

## FOCUS ON 3D/DIGITAL

### 3D or Not 3D? Is that a Question?

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**Abstract** Stereoscopic 3D images, although going back to the mid-nineteenth century, are becoming pervasive in cinema, the Web, electronic games, television, graphic simulations, personal photography, and the entertainment and education ecologies. The use of stereo 3D goes beyond a technology vogue to the creation of effective experiences that are more naturally engaging for audiences by conveying real physical depth perception and the illusions of tangibility and tactility. This paper claims that because museums are all about compelling, memorable, and visceral experiences, 3D will become an increasingly important tool for exhibitions, education, and interpretation; the challenge will be to know when, how, and why to use it. Stereo 3D is described and a trajectory of examples of past and current museum use is presented. The paper also provides a rationale for why, when many technologies are vying for priority and resources, stereoscopic 3D technology should be near the top of the list.

## INTRODUCTION

3D or not 3D? Hold on to those funny glasses as I predict that one of the most pervasive technologies for museum exhibitions, education, and interpretation in the years to come will indeed be 3D. *Stereoscopic* 3D.

I am not merely acknowledging the 150-year-old trajectory suggested by Oliver Wendell Holmes, when he wrote of the stereoscope in *Atlantic Monthly* (June 1861): “It is no toy: it is a divine gift, placed in our hands by science.” I don’t feel caught in the throes of the stereoscope rage of the last part of the nineteenth century (which is not the same rage some feel when they pay extra for that 3D movie). I am even distancing myself from the dioramas at the American Museum of Natural History—veritable machines of geographic and time travel, it’s been said—which museum chairman Lewis Bernard still calls “among the greatest treasures of the American Museum of

Natural History . . . amazing technical feats of illusion, which are recognized internationally as superb examples of the fusion of art and science.”<sup>1</sup> Nor am I yearning for the View-Master of my youth.

I am simply noting that there is something inherently and undeniably compelling about a stereo-3D experience. Since museums are all about compelling, memorable, and visceral experiences, and visitors are rapidly acclimating to 3D images they encounter in the media and the products they buy, the match seems a natural. The tools and techniques for creating and displaying 3D imagery are becoming better, cheaper, and easier to use. These advantages contribute to the feasibility and likelihood of museums first wading—then diving—into this pool. Hence, we should all be looking forward to the increasing use of 3D within and outside our museums’ walls. Of

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**Photo 1.** 3D animation brought a fourteenth-century table fountain back to life with “glorious clanking, ringing, and splashing” realism: wheels turn, bells ring, water cascades and ripples. *Photo courtesy of the author and the Cleveland Museum of Art.*

course, the key lies in knowing when to use it, how to use it, and why.

### WHAT IS “3D?”

The term 3D, although fundamentally defined by the three axes of height, width, and depth, has far more complex implications when used to describe computer and media presentations. For example, it can connote simulation and reconstruction of objects and places extant or long gone, and may represent real photographic or other scanned elements. For example, the Louvre’s online Villa Borghese, Versailles Staircase, and other 3D re-creations<sup>2</sup> use computer modeling and graphics techniques to depict these sites, which, in turn,

often incorporate or link to photographs and other documents.

The 3D objects that you spin, pan, and zoom in and out of probably comprise a series of photographs taken at small increments, 360-degrees around, compiled into a Flash or Quick-Time movie. Additional variations include participatory online sites and virtual worlds such as Second Life, virtual museums and galleries such as Museo Virtual de Artes, and gaming environments, all of which have become part of an even broader 3D taxonomy.

These modes of 3D are useful because the mind is able to enlist a variety of clues to discern some spatial relationships. However, most so-called 3D manifestations do not enable the real perception of depth that is provided by a

stereoscopic experience—the process by which slightly different images are sent to each of our eyes. Scientifically, we are safe in claiming that stereoscopic presentation of objects is engaging for humans because it requires less cognitive effort in analyzing perceptual stimuli.<sup>3</sup> David Trotter notes that such stimuli go beyond a simple visual experience. He describes it as an “overwhelming illusion of tangibility,” born of two visual systems that inform stereo 3D: optical and haptic (tactile feedback). “Stereoscopy, then, involves the visualization of tangibility . . . [objects that] we might want to touch take shape before our eyes” (2004).

