Visualization Platforms for Scientific Exploration of Mars.
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Introduction: We present results from an ongoing project ADVISER (ADvanced Visualization for Solar system Exploration and Research). The goal of the ADVISER project is to design and evaluate tools that advance the state of the art for scientific visualization of remote planetary bodies. In this abstract, we summarize our approaches and implementation on different display platforms, ranging from conventional desktops and a powerwall display, to a fully-immersive Cave system. We present instances of usage of ADVISER and our experiences with the different platforms.

ADVISER: ADVISER is an integrated environment that enables the planetary geoscientist with the capability to explore and analyze data as if they were on or near the surface of a planet [1] [2]. The system is based on a real-time terrain rendering system [3] and is able to handle large topographic datasets. In addition to topography, the geoscientist can import a variety of geo-referenced image datasets (MOC, THEMIS, HRSC, Viking). The system also provides a Virtual Field-Kit which is analogous to the operations carried out by a geologist in the field (Brunton compass, altimeter, etc). In addition, there are ancillary tools such as a virtual camera, virtual GPS, PDA and notebook. These tools enable the geologist to take notes and measurements which conducting their investigations in the virtual environment. ADVISER was designed for a fully-immersive experience in a Cave-like system; but has been subsequently ported to desktops and powerwalls. We describe our experiences in running ADVISER on the different display platforms.

Display Platforms: The choice of the display platform for conducting scientific visualizations is an important one. Different display platforms have unique characteristics and are suited for different tasks. In this section, we highlight some of the displays we have considered for ADVISER.

Desktop. Fueled by the video-game industry, commodity graphics cards sold by vendors like ATI and nvidia have become extremely powerful and inexpensive. Relatively large geometry (10s of Millions of Triangles) and image (100s of MBs) datasets can now be handled on modest desktop machines. We have ported ADVISER on a regular desktop machine for both research and outreach purposes. Desktops displays are clearly suited for extended analysis and most commercial software runs on desktops without any modification/customization. The disadvantages of a desktop display are the limited physical screen size (typically 13-19’’ diagonal) and relatively low resolution (1280x1024 pixels). It is possible to attach multiple monitors to a graphics card; and thereby increase the effective viewing areas. High-end monitors such as the IBM Bertha (3840x2400) and Apple Cinema (2560x1600) displays can provide relatively high resolution. Nevertheless, the field-of-view on a desktop display is still severely limited.

Powerwall. A Powerwall is a physically large, planar display typically tiled with multiple projectors. The advantage of using a large physical display with multiple projectors is that researchers can view much more data (imagery for instance) at once without the need for panning or zooming. Modern DLP projectors are relatively inexpensive and provide a bright, crisp image which helps in preserving the dynamic range in the imagery. Depending on the number of tiles, it may be possible to drive a tiled display from a single PC, as is often done in the Geowall (http://www.geowall.org) system. In such configurations, the visualization software may not need any modification. Our powerwall system (see Figure 2) uses 3x3 tiles and is driven by a cluster of five linux machines. We use nine InFocus DepthQ (800x600) projectors and nvidia 4500G cards to drive the displays. The powerwall gives us an effective resolution of 2400x1800 on a 6’x6’ display surface.

The disadvantages of using a powerwall system are the visible seams between the different projectors, additional complexity in the hardware/software configuration, limited field-of-view and higher cost. Seams between different projectors occur because the optical paths do not line up precisely. A geometrical correction and color correction typically needs to be applied to make the display look seamless. Techniques for these corrections have been explored in literature [4] and companies like Scalable Display Technologies sell products that can align projectors for powerwall displays.

Cave. A Cave [5] is a multi-wall display (typically four or six walls) that can surround users with im-

Figure 1: Students use a desktop system to explore Olympus Mons (Left). On the Right, Researchers use the Cave system to explore a THEMIS overlay on Valles Marineris.

agery. Stereo glasses help users to perceive the imagery in 3D and tracked devices help in providing input to the computer systems. Because of the large field-of-view and body-centric interaction, users typically feel an enhanced sense of presence in Cave-like environments which is distinctly missing in desktop and Powewall displays. There are other immersive VR displays such as Head-Mounted Displays and Immersadesks but Caves provide for the best collaborative experience. We have a 4-wall Cave system. Our Cave is an 8'x8'x8' cube room with display surfaces on the front, left, right and floor walls (see Figure 1).

The disadvantages of a Cave system are the cost of deployment, maintenance and additional complexity in the software. While modern projectors can be used to tile Cave displays, that typically further increases the complexity of the system.

Educational Outreach on Desktop: Since desktop systems are ubiquitous and readily deployable in the laboratories of researchers, we ported ADVISER to the desktop system and have made it available for educational and research use. Figure 1 shows the desktop system in action. The system has been used for educational activities in an introductory geosciences course (Geo5, "Earth, Moon and Mars"). Over 90 students participated in an exercise conducted on the desktop and Cave systems. The purpose of the exercise was to contrast the 3D visualization on the desktop (and Cave) to conventional media for learning about Mars such as referring to lectures, reading textbooks, looking at images, globes and Google Mars. Students were arranged in groups of three, posed questions about Mars (related to origin of various features, presence of water, etc) and explored the surface of Mars in address their questions. They used the Cave system to complement their experience. In general, we found that students preferred the 3D visualizations much more than using 2D image based tools. They were better able to appreciate the topographic features and interrelationships in a 3D environment.

