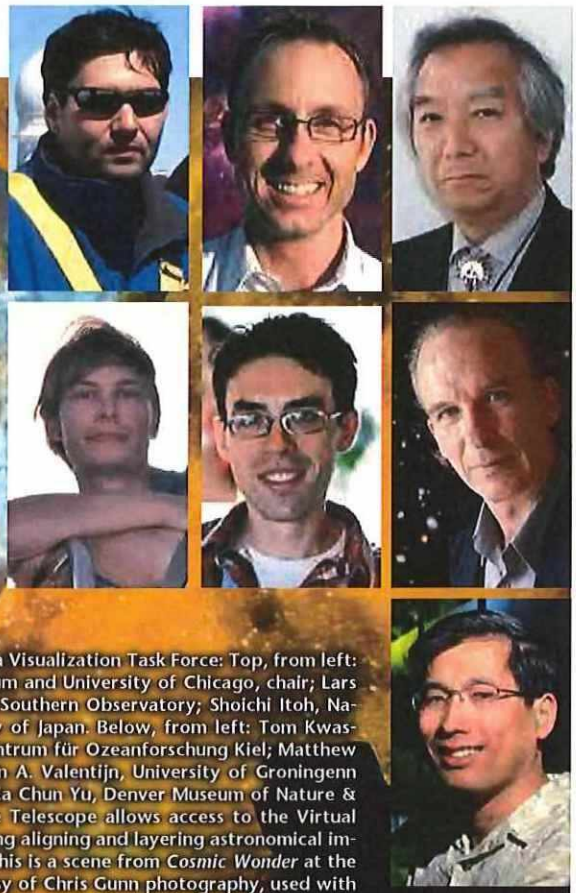
Science and Data Visualization Task Force

Bringing data to the dome: scientific visualization for all planetariums



Members of the Science and Data Visualization Task Force: Top, from left: Mark SubbaRao, Adler Planetarium and University of Chicago, chair; Lars Lindberg Christensen, European Southern Observatory; Shoichi Itoh, National Astronomical Observatory of Japan. Below, from left: Tom Kwasnitschka, GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel; Matthew Turk, Columbia University; Edwin A. Valentijn, University of Groningenn and the Infoversum; and Right: Ka Chun Yu, Denver Museum of Nature & Science. Background: Worldwide Telescope allows access to the Virtual Observatory, automatically pulling aligning and layering astronomical images form a variety of sources. This is a scene from *Cosmic Wonder* at the Adler Planetarium. Photo courtesy of Chris Gunn photography, used with permission.

If you've been reading the President's Message column, you've had an introduction to the new Science and Data Visualization Task Force. This article is designed to expand upon that introduction.

For this initative to be successful, we need both the attention of and feedback from the planetarium community at every step of the process.

Between the growth in the capabilities of digital planetariums and the explosion of data from a variety of sources, we believe that this is a critical time for the planetarium. How do we best position the community to take advantage of these new and expanding possibilities? The goal of the task force is to answer that question, preparing us for the big data era and positioning us to best exploit new opportunities at the nexus of science and education.

Data to dome

The mission of the Science and Data Visualization Task Force is to streamline the process of going from data to dome, increasing the potential for scientific communication and storytelling in the planetarium.

In the same way the "Farm to Table" movement has improved the culinary landscape by reducing the middlemen between the farmer and chef, "Data to Dome" is aimed at reducing the effort needed to go from scientific study to planetarium visualization.

We hope to bring the planetarium closer to the science and to make domain scientists more aware of the power of our immersive visualization tools. Our community has built visualization facilities of incredible potential all across the globe. The easier we make the path from science result to dome visualization the more fully we will be able to utilize them.

Communication and storytelling are specifically called out in this mission statement. While the activities of the task force will often involve technical details of data formats and protocols, the purpose of these activities is to enable planetarium presenters and creators to do their job more effectively.

The task force has identified some initial areas of activity. These include:

Preparing planetariums for the massive stream of data that will come from next generation telescopes, satellites, experiments and computational simulations.

The task here is significant. The European Space Agency's Gaia mission, for example, will increase the number of stars with measured distances by a factor of 10,000 to one billion. The Large Synoptic Survey Telescope project will open up the time domain in astronomy, issuing alerts for one million changing objects every night. Over 10 years of operation, it will generate approximately 200 petabytes of scientific data.

Even these huge quantities of data are dwarfed by what is coming out of the computational sciences. A simulation used in a

two minute sequence of a recent Adler Planetarium show consisted of nearly 400 terabytes of data.

