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"Pure Land": Inhabiting the Mogao Caves at Dunhuang

SARAH KENDERDINE

Abstract This article examines two exhibition installations that integrate high-resolution digital archeological datasets (photography and 3D architectural models) with immersive, interactive display systems. These analogous installations, *Pure Land: Inside the Mogao Grottoes at Dunhuang* and *Pure Land: Augmented Reality Edition*, allow visitors to engage in different ways with a full-scale augmented digital facsimile of Cave 220 from the UNESCO World Heritage site, the Mogao Grottoes, Gansu Province, northwestern China. The peerless treasuries of paintings and sculptures at Dunhuang are extremely vulnerable. Comprehensive digitization has become a primary method of preservation at the site. The digital facsimiles of this cultural paragon can be transformed, providing formative personal experiences for museum visitors. The *Pure Land* projects contribute to new strategies for rendering cultural content and heritage landscapes. Interpreting these installations through the lens of phenomenology and panoramic immersion helps situate them at the forefront of virtual heritage today.

INTRODUCTION

> [T]he Dunhuang visualization shows how cultural wealth can be multiplied. Adapted, augmented, and shared, vibrant Dunhuang imagery, audience-proven across a millennium of Silk Road travelers, could transform global culture.
> —Douglas Galbi (2012)

This article examines two exhibition installations that integrate high-resolution digital archeological datasets (photography and 3D architectural models) with immersive, interactive display systems. Exhibition technologies and content development strategies that support sensorial and experiential enquiry by visitors in the gallery are used to release the latent potential of imaging data from the UNESCO World Heritage site, the Mogao Grottoes, Gansu Province, northwestern China. The installations *Pure Land: Inside the Mogao Grottoes at Dunhuang* (see the cover of this issue) and

Pure Land: Augmented Reality Edition (photo 1) allow visitors to interact with augmented 3D digital visualizations of Cave 220, which is permanently closed to the public due to the importance of its early Tang mural paintings.[1] The multi-layered enhancements made to the underlying digital facsimiles of this cave can be interactively explored, analyzed, and understood as embodied 3D visual experiences that bring new life to the aesthetic, narrative, and spiritual drama of its mural paintings and sculptures. *Pure Land: Inside the Mogao Grottoes at Dunhuang* is the "exhibition experience of the future," according to Julian Raby, director of the Arthur M. Sackler Gallery and Freer Gallery of Art, Smithsonian Institution.[2] By stimulating a palpable sense of "being there" and co-presence with the past, these installations are conceived as theaters of embodied experiences within a "cultural imaginary" located in the *here and now*.[3] These installations transform today's

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Photo 1. *Pure Land: Augmented Reality Edition*, installation at the Shanghai Biennale 2012-2013. *Image © Applied Laboratory for Interactive Visualization and Embodiment (ALiVE), CityU Hong Kong.*

commonplace big screen documentary into kinesthetic and phenomenological encounters with the places they depict.[4]

Pure Land: Inside the Mogao Grottoes at Dunhuang (*Pure Land*) exploits an immersive 3D, 360-degree visualization system, the Advanced Visualization and Interaction Environment (AVIE).[5] Inside this 10-meter-diameter, 4-meter-high theater, up to 30 visitors are able to freely perambulate a true-to-life-scale virtual Cave 220 (the cover image shows the virtual construct). A single user interface, operated by one of the visitors or a docent, provides interaction with the digitally rendered cave, allowing the user to reveal key elements in the mural paintings on its walls. As well as offering a powerful space of embodied representation, *Pure Land* exploits various digital image processing techniques, 2D and 3D animation, as well as 3D cinematography to further develop its experiential and interpretative capabilities. The installa-

tion was first shown to the public at Gallery 360, City University of Hong Kong,[6] in 2011, to critical acclaim and subsequent worldwide attention.[7]

Pure Land: Augmented Reality Edition (*Pure Land AR*) uses mobile media technology to create a complementary "augmented reality" rendition of the same data from Cave 220. Walking around inside the exhibition space with tablet screens in hand (see photo 8), visitors are able to view the architecture of the cave and to explore its sculptures and wall paintings as they appear on viewers' mobile "windows"—a kinesthetic revealing of the painted architectonic space. Initially premiered at the HK Art Fair 2012, this singular expression of an embodied interface was installed for a mass public at the Shanghai Biennale (October 2012-March 2013) in China. To understand the influence of these two installations, two measures of their importance must be realized: 1) the singular, powerful

visitor experiences that are achieved in relation to both the digital and the virtual—which are more fully described later in this article—and 2) an appreciation of the works in the context of Chinese and world cultural heritage.

The Mogao Grottoes—also known as the Caves of the Thousand Buddhas—which these installations interpret, occupy a site at Dunhuang. A small oasis town in the desert of northwestern China, Dunhuang was a gateway to and from China on the ancient Silk Road, which carried trade between China, eastern and western Asia, and India from the fourth century BCE until the 14th century CE. These temple grottoes are not only a great art treasury but also an enduring record of globalization.

> The caves, however, are more than a monument to faith. Their murals, sculptures, and scrolls also offer an unparalleled glimpse into the multicultural society that thrived for a thousand years along the once mighty corridor between East and West (Larmer 2010).

The Mogao Grottoes consist of 750 caves, 492 of them with mural paintings, on five levels hewn into an escarpment in the desert. In total, there are 45,000 square meters of murals and more than 2,000 painted clay figures. Buddha statues, paintings of paradise, and angels adorn the walls, as do images of the patrons or donors who commissioned the paintings. The largest cave is 130 feet high and houses a 100-foot-tall Buddha statue installed during the Tang Dynasty (618-906 CE) (Larmer 2010).

