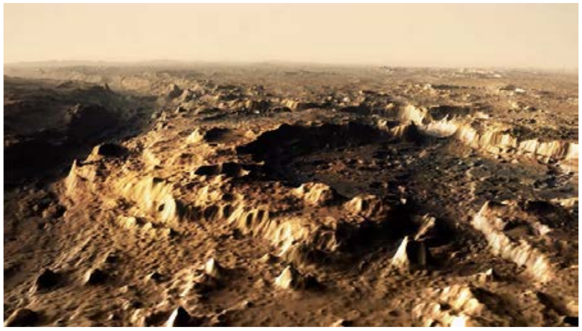

Fig. 3: Still frame from animation showcasing the HRSC MC11-E data set [8].

3.3 Immersive Interaction

Virtual environments have been set up using different software packages to experience planetary surfaces in all three dimensions. We regularly show selected Martian features in 3D flyovers for students or other interested visitor groups in our institute (Fig. 4).

Fig. 4: 3D presentation using stereo projector system showing Valles Marineris on Mars

A trend of the last years and one of the most immersive approaches is the use of virtual reality head-mounted displays. Due to their nature this can only be experienced by single users, therefore this technology is usually applied for individuals or small groups (Fig. 5).

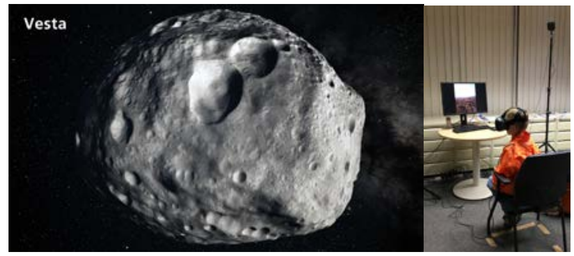

Fig. 5: Screenshot from Vesta VR environment (left), child wearing HMD during public event (right).

4. Summary

During the last 10 – 15 years we have tested and implemented modern visualization techniques to display large image and terrain data sets for scientific reasons and at public events. Our successful transition from analogue to modern digital techniques encourages us to follow that road.

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Interactive Solarsystem for High-Resolution Planetary Data Exploration

S. Schneegans, A.-C. Bernstein, A. Gerndt, M. Flatken and S. Utzig
German Aerospace Center, Simulation and Software Technology (simon.schneegans@dlr.de)

Abstract

We introduce *Virtual Planet*, an application which enables researchers to interactively explore huge planetary data sets in an intuitive way. The application allows users to navigate seamlessly between planets and provides different tools and interactive visualization to analyze the data.

1 Introduction

Space agencies have collected huge planetary data sets. Researchers want to be able to explore and analyze the data interactively and in realtime. This is a big challenge since the data is often too big to be processed in one step. Another challenge is the heterogeneity of the data. In order to gain new insights, it is important to consider the different data sets in context.

Our Software *Virtual Planet* solves many of these issues and provides researchers with interactive tools to analyze and visualize different kinds of data.

2 Virtual Planet

Our application allows planetary researchers to interactively explore huge planetary data sets interactively. This is a challenge since the data for a planet such as color images and elevation data is simply too big to be processed in real time. To be able to render the planets in realtime, we implemented an LOD-algorithm based on the healpix data structure [3].

Virtual planet is able to render the whole solar system. You can fly seamlessly from helgoland to the gale crater on mars, visit moons and spacecrafts or even zoom out of our solar system. To make this possible, we have developed a new dynamic scene graph which uses SPICE [2]. This allowed us to implement multiscale navigation which allows us to fly easily through our solar system and land on any planetary surface. With SPICE we get the correct planetary constellation for a given day and time.

In order to analyze the formation and alteration of geological features, we offer planetary scientists various tools as can be seen in figure 3. You can determine the strike and dip of strata, you can measure the size and extend of mountains and canyons by drawing profile lines and you can place annotations anywhere you like.

The flexibility of the system allows it to be used for other applications, such as rover mission planning. For example, we can draw profile lines for a possible route on the terrain. Or we can visualize the slope by mapping it to a color gradient. This allows us to easily see inaccessible terrain.