Creating professional development opportunities aimed at developing more "data savvy" planetarians.

The task force is working towards a future where more data will be available from more recent measurements spanning more scientific domains. This broadening of sources and increase in data stream rates will put an increased burden on the planetarium professional to understand, visualize and interpret.

Professional development is key to making sure that planetarians are able to take full advantage of the resources available to them. These opportunities need to span disciplines such as science, scientific visualization and science communication.

Developing and promoting best practices for data visualization in the dome.

Visualizing data for the public presents a unique set of challenges. Choices of color, methods of visualizing qualitative or quantitative information, and selection effects that are understood by professional audiences can be distracting or confusing for a public one. Likewise, the fulldome environment offers unique opportunities that need to be studied in order to be fully exploited.

Connecting data suppliers with vendors and planetarium end-users by setting and recommending standards for real-time (or near real-time) scientific content distribution: imagery, videos, tabular data, etc.

Standards and their adoption are a crucial factor in achieving the task force's mission to streamline the process of going from data to dome. Without clear and well adopted standards, content producers such as NASA, ESA and ESO will have less motivation to produce products for the planetarium community. Without community-endorsed standards, vendors will have to define their own, fragmenting our community and reducing opportunities for collaboration.

Encouraging the visualization of a wide range of scientific data in the dome (moving beyond astronomy).

The potential now exists to visualize anything in the dome. We've seen excellent examples of earth science and a handful of biology/medical visualizations. Many planetariums have presented music shows as an economic necessity, but have not embraced other scientific topics for lack of in-house expertise, content and the inherent necessity to somewhat redefine their identity.

Thus, special efforts need to be made to disseminate such content. One possibility may be the concerted attention to large-scale scientific projects (e.g. the Gaia project in astronomy), such as climate change or genomics. The fulldome digital planetarium as an all-purpose visualization environment is still just beginning to be explored.

Top: A fisheye rendering of body wave from a simulation of the Tohoku earthquake.The image was rendered using the visualization and analysis package yt. Below: Tom Kwasnitschka exploring hypocenters of earthquakes (white) across the Mid-Atlantic Ridge in the ARENA visualization environment. Data provided by Microsoft Research.

Redefining interactivity and networking.

To date, interactivity in planetarium software most often means the up-front ingestion of data describing a static universe that can be switched on or off, played back and be browsed with a freely moving camera. Although even just this degree of freedom may overwhelm the majority of planetarians for lack of intricate knowledge of the data sets and, consequently, lack in practice to move about them, researchers will find this sort of visualization unappealing.

A mere data viewer and movie player is not enough, they need to be able to manipulate, mark and derive metadata from the datasets displayed.

The best visualization is one that creates new data sets along the way. We, therefore, urge dome software developers for an increase in interactive capabilities along with a broadened support of the underlying data sets. We envision a planetarian who does not merely point at the stars but pulls apart the universe in front of the eyes of his audience.

Planetariums are about the sharing of an experience with others. Through networked planetarium sessions (e.g. "domecasting"), we not only increase our audiences but establish a new communication tool for researchers among themselves and with the public.

Advocating for the inclusion of dome visualization tools in standard scientific analysis and visualization packages.

If part of streamlining the path from data to dome is bringing the planetarium closer to the science, the other part is bringing science and scientists closer to the planetarium. Our visual language (the dome master) is not yet established anywhere else. Our profession needs to do more in terms of its visibility in the scientific community, and including dome visualization tools in standard scientific analysis packages will increase the number of scientists collaborating with planetariums and also increase the visualizations available to planetarians.

Encouraging planetariums to make their facilities available to researchers from their communities to use as a visualization tool.

Why is it that many researchers praise the capabilities of a newly-installed fulldome system, but never come back? Because the use of any new tool in science requires an up front expense on their side, most often in the form of their precious time and research money. It comes down to a problem of cost vs. revenue, and in reality, the justification for scientific visualization involving few individuals is much weaker than that of the education of large laymen audiences.

Since, for these reasons, it is much more difficult for research to acquire large scale network of visualization facilities, our profession has now, for the first time, the unique opportunity to give something back to the scientific resources we have always drawn upon.

Allowing these researchers (and some of their tools!) to access our facilities would create a richer dialog between science and education building collaborations that will extend the reach of the planetarium and hopefully advance science as well.

