

Science visualisation within a planetarium setting

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Abstract

In less than a decade, a dramatic shift has taken place inside planetariums. Hundreds of theatres of various sizes have adopted immersive video technology, filling domes with computer-generated visuals that can depict current astronomical discoveries with unprecedented fidelity. Whereas planetarium programming once depended on informed artwork to tell science stories, the opportunity now exists to incorporate science visualisation into high-impact “narrative journeys” that immerse audiences inside the content. Observed data and computational simulations can provide a rich basis for such simulated excursions, giving people an experience of 21st century astronomy that approximates an alternate reality.

Proper utilisation of the new technology requires the worldwide planetarium community to mature in certain ways. Broadened science topics require significant professional development on the part of educators, production teams need to devise ways of incorporating data into their work, and collectively, we must learn how to tell stories with an enriched palette of data-driven visuals. The international astronomy education community must consider how to support this emerging medium. Some ideas include the development of community standards (e.g. the Virtual Astronomy Metadata Project), specifically engineered content (e.g. HubbleSource’s pre-rendered sequences), and increased visibility of the medium at conferences (e.g. the special session at the 2006 Astronomical Society of the Pacific meeting). As the chair of the Fulldome Video Committee of the International Planetarium Society — and the director of an immersive theatre under construction—the author is seeking ways to increase collaboration and cooperation across our varied subdisciplines.

Introduction

A remarkable opportunity exists within a rapidly growing community of planetariums: fulldome video allows for the incorporation of accurately visualised astronomical content, and theatres hunger for content. Although most planetariums still follow a traditional model, with an optomechanical star projector complemented by slides and video, the medium is changing quickly. Technology offers new tools and new venues for teaching science, and public outreach professionals should take notice — the planetarium community will be grateful for the attention. The current opportunity results from a confluence of factors, including the changing nature of planetariums, of technology, and of science itself. Of course, it does not come without challenges — both technological and social — but the potential benefits are significant.

Changing nature of planetariums

The term “planetarium” has remained in flux for centuries, referring originally to complex mechanical devices that reproduced the motion of planets around the Sun (known as “orreries” in English). The breakthrough technology that gave birth to what most people think of as a planetarium occurred in Germany in the 1920s, when the Carl Zeiss Company developed the opto-mechanical star projector.

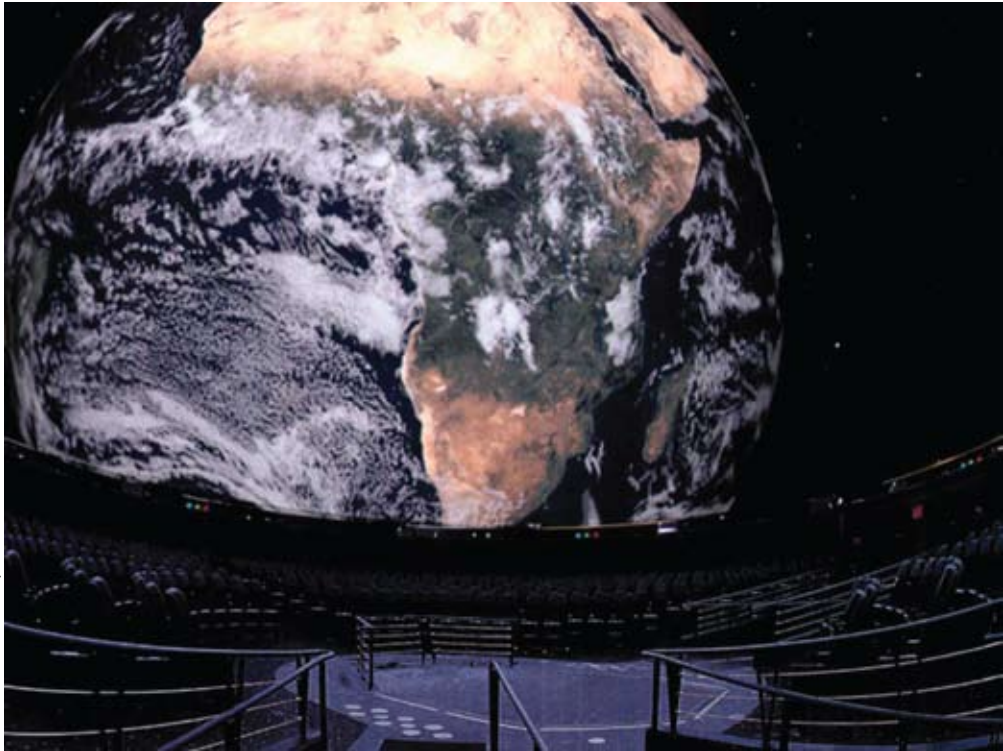
The original Morrison Planetarium at the California Academy of Sciences featured just such an instrument, shown in Figure 1. Basically, finely-tuned optics projected point-like stars on the interior of a hemispherical projection screen, thereby replicating the experience of a terrestrial night sky with varying degrees of authenticity. Over their 80-year history, planetariums extended this core experience with numerous additions and changes: slide and video projectors, multimedia shows, and even interactive buttons all made appearances over the years. The majority of planetariums worldwide use a suite of technology with the opto-mechanical star projector at its core. But a little over a decade ago, technology appeared that has radically changed the planetarium experience.