The system is easily extensible to support new kinds of data. We use the Web Map Service (WMS) protocol for fetching surface data over the Internet. This allows us to use other data sources such as openstreetmaps. We also integrated MRO SHARAD [4] data, atmospheric and climate simulation data [1].

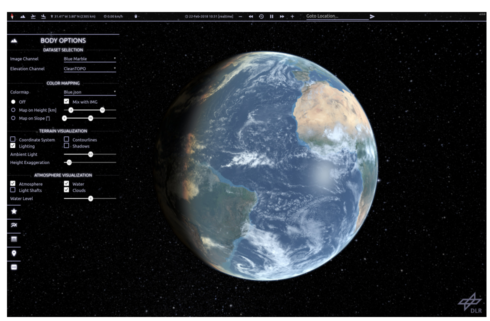

Figure 1: virtual planet in action.

3 Summary and Conclusions

We presented *Virtual Planet*, an application which allows researchers to interactively explore huge plane-

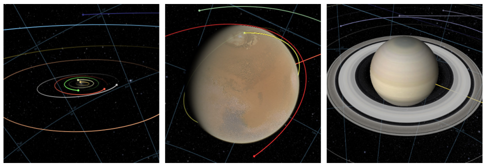

Figure 2: virtual solar system.

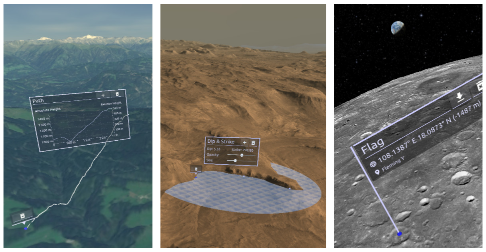

Figure 3: Tools.

tary data sets in an intuitive way. It is easily extendable to support new data sets and provides several tools and visualizations to analyze planetary data.

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BepiVR: Virtual Reality for BepiColombo outreach

Romolo Politi (1), Emanuele Simioni (2), Gabriele Cremonese (2), Valentina Galluzzi (1), Carmelo Magnafico (1), Valeria Mangano (1), Fabrizio De Marchi (3), Cristina Re (2), Domenico Romano(1)
(1) IAPS-INAF, Rome, Italy, (2) OAPD-INAF, Padua, Italy, (3) University of Rome "La Sapienza", Rome, Italy
(Romolo.Politi@inaf.it)

Abstract

We present the project for an application for Android to introduce the public to the ESA BepiColombo mission, by using the Virtual Reality (VR) technology. VR technology demonstrated its versatility and power in graphic or industrial ambient in the last years and it earned the consideration of science community, in particular in geospatial and astronomic field. We will describe the contents that will be disseminated by the application, some technical and scientific concepts and a demo of the videos that can potentially be produced to demonstrate the high level of involvement that the VR technology can provide.

1. Introduction

The ESA cornerstone mission BepiColombo - to be launched in October 2018 to Mercury - is one of first ESA mission that will benefit of immersive experience for visualization of the data analysis. Some instruments, like the stereo camera of the instrument suite SIMBIO-SYS [1] , are already devoted to produce data that fit perfectly with this kind of approach. In addition, the synergy of different instruments onboard BepiColombo can also benefit of this tool (i.e. by visualizing the ionized and neutral particles around Mercury together with the planetary magnetic field, or dual measurements of the magnetic field itself as observed simultaneously from the two spacecraft MPO and MMO) This new technology could be used also as a valid support to the public outreach associated to the BepiColombo mission, by offering an appealing experience and giving the opportunity to transmit to the public a wide variety of information on the mission, on Mercury characteristics and different environments, and on the many scientific questions still open about the planet Mercury. Here we present the concept of the novel application, with a focus on the contents that we want to transmit to the user, a conceptual scheme of the information offered, and a demo of the video to be considered as a teaser for our application.

2. The Contents

We can organize the information into four different categories: the mission; the Mercury planet, the cruise and the scientists work.