Dunhuang is a singular and astonishing art repository, like none other in the Chinese Buddhist world. This great heritage is under the custodianship of the Dunhuang Academy.[8] Its importance is recognized through major international collaborations with, for example, the Getty Conservation Institute for conservation[9]; Northwestern University[10] and the Mellon

Foundation[11] for pioneering digital photography (since 2000); while laser scanning has been implemented together with Wuhan University and more recently the Cyark Foundation.[12] Although the movable heritage found at the site (in the form of manuscripts) has been largely dispersed over the centuries, it has been digitally repatriated from over 18 countries via the International Dunhuang Project, led by the British Library.[13]

Dunhuang Academy's Dunhuang Mogao Cave Paintings Digitization Project Plan[14] focuses on the quest for a definitive model of preservation for this highly significant site, which is under extreme duress from climate change and human factors. Between 2002 and 2012, over five million people visited Dunhuang. In 2012 alone, nearly 800,000 people toured the caves; 90 percent of these visitors were domestic tourists. Like many other cave and subterranean sites worldwide, the Mogao Grottoes are under serious threat from this rising number of visitors and the increasing humidity inside the caves. The estimated carrying capacity for the caves is about 3,000 people per day, but during peak periods there are almost 6,000 visitors a day at the site (Wang 2012). During China's weeklong national holiday in 2012, more than 18,000 tourists visited the site.[15]

Maintaining careful monitoring, the Dunhuang Academy opens a limited number of caves (approximately 30) at a time, to ensure long-term preservation. In most caves, the murals and statues are protected (and often optically hindered) by glass panels, and the only lighting is via low intensity LED torches—one of them held by the guide who is explaining the narrative iconography of the paintings and sculptures. Thus a real-life visit suffers from restrictive, albeit necessary, limitations.

There is an obvious tension between the desire to show this rich and important treasury

Photo 2. Digitization station at Cave 61. *Photo: Zhi Jun Sun. Image © Dunhuang Academy.*

to the world, and the ongoing protection of the caves. A *New York Times* journalist who visited the site wrote:

> And Mogaoku is in trouble. . . . The caves now suffer from high levels of carbon dioxide and humidity, which are severely undermining conservation efforts. The short-term solution has been to limit the number of caves that can be visited and to admit people only on timed tours, but the deterioration continues. . . . Plans are under way to recast the entire Dunhuang experience in a way that will both intensify and distance it. Digital technology will give visitors a kind of total immersion encounter with the caves impossible before now (Cotter 2008).

Many believe that Dunhuang's future lies in its digitization program, which is a cornerstone of new initiatives—including a new Visitor Center, to be opened in 2013—being led by director Fan Janshi. "Versatile and efficient, digitization provides many new opportunities for study, research and enjoyment," says Harlan Wallach, one of the initiators of high-resolution photography at the site (Wallach 2008). Since 1999, 59 caves have been completely imaged at a minimum resolution of 72 dpi (Lu and Pan 2010) and more recently at 600 dpi, with one-to-one scale images as the benchmark (Wang 2012). Acquiring the images requires special cameras, custom-made railings on which these cameras can be moved, as well as ample computer processing power and trained staff (there are currently 50 members of the photographic team). After the ceilings, walls, niches, and statuary have all been photographed as a complex mosaic, technicians then stitch the data together into finished ultra-high-resolution pictures. It takes up to three months for a team to image a single cave (photo 2).

The *Pure Land* projects expand upon these world-leading digitization efforts. These installations represent a technological achievement

that integrates the high-resolution digital documentation and academic research efforts at Dunhuang into an interpretive experience that reaches beyond the already established practices of digital facsimile and "virtual heritage."[16] Museums—which are traditionally concerned with material objects—are increasingly recognizing these digital visualizations of important works, signaling a philosophical shift for heritage organizations, which are themselves embracing more of the digital and are legitimizing visitor experiences in the virtual. These installations complement tangible heritage as significant objects in their own right. Digital experiences amplify but do not replace the original.

PHILOSOPHIES OF THE COPY

To say that a work of art grows in originality thanks to the quality and abundance of its copies, is nothing odd: this is true of the trajectory of any set of interpretations.
— Bruno Latour and Adam Lowe (2012, 279)

Digital practitioners within museums have often struggled with shifting concepts of "aura."[17] Recently, the contemporary philosopher Bruno Latour and digital preservationist Alan Lowe have argued for the "migration of aura"—by which good quality digital facsimiles both propagate and add layers of significance and meaning to the original, providing the object with a biography, as opposed to being a weak surrogate for the original or competing with or supplanting it. The focus of our age has been on the reification of the original object, but Latour and Lowe see this frenzy of interest rising exponentially along with the number of copies of the original that are circulating. In other words, the intensity of the search for an original depends on the amount of passion and the number of interests triggered by its copies,

so the question that must be asked becomes: "Is it well or badly reproduced?" The authors theorize that

[F]acsimiles, especially those relying on complex (digital) techniques, are the most fruitful way to explore the original and even to help re-define what originality actually is (Latour and Lowe 2012, 278).

The role that facsimiles play in the interpretation and preservation of cultural heritage has been proven to be both essential and effective. For an increasing number of sites, the facsimile provides the only means of public access, and may even give a superior viewing experience because of the constraints of the original site. True-to-scale physically *built* models (it seems necessary to distinguish these from models that are virtually rendered) of caves and subterranean sites, enabled by high fidelity digital registration, now exist to represent the Lascaux Caves, Altamira Caves, and the Tomb of Thutmose III.[18] At the Dunhuang interpretation center there are already a number of life-size built reconstructions of important caves, with accurate replica murals covering the walls and ceilings. Such built facsimiles increase accessibility on-site and in traveling exhibitions, diverting stress away from the originals and involving visitors in a pro-active protection of the site through promoting awareness.