Sarah Kenderdine, a leading theorist and practitioner of 3D immersive environments in

the museum and cultural heritage fields, builds on this assessment: “3D images (moving or still) are indeed tactile, and their tactility and sensory quality can be amplified in very specific ways found only in immersive architectures and through stereographic materials.”<sup>4</sup>

As Holmes most elegantly described the sensation: “The mind, as it were, *feels round it* and gets an idea of its solidity.”

### RANGE OF USE OF STEREO 3D

But even within the rubric of “stereoscopic 3D”—in this article, from here on, the term “3D” means stereoscopic—we encounter quite a range of how 3D is used. Most prominently, recent 3D motion pictures have engendered both great enthusiasm and passionate enmity. Anthony Lane, in his history of 3D cinema in *The New Yorker* (March 8, 2010), generally bemoans the periodic pushes to 3D, but celebrates *Avatar*'s achievement in focusing audiences on the story, not the technology. He quotes James Cameron on a principle that should be sewn into every museum technology project: “The technology should wave its own wand and make itself disappear.”

Writing in *Newsweek* (May 10, 2010), Roger Ebert was far less kind than Lane, but did allow for a silver lining: “I once said I might become reconciled to 3-D if a director like Martin Scorsese ever used the format,” he writes. “I thought I was safe. [Now] my hero, Werner Herzog, is using 3-D to film prehistoric cave paintings in France, to better show off the concavities of the ancient caves. He told me that nothing will ‘approach’ the audience, and his film will stay behind the plane of the screen. In other words, nothing will hurtle at the audience, and 3-D will allow us the illusion of being able to occupy the space with the paintings and look into them, experiencing



**Photo 2.** The table fountain, ca. 1300-1350, gilt-silver and translucent enamel, French, possibly from Paris. Photo courtesy of the Cleveland Museum of Art.

them as a prehistoric artist standing in the cavern might have.” Apparently even Ebert concedes that 3D cinema can be put to great effect as well as affect.

Although this essay does not intend to focus on 3D cinema, its presence—especially at museums and science centers with IMAX theaters—is well felt. At this writing, the Smithsonian is showing *Wild Oceans*, *Hubble*, and *Legends of Flight* in 3D. The *Newseum* regularly runs the edutainment film *I-Witness: A 4-D Time Travel Adventure*, about the history of journalism (the fourth “D” stands for “de” shaking seats). In 2009, for its centennial, the Newark Museum commissioned the film *Newark in 3D* in homage to the 1920 classic *Manhatta*, which is in its collection. How this tacit museum endorsement of 3D will change audience expectations for other areas of museum interpretation has yet to emerge.

A theatrical 3D experience in a museum is not limited to cinema, as the British Museum brilliantly demonstrated with *Mummy: The Inside Story* in 2004.<sup>5</sup> Detailed X-ray and computerized tomography (CT) images, from many angles, were converted into an interactive 3D model from which museum researchers could discern new information about the life and final condition of Nesperennub, who lived around 800 B.C. They were also able to produce a reconstruction of his face. In a small theater especially designed for the occasion, the audience shared the researchers’ “journey within the body” through real-time computer-generated 3D and motion imagery. Although the tour through Nesperennub’s body followed a pre-defined sequence in order to accommodate content demands and time constraints, this system could also have allowed impromptu navigation by a “guide,” had the program allowed. The show included a short question-and-answer period with museum staff, after

which an enthralled audience exited to a room where the real mummy lay.

