Navigation System for Virtual Reality Visualization Of Large-Scale Astronomical Datasets

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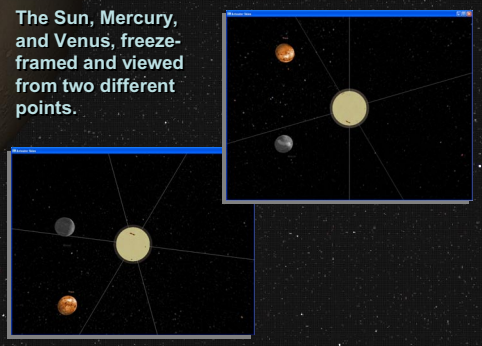
Overview

Visualization of large-scale datasets requires new approaches to data processing, hierarchical representation, and navigational techniques. We introduce an initial stage in the design of an interactive immersive virtual reality system allowing rapid high-resolution rendering of large scale datasets including, but not limited to, astronomical, biomedical, and seismographic data. A prototype implementation of the system framework is applied to a 3D model of the Solar System featuring an interactively controlled camera and time lapse. The spatial scaling issue, which is essential to the study due to specifics of sparse data processing, is addressed; a logarithm-based scaling method is introduced, and optimal scaling parameters for efficient representation of the Solar System are determined and used to run the space simulation.

Techniques employed in the design of this system can be used to build scalable, easily navigable and extensible models of entities such as stellar constellations, galaxies, and, ultimately, the known universe. The system can then become an intuitive astrophysical simulation tool, helpful in forming a completely new approach to such traditionally analytical applications as mission planning and control and visualization of simulated space flights. These techniques will also be used to create a modular system that can be used to navigate large datasets in a virtual reality system at the California Institute for Telecommunications and Information Technology, Cal-(IT)^2.

Implementation Features

- Programming Interface – OpenGL, complemented with the OpenGL Utility Toolkit (GLUT)
- Planetary coordinates calculated based on semimajor axis, eccentricity, orbit inclination, obliquity, etc.
- Magnitude and distance scaling issues are addressed due to the large scale of the Solar System and drastically varying sizes of the planets and the sun
- Textures saved in portable pixel map (PPM) format
- User control with mouse and keyboard; working on integrating with wand-type controllers and head/hand tracking (e.g. in the Responsive Workbench or the CAVE™ environments)
- Output to any monitor or projector; with minimal changes, adapted to stereo mode using 3D shutter glasses and compatible video equipment



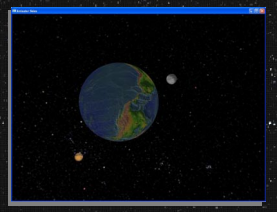
The Sun, Mercury, and Venus, freeze-framed and viewed from two different points.

Current and Future Work

This project is currently being developed in two key directions. The first direction is the further development of efficient visualization algorithms allowing interactive-fast rendering of large volumes of stellar and other types of data as well as working on dynamic spatial and temporal scaling methods. This direction will also include a design of hierarchical object representation, which should further increase the processing rates of the system.

The second prospective work direction includes porting the framework into virtual reality environments. Keyboard and mouse will be replaced with control devices increasing the "presence feel" such as force feedback joysticks or wand-type controllers in a CAVE™. This prospective direction would allow users of the system to have the universe "at their fingertips."

The work will ultimately result in the design of a highly portable modular navigation system that can be easily integrated into a virtual reality system at the California Institute for Telecommunications and Information Technology, Cal-(IT)^2, a joint project of UC Irvine and UC San Diego. This system will be used to visualize a wide variety of simulation tasks from different disciplines and will be instrumental to many studies, including ones that involve large volumes of data.



The Earth (middle of the night in Florida and the Atlantic), Venus and Mercury. Coordinate axes and planet names have been turned off and are not displayed.

The Sun and six planets, zoomed out.

This work was started in Winter 2004 as part of an independent research project at the Creative Interactive Visualization Group (CIVL), which is a part of the Visualization and Interactive Systems (VIS) Group in the Department of Electrical Engineering and Computer Science and the Department of Biomedical Engineering within The Henry Samueli School of Engineering at UC Irvine. We would like to thank the members of the laboratory for providing resources and invaluable assistance.