2.1. The Mission

We display a 3D model of the spacecraft, the Mercury Composite Spacecraft (MCS), with the possibility to explode it in its three main modules: Mercury Magnetospheric Orbiter (MMO), Mercury Planetary Orbiter (MPO) and Mercury Transfer Module (MTM). From the modules hosting the payload it will be possible to extract each single instrument, open it and see a simple functional scheme, with an introduction at the phenomena measured (at different difficulty levels as defined by the user), and the technology used for the measure.
A special dashboard will help the user to understand the scientific objectives of the mission and how the answers can contribute to increase our knowledge. A special section will be devoted to the technology challenges faced. It will be possible to explore, also, the information about the launch vehicle.

2.2. The Mercury Planet

Data acquired from the previous missions will be implemented to create a VR reconstruction of some of the many different environments of Mercury (i.e. exosphere, magnetosphere, surface and interior) in order to describe the heritage of the previous explorations and explain the open issues to which BepiColombo aims to provide an answer.
We are discussing about the possibility to use a virtual assistant that can drive the user on a standard path through the information, with the possibility to personalize the experience by the interaction with it.

2.3. The Cruise

A 3D diagram of the BepiColombo route to Mercury will be shown and accompanied by some sheets to describe the various phases and explain the details of some special maneuvers (like the gravity assists or the electric thrusted arcs) and the physics behind them. During the swing-bys at the Earth and at Venus, windows could be opened to give additional information on the Earth-Moon system, and on a reconstruction of Venus as derived from the ESA mission Venus Express.

2.4. The Scientists Work

We will be planning a "Who's Who" section with the personal card of the scientists involved in the mission, starting from Giuseppe (Bepi) Colombo, the Italian engineer and mathematician inspirer of the mission. We are also exploring the possibility of an interview with some protagonists using 3D videos, especially the Principal Investigators of the instruments on board the spacecraft.
A section will be dedicated also to describe the genesis of a space instrumentation starting from the first idea of a scientist, through the engineering development of prototypes and up to the final flight model and its integration on the satellite.

We are starting to develop the application for smartphones that will use the Android SDK technology. This approach, in our opinion, can maximize the audience. The possibility to host the information on a mobile device give the opportunity to have a high dissemination rate. The developing of the application without the requirement of an active viewer, that mean very low costs for the viewer i.e. using a Google Cardboard^{TM}, could be an added value for the application. We are evaluating also the possibility to create an option for a multi-user experience. In this case the computation load will be really high, and it could not be delegate to a smartphone, but to a little computation farm, using the smartphone as a simple display. It is clear that this option could be used only in controlled environment.

3. The Teaser

The teaser of the application is a stereogrammetric 3D video, created by Blender application [2]. It can be downloaded from the page [3]. Figure 1 gives an idea of the high level of immersion that can be achieved.

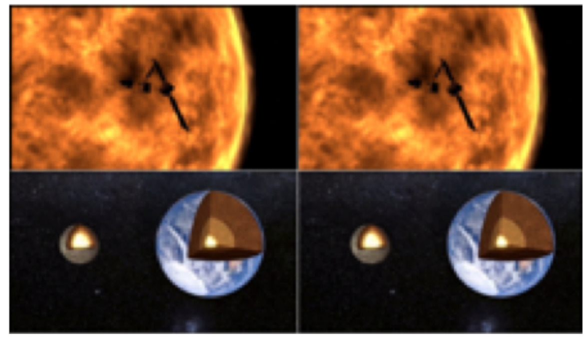

Figure 1: Frames Side by Side of the teaser showing the separation of the BepiColombo modules after the cruise phase (upper part) and the comparison between Earth and Mercury interior structure (bottom).