From here, let’s leap to perhaps the most complex type of 3D implementation, the fully immersive environment, a virtual space where you can see, experience, and control a world created for you. These types of visualizations have come a long way since the Guggenheim museum’s 1996 *Mediascape* exhibition, in which visitors would step up, take a seat, don a head-mounted display, and travel through virtual ancient and current St. Peter’s Basilicas. Visitors could also visit the Basilica of St. Francis in Assisi and enter right into the *City of Giotto* frescoes, or visit Nefertiti’s Tomb.<sup>6</sup> During their adventure, which included a multi-player game, participants might even encounter the avatar of the person stationed beside them. Each station was run by a computer the size of a small refrigerator. Visitor services staff had to have brown paper bags near by, “just in case.” The graphics and sometimes-bumpy movements might seem primitive today. But for its time, *Mediascape* was the cutting edge of art and environmental immersion. It opened a real-world window onto how we might use 3D and immersive environments, not only to enter the places of great art and cultural heritage, but even to explore the art itself. It also foreshadowed the roles of gaming and social spaces in a virtual world.<sup>7</sup>

Today’s technology has given us installations such as *PLACE: Hampi*, a complex, state-of-the-art 3D immersion whose technical and artistic application and sophistication suggests a direction in which museums might head.<sup>8</sup> Here is a summary description derived from various write-ups:

*PLACE: Hampi. This international exhibition offers visitors the opportunity to immerse themselves in the stunning UNESCO-designated World Heritage site of Hampi in southern India.*

*State-of-the-art digital technologies create this groundbreaking experience. The visitor is immersed in life-size stereoscopic 3D panoramic images of an extraordinary site and its landscape with all its mythological, archaeological, artistic, and historic significance, as well as captivating photography. Animations of Hindu myths and stories are presented and all of this is augmented by computer animations of Indian mythological deities and surround-sound audio recordings with specific classical Indian music. This dynamic matrix of technologies sets the landscape in motion, so that the tangible and intangible aspects of Hampi's archaeological imagery, essence, and vibrancy are all intimately brought to life.*

In PLACE: Hampi, a visitor is stationed in the center of a circular, enclosed arena. The visitor “steers” through an environment projected on a section of the panoramic wall, as he, and other visitors within the arena, experience all facets of their 3D visual and aural immersion. PLACE: Hampi was commissioned in celebration of “France-India Year” in 2006 and has toured for four years. Produced by Museum Victoria, and developed by their research group (led by Sarah Kenderdine and university partner iCinema),<sup>9</sup> it serves as both a research project and an artistic/interpretive commission.<sup>10</sup> As such, the project/installation has been anchored in theory and well documented in practice. The project produced a visitor evaluation study, which, according to the authors, “support[s] the strategy that multimodal worlds that focus on kinesthetic and multisensory amplification can play a significant role in the interpretation” of cultural heritage, and that “*stereoscopy*, panoramic visual and auditory immersion” (emphasis added) are key strategies in that regard (Kenderdine, Shaw, and Kocsis 2009). Such studies are rare in this genre. More are needed to understand and validate the effectiveness of stereoscopy and other tools of

engagement in helping museums meet interpretive and experiential goals.

Although similar projects may be beyond the reach of most museums, PLACE: Hampi presents a wellspring of ideas about how interactive media, augmented reality, and 3D immersion can be used. Readers are urged to visit the PLACE: Hampi website to view a video of the installation in use and review related research, backgrounds of the principals, implementation, and tour information.

From this stratosphere of cultural heritage interpretation, let's take another long leap, this time down to the museum gallery floor to look at some individual works of art. Here are two small projects from 2005 that explored the use of 3D for object interpretation at the Cleveland Museum of Art (CMA).<sup>11</sup>

### **The Table Fountain**

The museum owns a fourteenth-century French table fountain as part of its permanent collection. It's the only complete table fountain remaining from the Middle Ages. This table fountain was, at one time, a working, multi-tiered, water-driven, bell-ringing, intricately functioning mechanism, as well as an extravagant and fanciful work of art. Water pumped to the top of the fountain created jets that first streamed through a series of nozzles shaped as animals and drolleries, then turned water wheels and rang tiny bells. As the museum's description notes, “Clearly a feat of technical ingenuity, the fountain must have delighted and entertained guests at an elegant table.”