Figure 1 – The original Morrison Planetarium at the California Academy of Sciences in San Francisco, California, USA, featured a unique opto-mechanical star projector. The new Morrison will showcase entirely digital technology.

California Academy of Sciences

Full-dome video allows a planetarium dome to be treated as an immersive environment, effectively creating a gateway to a virtual space; Wyatt (2005) describes how this affects the creation of “narrative journeys” in planetariums. For the most part, theatres using full-dome video have focused on playback movies—essentially immersive films. The Rose Center for Earth and Space at the American Museum of Natural History (see Figure 2) in New York adopted full-dome technology in 2000, and millions of visitors have seen *Passport to the Universe*, *Search for Life*, and *Cosmic Collisions*, all of which follow a prerecorded, playback format. But the Rose Center also runs live programming, including a monthly *Virtual Universe* programme, which presents digital datasets and contextualises current discoveries and research. Many facilities follow a similar recipe, relying on playback content for most of the day while presenting live programmes somewhat less frequently. The new Morrison Planetarium will use a mixture of real-time and playback material, with a presenter in every show. Smaller theatres, especially those situated in school settings, may focus more on real-time capabilities.



American Museum of Natural History

Figure 2 – A single frame of the full-dome presentation “Search for Life” projected onto the dome at the Rose Center for Earth and Space.

Thus, planetariums with new technology continue to offer the variety of programmes that characterised traditional theatres. What has changed is the type of content they can offer, realistically addressing topics that extend far beyond the experience of the night sky. The potential now exists to create programming that relies on science visualisation in lieu of conceptual illustration.

Phenomena can be placed in relation to one another, with objects nested at their appropriate scales inside a digital model of the Universe, tacitly communicating the enormity of astronomical distances. Almost every full-dome system sold today includes some form of “virtual universe” software that a skilled pilot can manoeuvre and use as a presentation tool. For its fidelity to scientific concepts alone, full-dome video should be of great interest to the public outreach community.

Furthermore, the number of full-dome theatres is growing exponentially. Figure 3 shows how rapidly the number of systems has increased in the last decade, from a literal handful at the turn of the millennium to more than 200 last year. (The total number of theatres as of 8 October 2007, the date of this presentation, clocks in at 315 worldwide.) Also, an important tipping point took place last year: more than half of these systems are now in domes less than ten metres in diameter. This has dramatic implications for outreach potential, and it means that full-dome content can access a sizable variety of audiences.