Some steps in the right direction

Aligning to the Virtual Observatory Standards: The WorldWide Telescope:

WorldWide Telescope (WWT) is an emerging planetarium software platform freely available from Microsoft Research. It is in a unique position in that it was designed simultaneously as a tool for researchers and for public education.

WWT has adopted many standards from the virtual observatory (VO). For example, catalog data can be imported as VOTables, which have several nice properties. The metadata is carried along and described by Unified Content Descriptors that precisely define the meaning of a data column, allowing WWT to recognize them as coordinates or brightness values. WWT then automatically suggests how to visualize them.

VO data APIs, such as the cone search, are utilized as well. The user can query for catalogs by sky location and keyword and then select from the returned lists of datasets for visualization. This ease of going from dataset discovery to dome visualization is exactly the "Data to Dome" philosophy.

At the same time, WWT offers a broad interface for geoscientific data. Geographic point data can be imported and animated directly from text files and even the clipboard. A flexible API (Narwhal) and an interactive plugin for MS Excel allow the manipulation of data displayed on the dome in real time which is particularly interesting for higher level education and even research.

WWT facilitates the import and georeferenced positioning of textured 3D models and of large scale customized terrains, a feature that is rather unique among virtual globes. Programs (tours) complete with narration and music can be pre-scripted and easily distributed. The software scales from desktop to multi node clusters and is thus suitable for all levels of education while visualizations can also be prepared and tested by researchers who may only occasionally visit a dome.

Inclusion with science software packages: the yt project

yt is a software package for analyzing and visualizing volumetric, multi-resolution data from astrophysical simulations, radio telescopes, and a burgeoning interdisciplinary community. This open source project has reached out to the dome community, adding the functionality to create high resolution volumetric renderings in the domemaster format.

This addition dramatically increases the ability of the computational science community to create fulldome visualizations. By embedding visualization tools in the analytical routines and libraries used to conduct analyses for publications, yt hopes to bring the dome communities and computational science communities closer together.

Providing context: the Virtual Astronomy Metadata Project

The Virtual Astronomy Metadata Project (VAMP) defines an image format for astronomical public outreach images. Metadata is embedded in the image headers. This not only includes technical information, such as the WCS coordinates needed to position the image on the sky, but also information specific to the public images.

A title, description, credits and links to more information are all included, greatly simplifying the work of the content creator. There is currently wide support for this format among content providers such as Hubble, Chandra, Spitzer, and ESA. Thus we recommend full adoption in the planetarium community as well.

How can you help?

What should the planetarium of the future look like, and how will planetariums be used? The task force is in the process of preparing examples of future "use cases," which will also be used to inform the community on its activities. We would like to encourage you to send in your own "use cases"! Please forward them to the task force chair Mark SubbaRao (msubbarao@adlerplanetarium.org).

Here are some examples of the use cases we are currently working on:

Lars Lindberg Christensen suggests an Astronomical Weatherman functionality that allows the planetarium operator, every morning, to select interesting dataset previews downloaded overnight—planetary maps, images of sky objects, tabular data, event data, etc.—and mark up the full datasets and metadata (descriptions, web URLs, licensing) for download and for possible inclusion in show segments during the day.

Martin Ratcliffe describes a future supernova show based on LSST data. The presenter downloads last night's supernovae discoveries (in some cases the galaxy identification can be included) and the 3-dimensional position of the supernova creates a location identity in SDSS.

At the start of a show, the presenter presses a button and the night sky display shows a sampling of the 1000 supernovae discovered the previous day. The presenter can fly out of our Milky Way and show the relative positions of the host galaxies. Over the longer term of LSST, a bird's eye view of the universe could show a realtime time-lapse of supernovae going off covering years of data.

GEOMAR in Northern Germany is a multidisciplinary research facility focused on the oceans, branching into geology, geophysics, paleoclimatology, oceanography, atmospheric sciences, fisheries, marine biology and biochemistry.

As a common portal to merge scientific results, Tom Kwasnitschka operates the ARENA, a visualization environment using WWT exclusively dedicated to scientific audiences. It turned out that researchers rejected a dome above them since most earth science topics are perceived "on or beneath the ground" in contrast to stars, therefore the ARENA is a lower hemisphere populated by up to four researchers at once.

They are currently struggling with issues of accurate georeferencing and interactive data manipulation. It is planned to use several of these simulators for remote scientific collaboration as well as for domecasts to the planetarium community. A lack of interest from this side currently prohibits the allocation of resources towards public content development. ☆

Learn more about the International Planetarium Society at www.ips-planetarium.org