Visualizations in the Cave: ADVISER was originally designed as a fully-immersive Virtual Reality experience for planetary geologists. As outlined previously, a number of tools have been developed to enable an immersive exploration of the surface of Mars (or any other remote location). The Cave (see Figure 1) enables researchers to stand on the surface of the planet and explore it from a range of different perspectives, which are not really possible on a 2D display. We have presented several case studies from ADVISER in previous reports [1] [2]. Briefly, our experience from using the system in the Cave has been that researchers are better able to see spatial relationships of topographic features and correlate that with the imagery data. For example, for examining the north polar layered deposits on Mars, we found that the layering information present in the MOC datasets was not always consistent with the topographic profiles. We were able to discern many interesting locations to take strike and dip measurements, which were previously ignored using ArcGIS on a desktop system.

In accordance with our theme of combining multiple datasets, we have looked into visualizing GCM simulations [6] in the Cave. We have visualized various parameters such as wind velocities, ice-water mixing ratios, ice-deposition on the surface, clast densities from volcanic eruptions, etc. Visualizing these parameters in the context of the 3D topography and

Figure 2: Researcher uses a Powerwall display to view an HRSC image of the Dichotomy boundary. 9 projectors (Right) drive the imagery on a 6'x6' display.

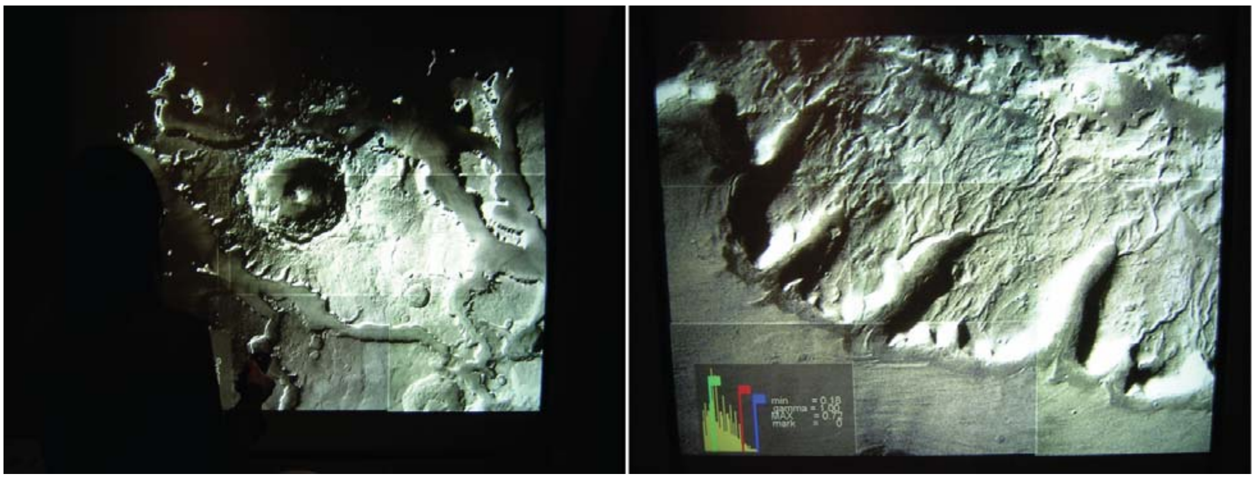

Figure 3: High resolution pan/zooms of a crater on the Dichotomy boundary. The system maintains real time interactive performance without compromising image quality.

imagery presents geologists with an integrated context in which they are able to make better interpretations.

High Resolution Image Display on Powerwall: We have recently added a specialized image viewing module to ADVISER which enables us to examine large high-resolution imagery data (such as the latest images from Hi-RISE and HRSC) on the powerwall with ease. Thus far, we have handled grayscale images of the size 30kx50k without compromising the display quality. Using OpenGL mip-mapping; the zooms and pans are seamless. As opposed to conventional imagery streamed on Google/Microsoft over the internet; users do not discretely switch from one zoom level to another with a pause in between. The zooms in our case are continuous; in our experience this makes it easier for users to preserve the context of their exploration.

Figure 2 shows a geologist exploring a HRSC image on the powerwall system. We provide them with interactive controls to navigate around the image; zoom/pan interactively; mark different spots and stretch the image. Enhancing contrast in large images is especially important because of the range of albedo variation in large swaths of topography. Stretching large images is typically non-interactive on conventional desktop software, but in ADVISER we use programmable graphics hardware to do this operation in real-time.

Initial feedback from geologists who have used the powerwall over the past few months is extremely positive. Researchers have reviewed over 30 datasets on the wall; with the nature of usage varying from 'exploratory' unstructured sessions, research discussions, to presentation of results. The uniform consensus is that the wall enables the sessions to be productive; effective and efficient. Researchers find it much easier to quickly explore large images; identify regions of interest; zoom in (while keeping the large context in mind); zoom back out and discuss inter-relationships.

Conclusion: We have presented our experiences from using the ADVISER system on desktop, powerwall and Cave display platforms. Each display platform has its own strengths and weaknesses, desktops are ubiquitous but do not provide for a high-quality immersive experience. Caves provide a highly immersive experience; but are expensive to setup and maintain. Powerwalls can provide a bright, high-resolution display which is suited for exploring large image datasets. With the availability of ever larger datasets and different display platforms in the future; researchers should be aware of the tradeoffs with different display modalities and make their choices accordingly.

References:

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