4. Conclusions

The application proposed has a high involvement of the audience, as well shown by the demo. The navigation interface (the first step in the application development) is presently under design, and a first version will be available for the meeting. With the present poster, we are also asking the support of the instrument teams to obtain all the information about their instruments and the related science to be included in the application. Presently, this work is supported by the BepiColombo Italian team for public outreach Bep-it

Acknowledgements

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Interactive Planetary Visualization and Analysis with NASA's Solar System Treks Portals

B. Day (1), E. Law (2)
(1) NASA Solar System Exploration Research Virtual Institute. NASA Ames Research Center. M/S 17-1. Moffett Field, CA, USA. 94035. (Brian.H.Day@nasa.gov, +01-650-604-2605)
(2) Jet Propulsion Laboratory, California Institute of Technology. M/S 168-200. 4800 Oak Grove Dr. Pasadena, CA, USA 91109. (Emily.S.Law@jpl.nasa.gov, +01-818-354-6208)

Abstract

NASA's Solar System Trek online portals provide web-based suites of interactive visualization and analysis tools enabling mission planners, planetary scientists, students, and the general public to explore planetary surfaces as seen through the eyes of many different instruments aboard a wide range of spacecraft. The portals present a vast collection of mapped data products from past and current missions for a growing number of planetary bodies. As web-based toolsets, the portals do not require users to purchase or install any software beyond current web browsers. The interactive and immersive capabilities of these portals are being used for site selection and analysis by NASA and a number of its international partners, supporting upcoming missions. They are also being used by formal and informal educators, students from elementary through university levels of study, and members of the public who are engaged in the excitement of solar system exploration. This presentation will provide an overview of the Solar System Treks and highlight many of the exciting new additions to the project implemented this past year.

1. Introduction

NASA's Solar System Treks program of lunar and planetary mapping and modeling produces a suite of interactive visualization and analysis tools. The program is managed by NASA's Solar System Exploration Research Virtual Institute and developed at NASA's Jet Propulsion Laboratory. These tools enable mission planners, planetary scientists, and engineers to access mapped data products from a wide range of instruments aboard a variety of past and current missions, for a growing number of planetary bodies. While originally initiated for mission planning and science, this technology has demonstrated great benefits for public outreach. As components of NASA's Science Outreach and Education Infrastructure, they are available as resources for NASA Outreach and Science Education programs, and to the greater outreach and education community. As new missions are being planned to a variety of planetary bodies, these tools are facilitating the public's understanding of the missions and engaging the public in the process of identifying and selecting where these missions will land.

The portals provide easy-to-use tools for browsing, data layering and feature search, including detailed information on the source of each assembled data product. Interactive maps, include the ability to overlay a growing range of data sets including topography, mineralogy, abundance of elements, and geology. They provide analysis tools that facilitate measurement and study of terrain including distance, height, and depth of surface features. They allow users to easily find and access the geospatial products that are available. Users have the ability to drill down to find the PDS data used to produce the geospatial products. Data products can be viewed in 2D and 3D, and can be stacked and blended together rendering optimal visualization that reveals details that no single data set can show. Data sets can be plotted and compared against each other. In addition to keyboard and mouse control, standard gaming and 3D mouse controllers allow users to maneuver first-person visualizations of flying across planetary surfaces. The portals also provide users the ability to specify any area of terrain for generation of STL/OBJ files that can be sent to 3D printers to make 3D models.

The new Virtual Reality Extension is an exciting addition to the Solar System Treks. Users can draw a path across the surface using the browser interface. A QR code is then generated which is read by the user's smart phone. Placing the phone in an inexpensive set of Google Cardboard-compatible goggles, the user then flies along their specified path in virtual reality.

Along with the web portals, the project supports additional clients, web services, and APIs that facilitate dissemination of planetary data to a range of external applications and venues. Through its APIs, the project is serving data to a growing community of digital planetariums.

Six Solar System Trek portals are available to the public, with more portals in development and planning stages.

2. Moon Trek

NASA's Moon Trek is the successor to and replacement for NASA's Lunar Mapping and Modeling Portal (LMMP). New tools have been added to facilitate traverse path planning including boulder detection and distribution analysis, and crater detection and distribution analysis. Many new data products have been added. Enhanced high-resolution views were added in direct response to areas of interest identified in the recent Lunar Science for Landed Missions Workshop held at NASA Ames Research Center. Users can interactively fly over spectacular lunar landforms and go roving across regions of special scientific interest.