But the water fountain did not “delight and entertain” visitors to the museum as it sat stoically, silently, in the medieval gallery. The fountain was to be featured in an upcoming major exhibition, so CMA brought together a team of animators, computer-modeling experts,

photographers, and audio specialists to build a highly accurate, photographically correct model of the fountain in glorious clanking, ringing, and splashing (non-stereoscopic) 3D animation. After months of development, the animation played as a loop on a screen, not far from the object itself, at the opening of the exhibition. With visual zooms, pans, and walk-arounds, as well as the sound of wheels clinking, bells ringing, and water splashing, the presentation was an immediate sensation. (See page 42 for the animation in virtual action.) Contrary to some concerns, the animation did not distract visitors from the real object, but instead drew attention to it. Viewers would detect details of the animation, and seek them out on the work of art. Soon after the exhibition opened, the curator noted that he had never seen so much—and such close—attention paid to the fountain as when augmented by this display. The use of animation, close-ups, and (non-stereoscopic) 3D proved a success. (The Getty currently has the actual animation on its website: <http://tinyurl.com/tablefountain>.)

CMA wanted to push this experience even further into stereoscopic 3D. Enlisting Jared Bendis, creative director of New Media for the Freedman Center at Case Western Reserve University and then virtual reality specialist for CMA, the museum reworked the animation for a 20-inch auto-stereoscopic display (one that shows 3D without special glasses). Although the 3D version did not arrive in time for the exhibition, it was shown at SIGGRAPH, the Ingenuity Festival of Art and Technology, and other venues and events to great acclaim. Bendis, in a recent conversation, looked back at what it took to create that project, then compared it with how it would be done now:

When we converted that simulation to 3D it took eight computers running for a week to create

the images for the multiple views, which would appear on our display. Since then, faster computers combined with the revolution in 3D cinema has resulted in mainstream tools for the creation and rendering of 3D content. Today, the creation would take a small fraction of the time. Additionally, I would just buy a large screen 3D-TV at any electronics retailer, which uses high-speed shutter glasses, which the public is getting pretty used to. It would not only be much cheaper, but the quality would be so much better. It's crazy . . . it really is.

Should the 3D version have been installed in the exhibition if the opportunity had arisen? The answer is not clear. A similar question will be visited later. Bringing 3D images of art to physical sites outside the museum, or to the museum's website, might be an easier decision. In any case, the proposition is no longer as expensive or complex as was just a few years ago.

### The Slant-top Desk

Cleveland has a stunningly beautiful eighteenth-century slant-top desk of straw marquetry. Aside from its elegant design and fragile inlay, it boasts external drawers, and a lid, which, when opened, exposes more detailed patterns, additional drawers, and access to secret compartments. As with the table fountain, however, it drew little attention on display. The museum wanted visitors to appreciate the special beauty of this desk—to make it come alive.

This time the answer would come in the form of a 3D video feature production. Bendis built a rig comprising two synchronized video cameras positioned eye-distance apart. Then the rig traversed, zoomed, and panned the desk as conservators carefully opened and closed the desk's lid using fine wire (later made invisible).

The drawers were also opened and closed. A 3D video seemed the perfect medium for exploring the desk as drawers pulsated in and out, the lid dramatically unveiled its inner workings, and the texture of the straw marquetry emerged in a way that viewers, in Holmes words again, “could *feel round it*.”

To turn raw video footage of the desk into a compelling presentation, Kasumi, an internationally recognized artist working in music and video, was commissioned to create what became an elegant, five-minute “desk ballet” set to period-evoking music.<sup>12</sup> The most frequent comment from viewers was that they found themselves focused on details that would have otherwise been ignored. With its musical backdrop, the show proved as entertaining as it was enlightening and memorable. Today, assembling such a video rig would prove simpler, since off-the-shelf 3D video cameras and readily available post-production software could put a similar project within any institution’s reach.

