Tools and techniques for real-time dome production and education

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Introduction

New York City's Hayden planetarium originally opened in 1935 with a Zeiss Model II planetarium projector. In 1997 it was shut down for renovation. The new Hayden Planetarium opened last year and has been hailed as the most advanced large-scale immersive theater in the world. In addition to a 7-projector full dome video system and 7-pipe SGI Onyx2®, the new Hayden also has the latest Zeiss Mark IX star projector. The 429-seat hemispheric theater is housed inside an 87 ft. diameter sphere.

This presentation reviews the real-time hardware and software tools employed at the new Hayden, and discusses techniques learned from the application of these advanced tools in the production of educational programs.

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Clockwise from top left, the Hayden Sphere at night, planetarium interior with Zeiss Mark IX projecting 9,100 stars, and having fun in the Cullman Hall of the Universe.

Real-time tools for the Hayden Planetarium

I. Hardware

Two SGI Onyx2 IR-2 graphics computers:

A. For Dome: In addition to running real-time applications, this machine runs stored show movies from disc arrays, performs as a rendering engine, and does astrophysics simulations:

Seven graphics pipelines, 28 processors, 16GB ram, 90GB internal drives, 2TB external storage on Ciprico-7000's

B. For production testing, real-time, rendering, HD video editing, and astrophysics simulation:

Three graphics pipes, 12 processors, 6GB ram, 45GB internal drives, 550GB external Ciprico raid arrays for HD video editing, and 270GB external Ciprico raids for development work.

Three SGI Octane's

Ten SGI O2's

II. Software

A. C-Galaxy, Aechelon Technology Inc.

Real-time, Performer based software co-developed by AMNH and Aechelon to visualize a digital model of our Milky Way galaxy. This development was part of the NASA sponsored foundation project for education at AMNH called the Digital Galaxy Project.

Display of 25,000 charted stars from the European Space Agency's Hipparcos Star Catalog blended seamlessly with one billion stars mapping out the extent of the Milky Way from an astrophysical statistical model. Additional non stellar objects as alpha texture maps also supported. Constellation line connectivity and additional support graphics available with real-time edit capability.

Three basic modes of scale available, including Solar

System, interstellar and external Milky Way viewing.

B. Everest, PEAK

Real-time production software primarily used for broadcast media.

Used at AMNH in daily production of electronic signage and constantly updated science bulletins. Supports high definition Earth Event Wall projection and Astro Bulletins multi screen power wall.

Seven synchronized channel version for dome used for support graphics in productions and presentations. Rapid diagrammatic prototyping and modeling is fast and easy in dome environment or from desktop workstations.

High definition and digital video inputs can be run through Everest for manipulation in virtual worlds for dome or fed out to bulletins.

C. Virtual Director, National Center for Supercomputing Applications

Interactive, remote collaborative, flight path scripting and scientific visualization display software.

Developed for use in NCSA's Cave immersive display, this software was configured to also work in dome to support show production. Collaboration between AMNH and NCSA is through the National Computational Science Alliance's Grand Challenge Cosmology Consortium. This collaboration has allowed us to co-develop models and applications that run in this environment as well as on a desktop/laptop version of the display set called Partiview which spans multiple platforms.

Scalability of visual data display from Virtual Director in our dome on down to multiple platform Partiview on desk and laptops allows maximum flexibility for educational use as well as production effort. Results will be demonstrated in class.

Collaborative potential allows remote viewing and manipulation between multiple sites and platforms.

Examples of models from different data sets will be shown, and include the AMNH model of the Milky Way made up purely of observed data, and University of Hawaii astronomer, Brent Tully's atlas of galaxies beyond the Milky Way.

III. Remote tools

National Center for Supercomputing Applications' Cave:

In production, models can be shared between AMNH and NCSA, where either site can create and edit flight paths through either static or animated data sets and simulations.

Desktop and laptop Partiview:

Data and support graphics can be set up and edited remotely in NCSA's Partiview for study. This preparation is the ground work for what can then be loaded into the dome display via Virtual Director. Flexibility of this kind means that one can study certain problems prior to dome scheduling.

Remote collaborative function means that multiple institutions, domes, caves, power walls, and smaller scale multiplatform end users can share in simultaneous viewing of real-time exploration of data sets, and sessions or paths can be archived for later reference. Educational potential of this is just beginning to be examined.

Techniques learned with real-time capability

Various results of this discussion will be demonstrated in class and at the CAL after the course.

Our goal is to simulate various astronomical phenomena. Subtle and constant motion elucidates the third dimensional nature of many of these astronomical environments and objects. This is perhaps the most important key to being able to interpret form from what is inherently an abstract realm given the alien environment it represents in comparison to the world we ordinarily confront.

Motion control in real-time allows for careful study of how best to examine structures within models displayed. Immediate feedback of manipulation saves iteration time of non real-time set ups. One gets to "live with" the environments and gains a familiarity from a basis of presence. For example, using Maya preview renderings, we had thirty three study moves on the Orion Nebula before we were satisfied with results. This technique predated our use of Virtual

Director, NCSA's interactive flight path scripting software. Now a much more intuitive process to craft camera moves in the dome environment can be accomplished.

From scripted camera moves in real time, software renderings to higher orders of quality and techniques such as volumetric rendering can then be used to create non real-time movies for playback. After our Orion move was approved, it was then carefully volume rendered with the San Diego Supercomputer Center's MPIRE renderer by Dave Nadeau and Jon Genetti.