3. Mars Trek

The project's Mars Trek portal has been assigned by NASA's Planetary Science Division to support site selection and analysis for the Mars Human Landing Exploration Zone Sites. This effort is concentrating on enhancing Mars Trek with data products and analysis tools specifically requested by the proposing teams for the various sites. Mars Trek allows users to explore current and past areas of robotic operation on Mars in great detail. Users can also examine the areas that have been identified as top candidates for future robotic and human exploration, gaining a better understanding of what makes these areas so compelling.

4. Vesta Trek and Ceres Trek

Vesta Trek was one of the original Trek Portals. Data gathered from multiple instruments aboard NASA's Dawn mission have been compiled into Vesta Trek's user-friendly set of tools, enabling users to study the asteroid's features. As Dawn nears the completion of its mission, the new Ceres Trek portal complements Vesta Trek portal with data returned from Dawn's current exploration of the dwarf planet Ceres.

5. Titan Trek and IcyMoons Trek

The Cassini mission conducted multi-instrument investigations of the Saturn system. It brought back a valuable collection of data about those worlds. The Cassini mission commissioned NASA's Solar System Treks Project to implement two new online portals enabling integration, access, and dissemination of data gathered through the mission's investigations of Saturn's moons. Titan Trek highlights Saturn's largest moon, and IcyMoons Trek features a number of Saturn's other moons as studied by the Cassini mission. Data include imagery from the VIMS and ISS cameras, as well as the RADAR synthetic aperture images, topography, derived physical parameters and community-sourced geological and hydrological mapping products.

6. Upcoming Portals

A number of new portals are in development. This year, we began work on a visualization and analysis portal for Mars' moon, Phobos. We are coordinating this effort with the International Phobos/Deimos Landing Site Working Group, with landing site selection and analysis for JAXA's MMX mission as a primary driver. Portals for other subject planetary bodies are in the planning stage.

7. Summary and Conclusions

NASA's online, web-based Solar System Treks planetary visualization portals provide exciting, interactive, immersive tools that allow scientists, mission planners, students, and the public to see and understand planetary surfaces in ways they never have before. The EPSC community is invited to provide suggestions and requests as the development team continues to expand the capabilities of the portals.

Acknowledgements

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Immersive Visualization of Planetary Reconstructions for Geological Interpretation

Thomas Ortner (1), Georg Haaser (1), Harald Steinlechner (1), Rob Barnes (2), Sanjeev Gupta (2), Chris Traxler (1), and Gerhard Paar (3)
(1) VRVis Zentrum für Virtual Reality und Visualisierung Forschungs-GmbH, Vienna, Austria, (ortner@vrvis.at) (2) Imperial College London, London, UK, (3) Joanneum Research Forschungsgesellschaft mbH, Graz, Austria

Abstract

In this paper, we describe how remote geological analysis of planetary surfaces can benefit from immersive virtual reality visualization and interaction. An extension of the PRo3D Viewer [1] (http://pro3d.space) allows planetary scientists as well as a non-expert audience to immersive themselves in a virtual, true-to-scale Martian environment.

1. Introduction

For planetary science, geology and particularly sedimentology are crucial to uncover the processes responsible for forming the present-day surface of a planet. Traditionally, geologists base their analyses on measurements and observations they collect in the field. Consequently, in the context of exploring the geology of Mars, they are limited to directly inspecting rover images or using 3D reconstructions derived from photogrammetry.

Although the interactive rendering of 3D reconstructions gives users a much better impression of scale and depth than 2D images can provide, the output is still confined to a rather small and flat computer screen. The loss of scale and depth perception typically is mitigated by using scalebars and 3D navigation, which is satisfying to both expert and public audiences. However, to use these interactions effectively requires training and true immersion cannot be achieved.

Therefore, this work strives to create an immersive 3D depiction of the Martian surface, which experts and laypersons can navigate in and interact with in a natural way. At the time of writing, the described work is ongoing. Therefore, after briefly outlining the data pipeline, we describe existing and planned features and we conclude with the reception of our work so far.