### **The Mourners Photography Project**

Lastly, we come to a current project that brings to the Web possibly the first high-resolution stereo 3D photographs of a full set of sculptures in support of a touring exhibition.<sup>13</sup>

During the fourteenth and fifteenth centuries, the Valois Dukes of Burgundy ruled over extensive territories in present day France and surrounding areas—a region which became a major center of artistic patronage. Their court’s sculpture workshop produced some of the most profound and original art of the period.

The tomb of John the Fearless represents the summit of their achievement. The tomb includes an arcade populated by a processional of alabaster figures of monks and clerics, known collectively as “The Mourners.” Each mourner is a sculptural masterpiece in its own right. In

the words of Sophie Jugie, director of Musée des Beaux-Arts de Dijon, where the tomb resides: “We cannot help but be struck by the emotion they convey as they follow the funeral procession, weeping, praying, singing, lost in thought, giving vent to their grief, or consoling their neighbor.”<sup>14</sup> Significantly—but unfortunately, because the mourners form a processional around the periphery of the tomb—most of the sculptures can not viewed in the round, and some of them are substantially obscured.

In 2010, the ongoing expansion and renovation of the museum created the opportunity for these exceptional works to travel together to the United States under the auspices of FRAME (French Regional American Museum Exchange), of which the museum is a member.<sup>15</sup> The exhibition *The Mourners: Tomb Sculptures from the Court of Burgundy* embarked on an unprecedented journey to the Metropolitan Museum of Art and six U.S. FRAME member museums over two years. This event provided a once-in-a-lifetime opportunity to create new high-resolution and stereo 3D photography of these masterpieces. The photos could serve as the core of a special website, supplementing and supporting the exhibition tour, as well as creating an enduring archive.

During the short interim after the Mourners were removed from their arcade and before they were to leave for the U.S., a team from FRAME, along with Dijon’s staff, and staff from the Dallas Museum of Art (the American tour organizer), created an ad hoc photo studio to capture the images for this project. Each of the 38 sculptures was photographed at very high resolution on a turntable in full 360-degrees, at five-degree increments, from five directions: straight on, from angles above and below, and again straight on from right-eye and left-eye perspectives to produce the stereo 3D images. All told, more than 14,000 photos



**Photo 3.** A screen capture from a 3D video of an eighteenth-century slant-top desk, its component parts “dancing” to period-style music. *Photo courtesy of the author and the Cleveland Museum of Art.*

were taken, which would be the source of the interactive stereo and non-stereo 3D images used on the website.<sup>16</sup>

*The Mourners* website permits rotation, panning, and zooming-in on each of the statues from three perspectives: above, below, and straight-on.<sup>17</sup> These angles enable viewers to appreciate fine details and aspects that would otherwise remain hidden. More germane to this discussion, a fourth “perspective”—stereoscopic 3D (straight-on-only<sup>18</sup>)—allows visitors to explore the statues, but with an important added value. It imparts that special spatial dimension and tangibility that lets one *feel round it*. The depth of the fold of the cloak, the outstretched hand grasping a scripture, the shape of a head as it turns away from you—these sensations can seem palpable. Interestingly, these 3D views not only seem to draw in those who are new to experiencing the allure of the sculptures themselves, but also may provide an additional, memorable,



**Photo 4.** The slant-top desk, 1750-1775, straw marquetry, possibly northern Italy near France. *Photo courtesy of the Cleveland Museum of Art.*

spatial and tangibility context for the other (non-stereoscopic) 3D perspectives.

In lieu of formal research, evidence of the success of *The Mourners* website emerges from good notices in the press and blogosphere, from where two examples are chosen. The first comes from the Artsjournal blog of *New York Times* writer Judith H. Dobrzynski on culture: “Right now, you can go there to get close-ups, with zoom-in capability, of each of the Mourners—and you can rotate them, 360 degrees. It’s not quite, but almost, as good as being there.”