The digital imaging of sites also creates a set of resources for in-depth study in preservation and conservation processes (Lowe 2004). Interestingly, digital modeling techniques based on buildings in Tang Dynasty murals at Dunhuang were used to create the extensive 15-building complex of the Chi Lin Nunnery,[19] now home to 60 nuns in Hong Kong; the nunnery is the sole interlocking wooden frame building in the region. Not only are archeological and heritage communities rapidly expanding

Photo 3. Installed at the beginning of *Pure Land: Inside the Mogao Grottoes at Dunhuang,* a browser displays significant caves distributed along the escarpment. *Image © Applied Laboratory for Interactive Visualization and Embodiment (ALiVE), CityU Hong Kong.*

advanced digital imaging techniques for conservation and preservation needs,[20] but they have also become necessary tools integrated into cultural memory and vital to living communities of practice. As we have seen, the Dunhuang Academy is at the forefront of this research, not only because the site demands it, but also because of its importance in the cultural memory and imagination of Chinese.

BEYOND FACSIMILE

Nothing is more destructive for thinking about the virtual than equating it with the digital. All arts and technologies envelop the virtual, in one way or another.
　　—Brian Massumi (1998, 309)

Pure Land: Inside the Mogao Grottoes at Dunhuang

Exploiting the high-resolution photography and laser scanning data recorded by the Dunhuang Academy, *Pure Land* reframes and reconstitutes the extraordinary wealth of paintings found in the caves at Dunhuang. A team of

30 artists and scientists at City University of Hong Kong developed the visualization strategies for their 360-degree 3D display system AVIE.[21] Inside its panoramic enclosure, visitors engage in a surrogate true-to-life experience of being inside this cave temple and seeing its magnificent Buddhist wall paintings at one-to-one scale. Following an interpretive script and art direction by the Dunhuang Academy and the project's sponsor, Friends of Dunhuang Hong Kong,[22] the project's team was able to re-draw, restore, and re-color key iconographic elements in the wall painting—and to create 3D animated objects and 3D video-captured dance sequences where such animation is implied and gives meaning to the painting's intent. A skilled docent[23] leads the tour as visitors begin their experience in a scene covering the full expanse of the escarpment of cave entrances, where important iconographic elements from 50 significant caves are presented (see photo 3). Choosing to enter Cave 220, visitors are suddenly surrounded by total darkness, which is only relieved by the docent's virtual torch beam, slowly revealing the nature of the cave space and

Photo 4. A visitor uses the magnifying glass to inspect a musician in the mural at *Pure Land: Inside the Mogao Grottoes at Dunhuang. Image © Applied Laboratory for Interactive Visualization and Embodiment (ALiVE), CityU Hong Kong.*

its wall paintings and sculptures. This initial immersion in the virtual cave is meant to simulate what the viewers' rather limited experience would be if they were visiting the real Cave 220.

The north wall portrays the Bhaisajyaguru's Eastern Paradise Sutra. The east wall depicts the Vimalakirti Sutra, and the south wall the Western Pure Land Sutra. *Pure Land* concentrates its visualization on the Eastern Pure Land paradise of the Medicine Buddha from the north wall, which is dominated by the seven forms or emanations that Bhaisjyaguru can assume as a healer. The Buddha-forms stand in a row on lotus platforms with a pool below and 24 musicians and four dancers alongside. The narrative of the painting relates to the 12 great vows of the Buddha and the provision of food,

drink, clothing, medicine, and spiritual aids.[24] The interactive features of *Pure Land* allow this world to be transformed from a mimetic representation to a navigable space, rich with layered interpretation and fully illuminated—impossible if one were there in person.

Visitors are then familiarized with one of the most powerful interactive tools available, a virtual 3D "magnifying glass" that takes advantage of the system's very high-resolution photographic data sets (see photo 4). A circularly framed portion of the screen—the magnifying glass—can pan anywhere over the cave's wall surfaces and zoom progressively into the finest details of the cave's paintings. As the zoom factor increases up to 10 times, so does the size of the magnification window, which appears to

Photo 5. Viewing vividly re-colored Medicine Buddhas in *Pure Land: Inside the Mogao Grottoes at Dunhuang. Image © Applied Laboratory for Interactive Visualization and Embodiment (ALiVE), CityU Hong Kong.*

detach itself from the plane of the painting and float closer and closer to the viewer. In effect, what is being simulated is the real-world dynamic of a viewer approaching closer to the mural to examine it in more detail—but in *Pure Land* this greater detail enlarges and approaches the stationary viewer, a digital *trompe l'oeil* effect that has a powerful perceptual impact.

The figures and objects in these paintings are dramatized by means of interactive digital effects that reveal their painterly beauty and underlying narrative meanings. Using pigment studies by the Dunhuang Academy, and a laborious process of hand painting, "restored" Medicine Buddhas are activated for viewers as a layer, floating out in 3D space in front of the original

painting (see photo 5). Particular objects within the painting, such as six incense burners beneath the feet of the Buddhas, and numerous musical instruments of traditional Chinese and Central Asian varieties (being played by two groups of musicians in the painting), have been studied and transformed into fully textured 3D models. These elements can be activated to float out in front of the painting, where they then rotate in two axes to reveal their forms and features (see photo 6). Other events that can be triggered are traditional 2D animations that include the "lighting of the lamps" and the Sumatrabhadra (Wonderful Sound) Bodhisattva's coming to worship in front of the Medicine Buddha. *Pure Land* also takes advantage of live performances to interpret the four dancers depicted in the

Photo 6. Examples of the 3D reconstructed instruments (left to right: yaogu, sheng, konghou, and ruan) in *Pure Land: Inside the Mogao Grottoes at Dunhuang. Image © Applied Laboratory for Interactive Visualization and Embodiment (ALiVE), CityU Hong Kong.*

painting. Two performers from the Beijing Dance Academy were filmed in 3D and inserted ("composited") into the mural scene (photo 7), giving the painting yet another dimension of "aliveness."

Pure Land presents Cave 220 as a prototype for analysis, laying the framework for expansion to include many other caves. Ultimately, all 492 caves could be incorporated in the display system, and a sustainable and extensible production strategy is being developed for model optimization, integration, and augmentation. The virtual torch, the digital magnifying glass, 3D modeling (including architectural elements) will all be further developed. A browser for comparison of cave elements will be part of the ongoing visualization methodologies that are supported (for example, caves depicting the same sutra; caves of the same time period, and so on).