Other scenes from our premier show "Passport to the Universe" were Choreographed and polished by Bob Patterson, Donna Cox and Stuart Levy in the NCSA cave. Traversal of the Tully galaxy atlas and Jeremiah P. Ostriker's simulation of large scale structure of the universe was crafted in the cave and then approved in dome.

Real-time adjustment of visibility and relationships of objects and appearance is key in the dome given its unique display environment. Projection display issues such as cross reflectivity and color saturation are best adjusted interactively in dome when possible. This is a great time saver as well.

The abilities to control astronomical models in real-time and interactively adjust the display of data groups and their appearance is an obvious path toward teaching the relationships and meanings of the models. Perhaps the best way to educate visitors about these concepts is to demonstrate them interactively as if they were there in front of the audience. We find that interactivity in the manner of "tour guide" is perhaps the best use of the real-time capability for educating.

Links

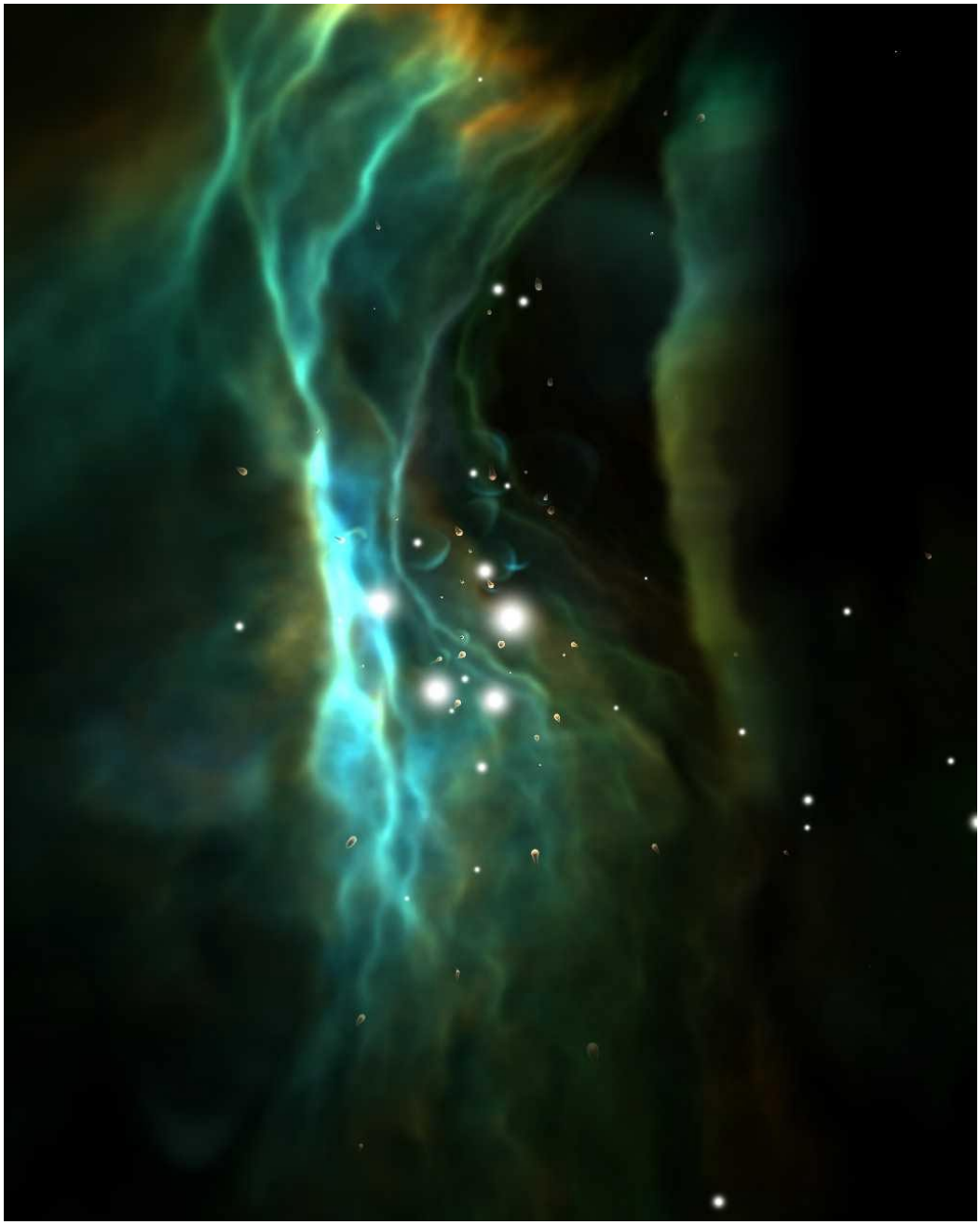
GALACTIC MPIRE: Flying through the Digital Galaxy
http://mpire.sdsc.edu/hayden99.html

Rose Center for Earth and Space
http://www.amnh.org/rose/

National Center for Supercomputing Applications (NCSA)
http://www.ncsa.uiuc.edu/

Grand Challenge Cosmology Consortium
http://zeus.ncsa.uiuc.edu:8080/GC3Home.html

San Diego Supercomputing Center
http://www.sdsc.edu/



A Voyage to Orion: This view of the stars, gas, and dust clouds at the center of the Orion Nebula is an example of the images produced using the MPIRE Galaxy Renderer. The image is based on a 3-D model and color-corrected images by C. R. O'Dell and Zheng Wen of Rice University.