2. Reconstructions from Imagery

The processing framework PRoViP (Planetary Robotic Vision Processing) [2] provides a versatile workflow to generate 3D vision processing products out of stereoscopic images as designed to be obtained from ExoMars PanCam, Mars 2020 Mastcam-Z and other past and present planetary imaging sensors from Rover missions (MER, MSL), such as:

a) Digital Elevation Models

b) Ortho images in various filter wavelengths

c) 3D meshes, superimposed with textures

d) Derived thematic maps of the surroundings describing reconstruction accuracy, occlusions, solar illumination, slopes, roughness, hazards etc.

These data products are made available to the further PRo3D workflow in the geographical coordinate system context of the respective planetary body (e.g. Mars), via an optimized hierarchical data structure (OPC – Ordered Point Cloud) [3].

3. PRo3D Existing VR Features

Our current implementation supports the HTC VIVE head-mounted display with two VIVE controllers. We render the processed 3D digital outcrop models (DOMs) at their highest resolution in their true scale. Therefore, when users walk one meter in the real world they also cover one meter of the virtual surface. Since most Martian outcrops are very flat we raise them to about 50cm above ground, otherwise users would have to kneel to inspect surface details. So far, we prepared scenes with DOMs of Garden City and Yellowknife Bay, which are sites of the MSL mission.

While the true-to-scale stereoscopic rendering of DOMs gives users a great sense of the dimensions of the whole outcrop, we also added a virtual tape measure to investigate surface details such as rocks or sediment layers. When holding down the triggers of the controllers, a line appears connecting them with a text label on top showing the current distance. The accuracy of the tracking allows the user to measure distances down to mm scale. Due to walking and head tracking for the navigation and the simplicity of the virtual tape measure geologists, as well as laypersons could naturally navigate the virtual scene and take measurements.

Figure 1: Robert Barnes measuring bedding thicknesses in PRo3D VR in Yellowknife Bay

4. Planned VR Features

With walking as our only mode of navigation, the area of exploration is limited to about 4x4m according to the VIVE specification. Currently we are working on two additional navigation interactions: As common to many VR environments, we will support a teleport interaction, which allows the users to jump to a point they target on the surface. Second, by using the two controllers, users shall be able to scale and rotate the scene arbitrarily including reset mechanisms for true scale and horizon levelling.

We also plan to extend our measurement interactions by using the tape measure to create polylines for delineation of bedding contacts. Since dip-and-strike measurements are essential to geological analysis [4][5], we plan to use the pose information of one controller to orient a plane in 3D and use the distance to the second controller to specify the size of this plane.

5. Conclusion & Outlook

We started the development of the PRo3D VR extension only recently. However, our preliminary results were already tested at a dedicated workshop, involving geologists, planetary scientists, and people from other fields. We complemented these tests by in-depth sessions with planetary geologists to gather additional feedback on the user patterns and efficiency gain. In general, PRo3D VR was well received and the feedback gathered led us to the extensions described in Section 4. Even the geologists, although trained in the interpretation of DOMs, were amazed by experiencing outcrops in their true scale.

Acknowledgements

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Immersive Visualization in Planetarium Domes

Björn Voss (1,2), Tim Florian Horn (3)
(1) LWL-Planetarium Münster, (2) Gesellschaft Deutschsprachiger Planetarien e.V.,(bjoern.voss@gdp-planetarium.org), (3) Stiftung Planetarium Berlin

Abstract

Most planetariums today offer immersive presentations of scientific topics, with a focus on astronomy and planetology, to their audiences; making them highly relevant for outreach activities in planetology. To further facilitate the use of planetariums in planetology outreach, easier methods for transfer of visualization data to the planetariums would be required.

1. Planetarium Presentations

Most planetariums are equipped with a video projection system that delivers a dome-filling immersive video image ("fulldome projection"). In Germany alone, planetariums have more than a million visitors per year. Planetariums are thus the probably most common place for the public to experience immersive scientific visualizations. Therefore they are highly relevant for outreach activities, since an immersive presentation allows to convey content to an audience in a more sustainable and more effective way than non-immersive presentation methods.

Such presentations in planetariums are created using proprietary software that allows to either playback pre-rendered immersive video, or to create realtime-rendered, live controlled immersive visualizations.