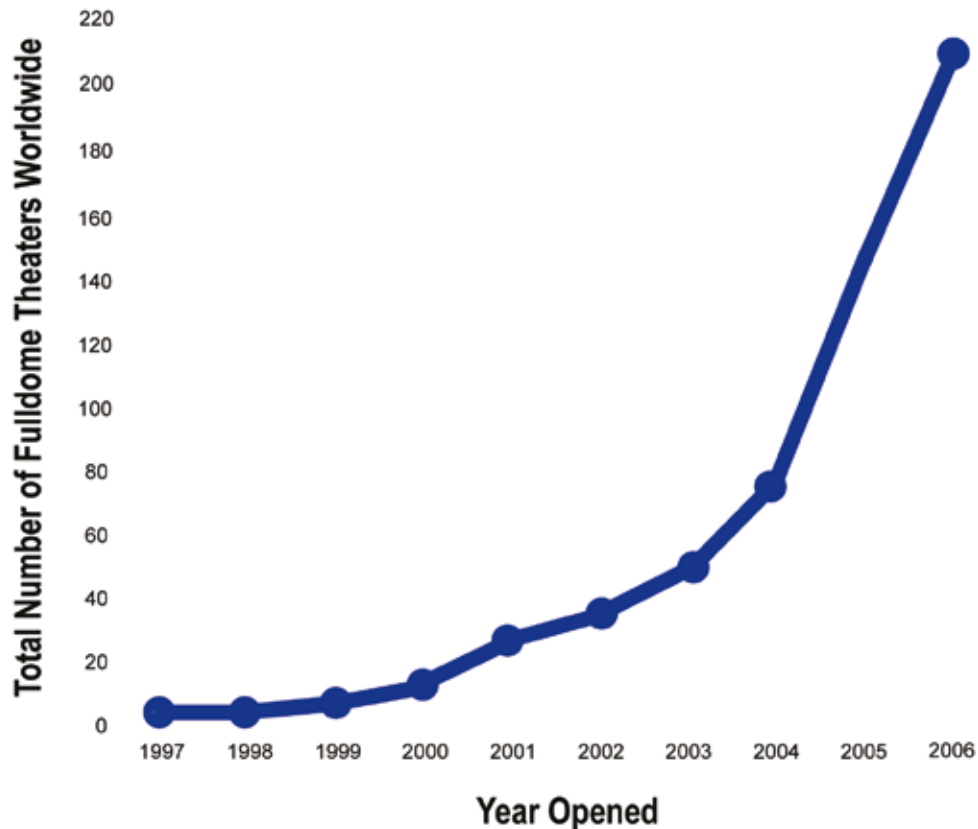


Figure 3 – The number of full-dome theatres worldwide is increasing exponentially. Adapted from Lantz (2007). Current numbers available from Petersen (2007).

Changing nature of technology

Technology changes quite quickly, particularly the computer graphics hardware that has helped fuel the digital revolution in planetariums. Video games demand increasingly fast graphics cards, and although the planetarium world requires specific enhancements (e.g. genlock) to such hardware, the fundamental performance advances are driven by the gaming industry. fulldome video thus rides on the coat-tails of a much, much larger community.

The planetarium community's dependence on commodity hardware represents an important shift in the economics of technology for the medium. When the aforementioned Rose Center opened in 2000, its real-time capabilities required highly-specialised computational power, which increased expenses not just in terms of the initial purchase price, but also in terms of upkeep and staffing costs. The opportunity to make use of widely-available computer equipment means that the overall affordability of these systems will make them more and more commonplace.

Changing nature of science

Of course, science itself is changing. Research is not only increasingly digital — astronomy blazed the trail, in many ways, with digital detectors that date back to the 1970s — but it is also increasingly computational. Digital data favour digital displays, and science visualisation can now provide the basis for storytelling within planetariums.