While *Pure Land* was conceived for general public interpretation, its features also have significant potential as scholastic tools. An expert-led tour of Cave 220 using the digital 3D magnify-ing glass alone can last several hours, as more and more is discovered in the mural. With the ability to freely navigate every part of the digital model, including the upper reaches of the walls and the ceiling, *Pure Land* provides scholars with unparalleled access to the totality of the caves' surfaces and imagery. Furthermore, while maintaining context within the overall painting, the 3D magnifying glass greatly enlarges the high level of detail to reveal the density of discoverable iconographic elements in these paintings, and it offers many advantages for in-depth study of the iconography.

VIRTUAL REALITY, PANORAMIC IMMERSION, PHENOMENOLOGY

> *In virtual reality, the panoramic view is joined by sensorimotor exploration of an image space that gives the impression of a "living" environment.*
> —Oliver Grau (2003, 7)

Understanding the history of its immersive view helps to further explicate *Pure Land*. As media historian Oliver Grau points out,

Photo 7. Filming in a blue screen studio, dancers are added to the imagery. *Image © Applied Laboratory for Interactive Visualization and Embodiment (ALiVE), CityU Hong Kong.*

images have always been subject to media technologies of spatial illusion, immersion, and display, and "every epoch uses whatever means available to create maximum illusion" (Grau 2003, 5). Museum visitors gaze through lenses that have been refined over many centuries. Finding "presence" (or literally "being there") in today's virtual environments[25] is the result of traversing the histories of technologic immersion—generations of 'oramas, sensoriums, and all manner of optical devices. It is to delight in automata, to believe in magic and the phantasmagoric, and to be transported by special effects.

The painted panorama in its many forms has been at the forefront of understanding new ways of seeing in digital and virtual environments and is present in many seminal virtual heritage installations.[26] The historic panorama as public screen entertainment has been the subject of a number of extensive analytical histories,[27] which led Stephen Oettermann to claim the panorama as "the first true mass medium" (Oettermann 1997, 7). In current media practices, the re-emergence of the panoramic scheme as "the new image vogue" (Parente and Velho 2008, 79) is based on the desire to design virtual spaces and places that can be inhabited by the viewer, maximizing a sense of immersion and ultimately "presence" or "being there."[28] Maria Elizabeth Grabe, a telecommunications expert, noted that there is "substantial evidence for the

idea that large screens promote perceived realism of media content and perceptions of presence" (Grabe et al. 1999, 5). Since the human brain is wired to react to visual stimuli by emotional responses that then play a role in attention and memory, this can be expressed behaviorally, linguistically, and physiologically (Lang, Dhillon, and Dong, 1995 cited in Nucci 2002).

In a study by visual cultural theorist Jonathan Crary on the relationship of nineteenth-century ocular devices and modernity, he observed that "techniques of the observer" involve an array of perceptual and spatial expansions. Virtual environment technologies create new forms of perception and social interaction. Crary suggests in *Suspensions of Perception: Attention, Spectacle, and Modern Culture* (2001) that certain elements made artificial "ways of seeing" more successful than others. Rather than accepting the dominant history of an evolutionary narrative culminating in cinema, he shows a history of the politics of the conformation of the body— that is, the sublimation of the body to the demands of the machine. For him, the optical devices that survived were the ones that combined two attributes: first, they were sufficiently "phantasmagoric" (meaning that they possessed the capacity to create illusion and to conceal the process of production); second, those devices were the ones that had the ability to create a visual experience that presupposes the body as *immobile* and *passive*. The *Pure Land* projects

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thus can be seen to significantly diverge from former exhibition practices and contemporary cinematic viewing through strategies that support the mobilization of the viewer in virtual and real space. By activating strategies for the embodiment of the visitor, these installations reactivate the history of the immersive view in museums and reinvigorate archeology with aliveness.

The full omni-directional potential for the tradition of panoramic enclosure is fully realized in *Pure Land,* where the user is surrounded by the stereographic image space. Omni-directional attention dispels the ego-centered view, since there is always something going on inside the same space but outside the user's direct field of view. One can invoke the notions of allocentric and egocentric cognition and spatial perspectives, where the "allocentric" are those pertaining to a perceived, fixed external framework (that is, a reality that exists "all around" and is distinct from oneself) and the "egocentric" contains your relationship with a given object or frame. A cognitive map of an omnidirectional, immersive space allows for allo- and ego-centric interpretations simultaneously.[29]

Understanding phenomenology from an archeological perspective can also provide a radically different way of thinking about the past in the present, which is relevant to understanding *Pure Land*. Archeologist Christopher Tilley demonstrates the manner in which, through a phenomenological perspective, the past can be understood and interpreted via a sensuous human scale as opposed to an abstract, analytical gaze. His reasoning provides grounding for the research designed for the experience and embodiment of cultural heritage (Tilley 2004). Using frameworks from post-Processual Archeology, he emphasizes approaches to archeological assemblages that go beyond their material manifestation. In his book *Body and Image: Explorations in Landscape Phenomenology* (2008),

he contrasts iconographic approaches to the study of representation with those of kinesthetic enquiry. In this context it is useful to quote his discussion of the interpretation of rock art:

> Iconographic approaches are usually primarily cognitive in nature. . . . It is the mind that responds in a disembodied way. . . . Kinaesthetic approaches, by contrast, stress the role of the carnal human body. The general claim is that the manner in which we perceive, and therefore relate to visual imagery, is fundamentally related to the kinds of bodies we have. The body both limits and constrains and enables us to perceive and react to imagery in specific embodied ways (Tilley 2008, 18).