And from an unexpected voice, the John’s Bailiwick blog, American Society of Cinematographers: “Even if your idea of a hip website would not happen to include one dedicated to medieval Burgundian tomb sculptures—this one, showing a veritable platoon of flawless, white alabaster figures against a rich, black field in 3-D is, dare I say it, way cool.”

Perhaps even more tellingly, an art history professor told FRAME of her intent to purchase 3D glasses for her entire class in order to best appreciate the sculptures.

*The Mourners* website was designed in a manner to be repurposed for in-gallery use. The St. Louis Museum of Art installed a kiosk version when it hosted *The Mourners*. St. Louis decided not to include the stereoscopic 3D version of interactives, opting instead for only the non-3D versions, after considering at least two concerns: 1) Are stereo 3D images really preferable to non-stereo 3D images for interactive discovery and exploration of details when the real objects are nearby? And 2) Does any incremental value derived from using stereo 3D justify the expense and logistics of providing the required glasses to visitors? These are legitimate questions and there is no one correct answer at this time. Looking forward, though, the first question would seem to demand more research (or may become moot if stereo-3D

becomes *de rigueur*) while the second question may simply evaporate as glasses-free stereo-3D displays become the norm.

## STEREO-3D IN CONSUMER CULTURE

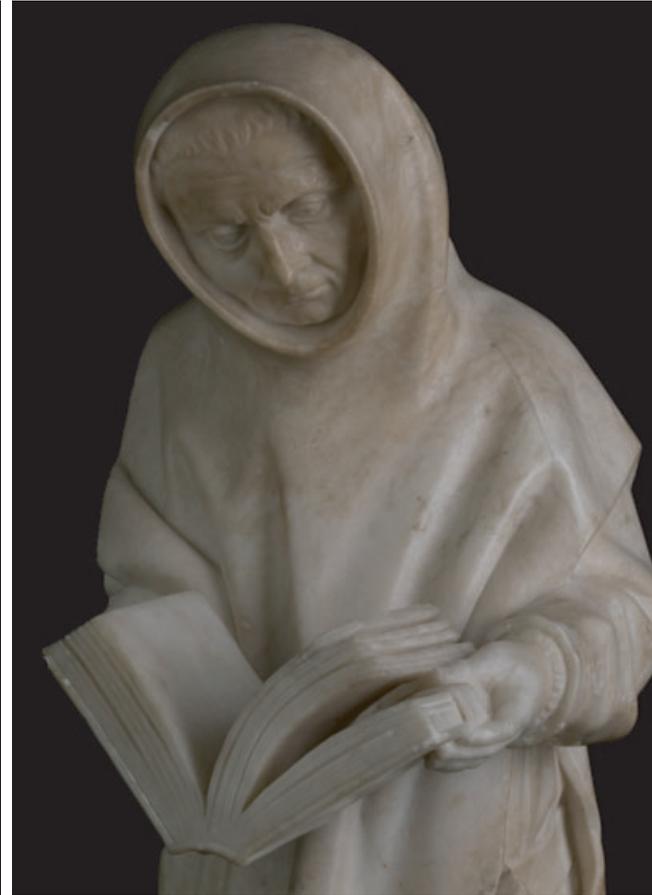
The pervasiveness of 3D technology in our consumer culture is increasingly evident. One need only search for “3D” at any big box store in person or online. The new technology includes Panasonic’s Hi-Def 3D camcorder, Fuji’s 3D 10 Megapixel camera with built-in auto-stereoscopic screen (it does video, too), and a parade of up-to-60-inches-wide 3D plasma and LCD TVs with 3D glasses to match. Blu-Ray 3D movie discs have recently started to ship, and 3D projectors are being rushed onto the shelves. Sony Playstations now have stereoscopic 3D, and here come the games. Portable computers with 3D screens are available, too, of course. ESPN has unveiled its 3D broadcast network with football games in 3D, which started in the fall of 2010. Sony and CBS have partnered to create the Sony 3D Experience in Las Vegas to gauge public reaction to both gear and content.<sup>19</sup> (Norelco has introduced a new “3D” electric shaver, a testament to the presumed power of “3D” marketing.)