Planetariums employ these tools in a number of ways:

1.1 Day-to-day live presentations

Most planetariums offer live-presented shows, in which a trained staff member presents basic facts as well as news items to the public, using the according features of the proprietary planetarium software and live-controlling the visualization, e.g., interactively controlling camera movement as to create the impression of a flight to and a landing on Mars, to name just one example.

It would be useful to ingest latest planetology data into the planetarium software on a day-to-day basis in order to present latest news in such regularly scheduled, staff-presented shows, but currently the necessary workflow makes this a challenge.

1.2 Scientific talks

The immersive visualization of planetology data in planetariums is especially useful during invited talks by planetology scientists. Data that are relevant to the talk can be prepared and then presented using the planetarium software, which requires some lead time and the availability of the speaker to aid in the correct representation of his or her data in the planetarium software. Such an immersive presentation to the public can be very captivating and thus can serve to convey points of a talk much more effectively than by traditional means; thus the extra effort that has to be made by the speaker is always justified, in our experience.

1.3 Pre-rendered planetarium shows

Another common form of planetarium presentations are pre-rendered immersive movies, similar in style to TV documentaries. Some institutions have created such presentations on planetology topics, e.g. the California Academy of Science ("Incoming!", 2014) or the production company Mirage3d ("Mars 1001", 2018), just to name two examples.

Another relevant example, "A Journey Through The Solar System" (2017) was created by a collaboration of 19 planetariums in Germany, Austria and Switzerland, led by LWL-Planetarium Münster. Data that were provided for this project by ESA, DLR, MPS, and TU Berlin, e.g. DTM and shape models, were rendered into immersive graphics that serve to explain basic concepts as well as latest research results on different solar system bodies in an entertaining way. This production is very well received by audiences and thus effectively serves to convey planetology topics to a wider audience.

2. Planetarium Software

Planetarium visualization software is heterogeneous and proprietary; currently, about five software products exist that offer the features that planetariums require to operate and present immersive video or realtime-rendered immersive graphics. Not all of them allow to ingest and present planetology data, and those that do cannot interpret the common scientific data formats.

For pre-rendered visualizations (1.3) this is not a challenge as long lead times and budgets of such projects allow to process all kinds of data. For more ad hoc presentations (1.1) however, data conversion and ingestion into the planetarium software is a challenge that hinders most planetariums from employing such data in their day-to-day live-presented shows.

ESO's (European Southern Observatory) EPO department recently spearheaded the definition of an interface ("Data2Dome", www.data2dome.org) to easily transfer outreach media from EPO departments directly to the planetarium domes. This transfer standard allows a planetarium staff member to display a news item (e.g., an image) in the planetarium without any human preparation (e.g., without any human work related to copying or converting of files). It could be envisioned to expand this interface in the future to allow the direct, automated ingestion of planetology data, e.g. DTM data, into the planetarium software.

3. Summary and Conclusions

Modern Planetariums are a highly relevant outreach instrument for the planetology community, and speakers invited to planetariums should strive to present their talks not just through standard means but employing "Fulldome" immersive visualizations related to their topics. Such visualizations can be created by the planetarium software as interactive realtime renderings of e.g. DTM or shape model data.

In the future, such talks and projects would be facilitated if data conversion and ingestion into proprietary planetarium software were to become more streamlined, e.g. through an expansion of the existing "Data2Dome" framework. This would enable presenters to create immersive visualizations of latest planetology data on a day-to-day basis.

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Using techniques from the visual effects industry to process raw JunoCam imagery for 3D presentation

Matt Brealey
United Kingdom (mattbrealeyis@gmail.com)

Abstract

Processing raw space data typically involves aspects of image processing, 3D data creation/manipulation, and data management - problems also common to the Visual Effects (VFX) industry.

Using VFX techniques learnt over the past decade, along with NASA's SPICE toolkit, I have used common VFX tools to process raw JunoCam imagery from scratch. The result is a 3D projected version of the image set, which I am subsequently presenting in an interactive web application, Juno Observer. The final imagery is also suitable for display in immersive AR/VR mobile applications.