Tilley also defines the mediation of past and present, its enfolding and re-articulation through embodiment. These notions are explored in this article as the hybrid-realities of immersive displays, as virtual settings for the presentation of archeological places that provide vibrant theaters that co-locate both historic landscapes and the present. Tilley says:

> The body carries time into the experience of place and landscape. Any moment of lived experience is thus orientated by and towards the past, a fusion of the two. Past and present fold upon each other. The past influences the present and the present re-articulates that past (Tilley 2004, 12).

Pure Land lies at the intersection between embodiment and representations of the material. Likewise, the immersive display system described in this essay promotes the visualization of the material—of "things"—*and* aspects of embedded meanings found within those things. Further, the prosthetic devices of magnification, animation, and video reenactment amplify the sensorial and allow the senses to go where they have not gone before.
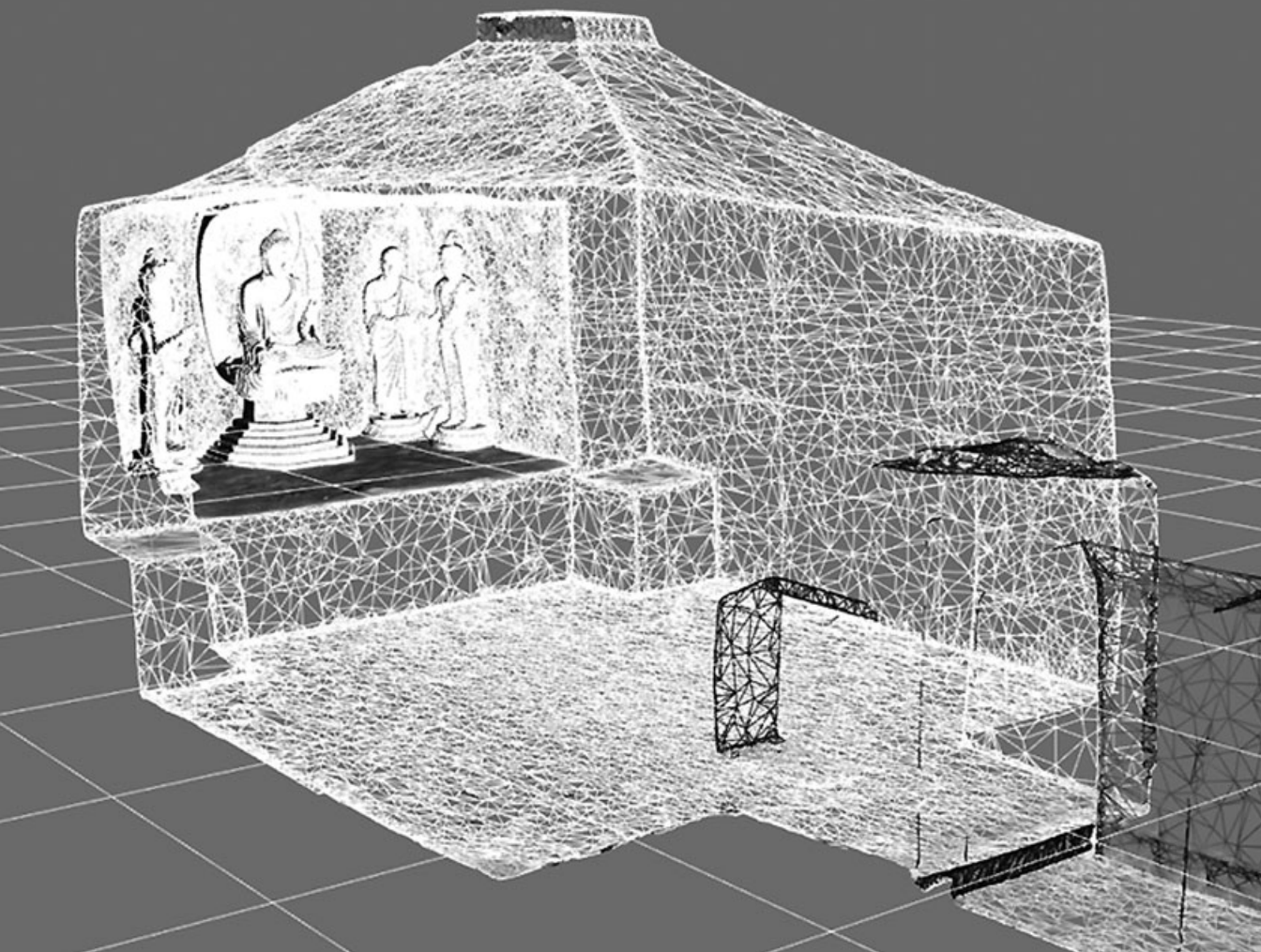
Photo 8. The wireframe polygonal mesh derived from point cloud laser scans of Cave 220. *Image © Dunhuang Academy.*

Pure Land – Augmented Reality Edition

Mobile media technology was used to create an augmented reality rendition of Cave 220.[30] In this installation, the walls of the exhibition room (which share the same scale as the real cave) are covered with one-to-one scale prints of Cave 220's "wireframe" polygonal mesh—which provides users with visual cues as to what to explore (photo 8). These derive from the Dunhuang Academy's original "point cloud" laser scans of this cave. Inside a virtual model, the high-resolution photographs of the cave's paintings and sculptures are digitally ren-

dered onto this polygonal mesh to create the composite 3D representations that are then presented to the visitors on the tablets as they navigate the exhibition space. Infrared cameras track the position and orientation of the visitor tablets, while computers render the appropriate views of the digital cave, transmitted via Wi-Fi, in real-time (see photo 9).