Significant efforts are also underway to bypass the need for those funny glasses. Sony recently unveiled its prototype 360-degree 3D auto-stereoscopic color display, RayModeler.<sup>20</sup> RealFiction’s Dreamoc calls itself 3D, with free-floating animations in a glass vitrine.<sup>21</sup> Microsoft’s Applied Sciences Group is developing “The Wedge,” a completely new technology for seeing 3D without glasses.<sup>22</sup>

And should one need any proof that the public waits for no museum, those who search for “museum” and “anaglyph” (a type of 3D photography) in Flickr and YouTube are in for a treat.



**Photo 5-7.** Two of the Mourners: A cantor sings while holding an open book (above). And a Carthusian monk with a book is seen from two perspectives. From *The Mourners: Tomb Sculptures from the Court of Burgundy*, a touring exhibition. Photos by Jared Bendis and François Jay, copyright © FRAME 2010.



## CONCLUSION

Stereoscopic 3D still and moving images, interactivity and immersion have a rich and exciting future ahead as effective means for engaging, educating, and entrancing audiences. Especially as this technology becomes a common part of our technology ecology, museums should at least evaluate the possibilities—and certainly not ignore them. The case studies presented here demonstrate just a few ways in which this technology can be used: cinema and video, immersive environment, live-action theater, Web-based, and simulation.

These examples don't come close to exploring the full range of 3D possibilities and the kinds

of institutions that might pursue them. Imagine how stereoscopic 3D can be used to create smiles at the blooming of a flower; make visitors voyeurs of the motion in a molecule; show the subtle scribing of an engraving; behold the birth of an animal; draw wonder from our weather patterns; or travel through the town that used to be.

In many ways, 3D is just the next stop in a technology journey that museums have been on for decades. Never have so many technologies been so intrinsically entwined with audience lifestyles and expectations. Although new technologies vie for museum attention and limited resources, there is a case to be made that stereoscopic 3D technology should be near the top of the mix:

- Stereoscopic viewing of visual content is—due to its biological roots—naturally more engaging.
- The public has gravitated toward constructed 3D experiences for more than 150 years.
- Museums can choose to use 3D experiences in support of better educational and interpretive outcomes; 3D need not be a gimmick or a tease.
- As 3D technology becomes more mainstream, visitors will expect a media experience in the museum that is no less effective and engaging than that which they experience at home.
- The tools and techniques of content creation and presentation continue to increase in variety, diminish in complexity, and decrease in cost.
- Stereoscopy can often be integrated into existing or planned multi-media and object photography endeavors.
- Although more research on the net effectiveness of 3D is needed, that is not a reason to ignore its possibilities; museums should experiment and researchers should create and test evaluation criteria.
- The use of 3D crosses boundaries of theater, gallery, immersive environments, and Web presence.
- Whether or not museums present images of their collections in 3D, the public will start doing it for them.
- Younger audiences will increasingly consider 3D a visual lingua franca.

Timothy Hart of Museum Victoria—his research group produced PLACE: Hampi, as well as other advanced interpretive installations—summed it up eloquently in a conversation as this article was being written: “We are at

the forefront of a new convergence of experimental design/3D technology with the artist’s eye, a curatorial sensibility, and evolving visitor expectations. Blended together under the umbrella of museum authority, we know how to do these things right, and we know it’s the right thing to do.”

Perhaps the question—3D or not 3D?—is not “if” but “when.” Answers will rightfully evolve differently among museums, just as has been the case for other pivotal technologies such as digital photography and Web presence. Once museums grasp stereo-3D’s implications, a measured, deliberate approach will assure that it will be used in a way that both enhances interpretation and collection sharing while meeting and embracing audience expectations. As for the cynics, they might be reminded of Oliver Wendell Holmes’s words: “It is no toy: it is a divine gift, placed in our hands by science!” **END**

**ACKNOWLEDGMENTS**

The author wishes to thank Jared Bendis, Timothy Hart, Sarah Kendarine, and Slavko Milekic for conversations and insights that helped shape this essay.