The prevalence of digital displays should affect how we think about the data we provide to educators and the public at large. Take, for example, the compelling images released by Hubble, Spitzer, Chandra, and other observatories. Such image products can have associated metadata — including coordinates, orientation, and scale as well as captions and other information — accessible by planetarium software. A planetarium operator (a.k.a. a “planetarian”) could potentially display an image, properly aligned in the sky, while having portions of the caption or press release appear on a computer monitor at the console. This kind of value-added media plays an important role in supporting planetarians and other educators, and Hurt et al. (2006) describe an emerging standard in the form of the Astronomy Visualization Metadata (AVM). Hurt et al. (2007) also outline an implementation of an AVM archive that will facilitate access to imagery.

Indeed, the inclusion of metadata about the imagery allows the experience to transcend the merely aesthetic. A “pretty picture” offers an enticing gateway into astronomy, but added information and interpretation helps an individual pass through the gateway into a deeper appreciation of the topic.

Technological challenges

An enormous variety of companies produce hardware and software for fulldome planetariums in an environment with little standardisation. This creates significant challenges for users who wish to exchange content — and for content creators who want wide distribution across systems. The proceedings of a 2004 summit by Lantz et al. (2004) provide a primer on the breadth of technical issues that confront the user community.

Social challenges

Even if the technological challenges of file formats and display systems can be overcome, we face an additional hurdle: the actual implementation and interpretation of data necessitates solid lines of communication between the sources of data and their users. A planetarian needs to understand fundamental topics in astronomy and the context for the imagery and datasets that might appear in a programme. Planetarium vendors need to have access to new discoveries and need to integrate them appropriately into their software. Facilitating such information exchange amounts to a social challenge.

We need to create more opportunities for astronomers to interact with planetarians and other educators, especially since the new universe of complex datasets requires a deeper understanding of astronomy than the typical night-sky programmes of a traditional planetarium. Furthermore, the vendors who supply data and imagery to planetarians need to be included in the loop as well; often, they assume the burden of accurately incorporating new discoveries into the digital systems they sell.

Figure 4 suggests a cartoon of the relationships, with the boldness of the double-headed arrows suggesting the strength of connections as they currently exist. Planetarians typically have well-developed relationships with the vendors who support them, and more tenuous lines of communication have developed between professional astronomers and planetarians as well. However, planetarium vendors often have not developed connections with the research or public outreach communities. Note that the arrows in Figure 4 point in both directions: astronomers must act not merely as sources of information, but also have to listen and respond to the needs of the planetarium community.

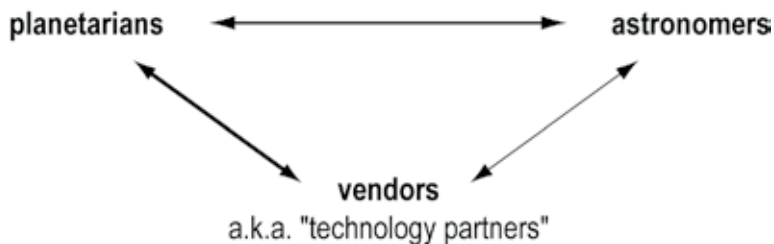


Figure 4 – The author's schematic of relationships between planetarians, their vendors, and members of the astronomy community. Line strength is intended to suggest the strength of the relationships between the various groups; astronomers need to cultivate relationships not just with planetarium professionals but also with the companies that supply planetariums with software and (effectively) data.

Conclusion

Thanks to the increasingly popularity of fulldome video, astronomical data can reach a much broader audience than ever before. Planetarium audiences (and others) have an opportunity to experience storytelling rooted in the same data that researchers use to understand the complexities of the Universe. The confluence of high-speed graphics cards and our constantly expanding collection of digital datasets gives us both a medium and a message to communicate. By working closely with planetarians and their associated vendors, astronomers and public outreach

professionals can facilitate access to existing data and enhance the impact of astronomical research within planetariums. Fulldome video is a remarkable opportunity; it deserves to overcome its associated challenges.

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