In doing so, the tablet screen shifts from being considered as an object in and of itself, to functioning as a mobile framing device for the staging of a "virtual" rendering of the real cave that relies on an intricate spatial tracking system. This is not a passive televisual environment, but

Photo 9. Visitors crowd around a digital tablet giving augmented views of Cave 220. *Pure Land: Augmented Reality Edition*, Shanghai Biennale 2012-2013. *Image © Applied Laboratory for Interactive Visualization and Embodiment (ALiVE), CityU Hong Kong.*

an interactive performance. Cave 220 is being exactly mapped between real space and the digital model. In this instance, *Pure Land AR* is activated in the twists and turns of the hand-held screen. By moving the monitor around the space, the viewer can examine three walls of the cave, and by holding the tablet aloft, he or she can also see the magnificent ceiling painting (see photo 10). Thus the tablet reveals the cave as something that is apparently located in the real space of the gallery. As the visitor/user entertains the various possibilities of moving through the space with the tablet, the changing views of the cave are fluidly and accurately shown on the screen. In this way the classic trope of a "window on the world" is virtually enacted. And given that this world is bounded by Cave 220's walls, when the viewer brings that window into contact with the exhibition wall sur-

face, its painting appears at exactly 1:1 scale within the frame of the tablet screen (photo 11).

The conjunction between the actual wireframe image on the exhibition walls and the life-like cave rendering seen on those walls via the tablet window operates in the borderline between the indexically real and the phantasmally virtual—between re-embodiment and dis-embodiment. *Pure Land AR* thus weaves a set of subtle paradoxes into its web of virtualization and actualization, and these paradoxes feed the kinesthetic excitement that is clearly evident in all visitors' astonished enjoyment of this installation (photo 12). It thus aligns with the technologies of telepresence that virtually transport the viewer between the present location and another place—in this case, from the exhibition space to Dunhuang.
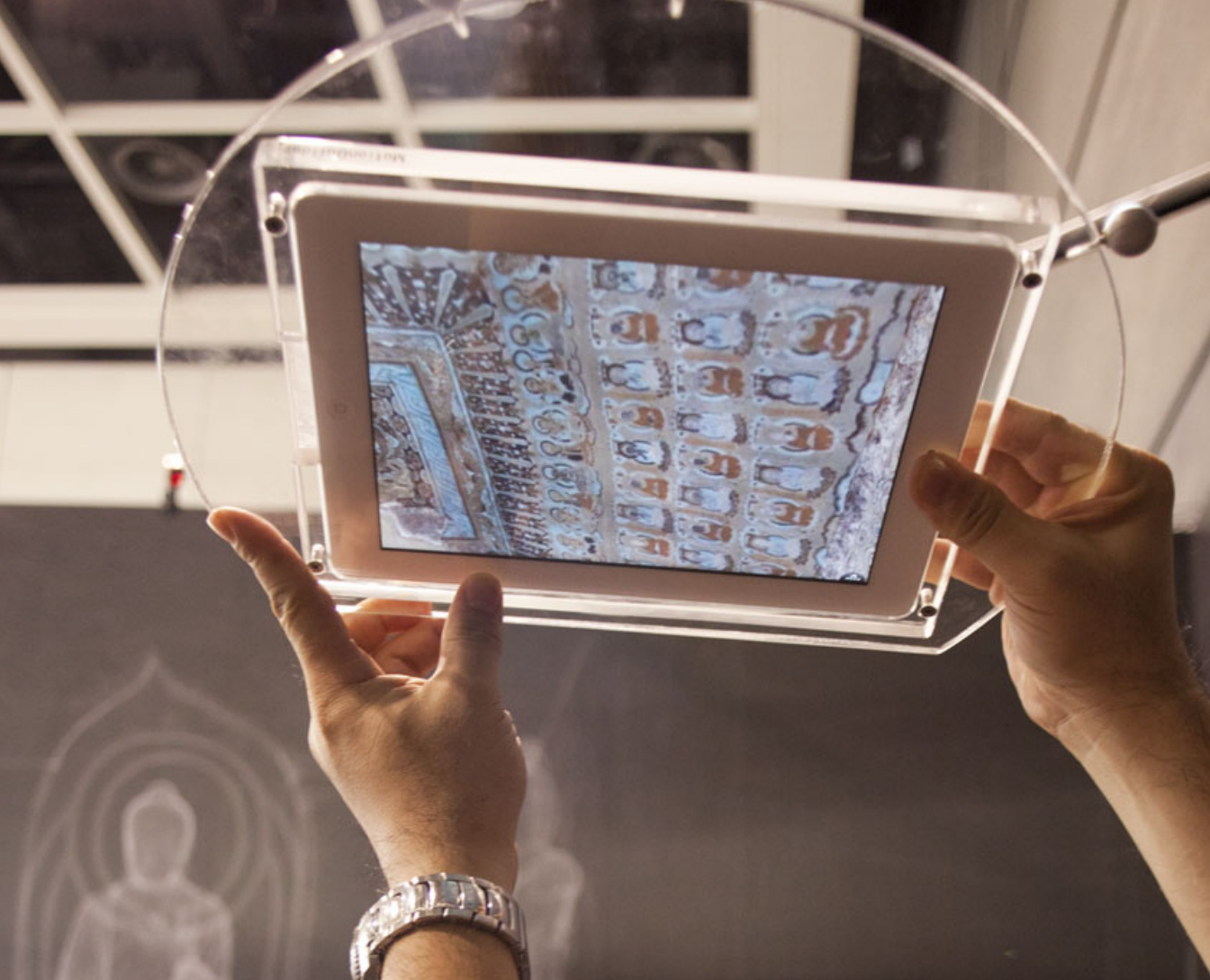
Photo 10. Holding up the tablet to see the ceiling of Cave 220. *Pure Land: Augmented Reality Edition*, Shanghai Biennale 2012-2013. *Image © Applied Laboratory for Interactive Visualization and Embodiment (ALiVE), CityU Hong Kong.*

For this installation, which has an area (24 square meters) equal to the actual Cave 220, two mobile tablets allow two users and, typically, groups of three to 10 people to follow the tablets around. This method has proven to be very successful, reinforcing the social qualities of the interpretive experience. *Pure Land AR* thus demonstrates the dynamics of a single-user, multi-spectator interface that is important to the notion of museums as places of socialization. A group of people will always surround the user, and will follow, direct, gesture, prompt, and photograph the user's view of the world. This dynamic is integral to the interpretation, and to

the performance of the work. The view that everyone should have his or her own tablet interface would deny the dynamic of this interchange and only advantage more isolated journeys of discovery.