**NOTES**

1. See <http://www.amnh.org/exhibitions/dioramas/>.
2. See [http://www.louvre.fr/llv/dossiers/liste\\_ei.jsp?bmLocale=en](http://www.louvre.fr/llv/dossiers/liste_ei.jsp?bmLocale=en).
3. Personal conversation with Slavko Milekic, associate professor, Cognitive Science and Interface Design, Department of Art and Museum Education and Art Therapy, University of the Arts, August 28, 2010.
4. Kendarine, S., personal e-mail correspondence, September 2010.
5. For the British Museum website description, see <http://www.britishmuseum.org/explore/>

online\_tours/egypt/mummy\_the\_inside\_story/mummy\_the\_inside\_story.aspx. A BBC-TV report with a video showing the experience can be found at <http://news.bbc.co.uk/2/hi/entertainment/3839523.stm>.

6. *Mediascape* was presented at the Solomon R. Guggenheim Museum (SoHo) from June to October 1996. The author was Chief Information Officer of the Solomon R. Guggenheim Museum (New York) during *Mediascape* and responsible for its technical support.
7. The virtual reality reconstructions were developed by Infobyte, SpA, based in Rome, Italy and CNR, Italy's National Research Council. The system was run on two linked SGI Onyx2 computers and proprietary software (PICTURETEL) for the imagery. The headgear was a Fakespace BOOM3C. The installation was in a room aside from the main digital/computer-based art galleries that formed the core of the *Mediascape* exhibition.
8. See <http://place-hampi.museum/>.
9. PLACE-Hampi is a project by Museum Victoria and iCinema Centre for Interactive Cinema Research, University of New South Wales, and is supported by an Australian Research Council Linkage Grant.
10. Kenderdine has long been at the forefront of research into immersive experiences for museum and galleries, "focusing on immersive architectures and evolving narratives with tangible and intangible aspects of culture and heritage." The co-producer of this project, Jeffrey Shaw, has long been a leading figure in new media art and a pioneer in "virtual and augmented reality, immersive visualization environments, navigable cinematic systems and interactive narrative." See <http://place-hampi.museum/contents/credits.html> for credit and bio information.
11. These and other projects, which focused on use of stereoscopic 3D, were primarily technological and interpretation demonstration projects used to explore feasibility and public response, and were not intended for permanent display. The Cleveland Museum of Art's exploration of new uses of technology for interpretation was made possible in part by a grant from the United States Department of Education, under the Fund for the Improvement of Education, in advance of the renovation and expansion of the museum and its Lifelong Learning Center. The author, as Chief Information Officer of the museum during this period, was responsible for these projects.
12. For more information about Kasumi and her work, see <http://www.kasumivideoart.com>.
13. The Mourners Photography Project was made possible by a grant from the Samuel H. Kress Foundation. The author served as Project Director for FRAME. The VR and 3D design was by Jared Bendis. Web design and art direction was by Rory Matthews, <http://www.rorym.com>. See <http://www.mourners.org> for additional credit information.
14. See <http://www.mourners.org/about>.
15. The French Regional and American Museum Exchange (FRAME), founded in 1999, is a formal collaboration of museums in 12 cities in France, 12 museums in the United States, and one Associate Member in Canada. See <http://www.framemuseums.org> for more information.
16. Readers are welcome to contact the author for more detailed technical information about photograph specifications and process design.
17. See <http://www.mourners.org>.
18. Stereoscopic photographs were restricted to only one perspective due to limited time available.
19. See <http://www.sonyinsider.com/2010/03/02/sony-3d-experience-opens-at-cbs-television-city-research-facility-in-las-vegas-mgm-grand-hotel/>.
20. See a video demonstration at <http://www.youtube.com/watch?v=6BFKC-NKRFw>.
21. See <http://dreamoc.eu/#/dreamoc/>.
22. See <http://www.microsoft.com/appliedsciences/content/projects/wedge.aspx>.

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