It is useful to compare *Pure Land AR* with the original 360 panoramic version of *Pure Land*. The former presents an actual one-to-one scale correspondence between the dimensions of the exhibition space and the dimensions of the real cave. The latter creates this correspondence virtually by means of stereoscopic visualization techniques so that the smaller dimensions of the actual cave become optically rendered and

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Photo 11. When the tablet is held against the wall, the murals appear at one-to-one scale. *Pure Land: Augmented Reality Edition*, Shanghai Biennale 2012-2013. *Image © Applied Laboratory for Interactive Visualization and Embodiment (ALiVE), CityU Hong Kong.*

perceived in 3D within the larger circumference of the circular projection screen. These are complementary yet different approaches to the challenge of digitally reconstituting the space of the actual cave, at scale.

FUTURES FOR VIRTUAL HERITAGE

The *Pure Land* projects may be further contextualized within developments in virtual heritage. As early as 1970, the writer and futurist Alvin Toffler, in his book *Future Shock*, foresaw the use of virtual reality and "simulated environments" for the experiential immersion in cultural heritage:

Thus computer experts, roboteers, designers, historians, and museum specialists will join to create experiential enclaves that reproduce, as skillfully as sophisticated technology will

permit, the splendor of ancient Rome, the pomp of Queen Elizabeth's court (quoted in Wills 1976, 198).

For some, the failure of most virtual heritage to live up to its scientific potential invites dismissive labels such as "edutainment" and even the "Disneyfication" of culture. Virtual heritage has long been challenged (since, for example, Barceló 2000, 28) to emerge from a period of increasingly sophisticated digital model-making and creation of navigable landscapes of "pictorially rendered objects," and to embark on a critical examination of the meaning of representations of space and place in order to facilitate dynamic, inter-actor participation and cultural learning.

A *Pure Land* exhibition was installed in November 2012 for the 25-year anniversary of the Freer-Sackler Gallery of Asian Art at the

Photo 12. Astonished visitors explore the digital Cave 220 in a multi-user social experience. Shanghai Biennale 2012-2013. *Image © Applied Laboratory for Interactive Visualization and Embodiment (ALiVE), CityU Hong Kong.*

Smithsonian Institution. In a review in the *Washington Post* of the show's highlights and the shift that this work represents, Philip Kennicott wrote:

> A decade or more of efforts to use virtual reality to reproduce aesthetic experiences have [*sic*] generally led to unsatisfying, cumbersome and distracting technologies. The transient buzz of interactivity overwhelms the actual content or educational value. But the "Pure Land" cave is different. . . . [I]t points the way forward, demonstrating how the immersion environment can be used to let visitors actively explore and understand complicated cultural objects. . . . [A]t last we have a virtual reality system that is worthy of inclusion in a museum devoted to the real stuff of art (2012).

The *Pure Land* projects not only provide benchmarks for the integration of archeological data and interactive and immersive technologies. They also give us fresh directions for the future of interpretive experiences in museums. Diverging significantly from former exhibition practices and contemporary cinematic viewing, *Pure Land* and *Pure Land AR* mobilize the viewer to coalesce his or her experiences in virtual and real space. By defining strategies for the embodiment of these experiences for visitors, these installations reactivate the history of the immersive view in museums and reinvigorate archeology with aliveness, extending the role of digital facsimiles for new levels of aesthetic and interpretative experience. With the original caves under threat by time and circumstance, the innovative digital strategies offered by the *Pure Land* projects and their successors may be the only way to keep the artistic and spiritual brilliance of the Mogao Grottoes alive for the "cultural imaginary" of this and future generations. **END**

ACKNOWLEDGMENTS

NOTES

1. The images provided in this text can be supplemented by watching video documentation of the respective installations. See *Pure Land: Inside the Mogao Grottoes at Dunhuang*, accessed at http://alive.scm.cityu.edu.hk/projects/alive/pure-land-inside-the-mogao-grottoes-at-dunhuang-2012/, and *Pure Land: Augmented Reality Edition*, accessed at http://alive.scm.cityu.edu.hk/projects/alive/pure-land-ii-2012/.

2. Smithsonian press release: "New Technology Resurrects Ancient Chinese Cave at Smithsonian's Sackler Gallery: 'Pure Land' Digital Installation Brings Buddhist Treasures to Washington, D.C." Nov. 26, 2012. Accessed at http://www.asia.si.edu/press/2012/sackler-25-digital-cave-release.asp. See also video documentation, accessed at http://www.youtube.com/watch?v=rrTKARGeUfQ.

3. Mario Valdés, researcher in literary history, describes the "cultural imaginary" as how people see themselves and make sense of the world around them in a given time and place (2004). This interpretation of the world is necessarily informed by politics, religion, economics, history and so forth. In the cultural imaginary, the *Pure Land* projects reach beyond the material remains of the past and mimetic representation, offering new opportunities and possibilities for the imagination and for imaginative action marked by independent and creative thought, and informed by cultural processes and by memory and its deformations.

4. Phenomenology simultaneously analyzes and describes consciousness, while also searching for understandings of "space," "time," and the world in non-cognitive terms, or as they are lived through embodiment. See Tilley (2004; 2008) and Merleau Ponty (1945/1962).

5. AVIE was developed at the iCinema Research Centre, University of New South Wales, Australia. Accessed at http://www.icinema.unsw.edu.au/.

6. City University of Hong Kong press release, March 16, 2012. Accessed at http://wikisites.cityu.edu.hk/sites/newscentre/en/Pages/201203161700.aspx.

7. Over 100 news articles have been published on this work. At the time of the premiere, see Christy Choi, "Virtual Cave Shines a Light on the Past," *South China Morning Post*, March 16, 2012. In Chinese, see a representative article by Yu Zeut Bat, *Hong Kong Economic Journal*, March 23, 2012. See also *Newsweek*, accessed at http://www.thedailybeast.com/newsweek/2012/12/16/virtual-tourism-china-s-dunhuang-buddhist-caves-go-digital.html. The BBC (http://www.bbc.co.uk/news/magazine-20802947) and CNN (http://edition.cnn.com/2013/01/15/world/asia/china-digital-caves/index.html?hpt=hp_c5) have also published articles.

8. The Dunhuang Academy website is primarily in Chinese (http://www.dha.ac.cn/) with a more limited English version (http://enweb.dha.ac.cn/).

9. See, for example, the Getty Conservation Institute, *Wall Painting at Mogao Grottoes*, accessed at http://www.getty.edu/conservation/our_projects/field_projects/mogao/. Previous sand dune stabilization projects, see *Site Conservation at the Mogao and Yungang Grottoes (1990-1995)*, accessed at http://www.getty.edu/conservation/our_projects/field_projects/sitecon/index.html.

10. See, for example, Wallach (2004).

11. The Mellon International Dunhuang Archive (MIDA), a component of the ARTstor Digital Library, is funded by the Mellon Foundation (http://www.artstor.org/what-is-artstor/w-html/col-mellon-dunhuang.shtml).

12. Cyark Foundation (http://archive.cyark.org/).

13. International Dunhuang Project (http://idp.bl.uk/).

14. The Dunhuang Mogao Cave Paintings Digitization Project Plan is set out as a key program for the nation. See Digital Centre's introduction to the digitization of the wall paintings at Dunhuang, Dunhuang Academy, April 30, 2010, accessed at http://www.dha.ac.cn/02DB/index.htm.

15. Katie Hunt reported on "Buddhas in 3-D: Technology and the battle to preserve Asia's heritage," CNN, Jan. 15, 2013, accessed at http://edition.cnn.com/2013/01/15/world/asia/china-digital-caves/index.html?hpt=hp_c5.

16. Virtual heritage examines the intersection of cultural heritage research, documentation, and interpretation as it is mediated through the techniques and modalities of virtual reality. It is a process of visualization. The term "virtual heritage" is generally accepted to mean "virtual reality" (specifically 3D and 4D computational and computer graphics systems that support real-time, immersive and interactive operations) employed for the presentation, preservation, conservation, and documentation of natural and cultural heritage. "Virtual heritage" is distinguished by its preoccupation with replication or facsimile, and reconstruction or recreation.

17. See the original thesis on loss of aura in the processes of reproduction, by Walter Benjamin (1969). For one of the many essays on aura and the photographic museum, see Walsh (2007).

18. See, for example, the Facsimile of the Tomb of Thutmose III by Arte Factum. Accessed at http://www.factum-arte.com/eng/conservacion/tutmosis/default_en.asp.

19. See, for example, Li, Zhu and Du (2008), accessed at www.isprs.org/proceedings/XXXVII/congress/5_pdf/170.pdf.

20. See, for example, the European Union project 3D-COFORM (http://www.3d-coform.eu/).

21. As a research project, the hardware was available from ALiVE "in-kind." ALiVE has been commercialized and is available at http://www.immersive-realisation.com.

22. *Pure Land: Inside the Mogao Grottoes at Dunhuang* is entirely funded by a single donation from the Friends of Dunhuang HK, HK$500,000.

23. For the purposes of this description, a docent-led tour is described. A member of the public, using an iPad Mini as the interface, can lead the interaction in situations where time inside the experience is not restricted by the museum.

24. The murals of this Medicine Buddha sutra were recovered after a later painting of Wudai Thousand-Buddhas was removed from the North Wall.

25. The increasing trend towards research requiring "unlimited" screen resolution has resulted in the recent growth of gigapixel displays. Visualization systems for large-scale data sets include tiled displays such as HIPerSpace at Calit2 (http://vis.ucsd.edu/mediawiki/index.php/Research_Projects:_HIPerSpace), and next-generation immersive virtual reality systems such as StarCAVE at the University of California, San Diego (see, for instance, http://www.calit2.net/newsroom/release.php?id=1383) and Allosphere at the University of California, Santa Barbara (http://www.allosphere.ucsb.edu/).

26. In cultural heritage, important panoramic immersive environments include the real world stereographic panoramic works *Sacred Angkor* for The Virtual Room (2004), *PLACE-Hampi* (2006), and *PLACE-Turkey* (2010) for PLACE display platform; *Hampi-LIVE* (2010) for AVIE, the spherical panoramic installation *Eye of Nagaur* (2008) for an interactive 3-meter circular screen, and *iJaio* (2011), a study in intangible heritage capture using 360-degree video for the iDome. The *Pure Land* projects expand the repertoire of strategies for interaction and visualization established in this series of installations. Many of these are documented on the ALiVE website http://alive.scm.cityu.edu.hk/projects.

27. See Oettermann (1997); Hyde (1988); Altick (1978); Avery (1995); Huhtamo (2004; 2012).

28. "Presence research" is an established body of inquiry for virtual environments. See for instance the International Society for Presence Research (ISPR), accessed at http://www.temple.edu/ispr/. See also Presence and Interaction in Mixed-Reality Environments (Presence II), accessed at http://cordis.europa.eu/ist/fet/pr.htm.

29. As sound theorists Blesser and Salter point out, different cultures may associate different aspects of their culture as either "ego" or "allo." The cognitive maps will vary across cultural groups; in one culture, language may be spatialized as egocentric (that is, things are described in relation to the viewer, which is good for encoding relative locations), or in the case of the Mayans, the allocentric framework means they have better sense of absolute locations and therefore navigation in wide open spaces (Blesser and Salter 2006, 39–40).

30. *Pure Land Augmented Reality Edition* was installed at the Hong Kong Art Fair (May 2012) and at the Shanghai Biennale (Oct. 2012–March 2013).

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