Panoramic Video: Recording and Representing the Digital Heritage Experience

TAKEHIKO NAGAKURA, DANIEL TSAI, JOSHUA CHOI
Massachusetts Institute of Technology, USA

Documenting a heritage site is difficult since no representational method can make an exact copy without loss. This paper specifically examines panoramic recording media and related technologies as new means to archive and represent architectural heritage. It looks at cost-effective and widely available systems such as 360 video recording and immersive Head Mounted Display (HMD) equipment. Tests with subjects are conducted to probe how the experience of recorded panorama compares to the spatial and temporal experience in the physical space, which analyze the roles such systems can play in conveying the spatial environment, especially in representing some of its intangible aspects.

The paper presents examples of exhibit prototypes that utilize panoramically recorded onsite footage in derivative forms. Recordings of sites, such as Palladio's villas and the Acropolis in Athens, are used to demonstrate spatial and temporal editing, interactive panoramic walk-through combined with a map, and creation of a framed-video narrative reduced from panoramic videos. These methods illustrate a range of possibilities that put each dislocated recording back into context while controlling a balance between the viewer's exploration and the intent of the curation.

1. INTRODUCTION

This paper discusses the panoramic recording and viewing device as an emerging tool for digital heritage projects. Spatial cognition of its viewers is examined through subject tests, and experiments of editing panoramic video recordings are presented as means to enhance the curation of spatial design representation.

Panoramic video became a part of the YouTube culture when Google officially launched it in March of 2015 as part of the platform's media types that allow a user to scroll around the camera 360 degrees while watching the video in a browser's frame. This platform also supports the use of Google

Cardboard, a low-cost HMD system that works with a high-end smartphone placed in a cardboard box with binocular optical lenses. Today, we see an increasing number of music performances and sports events captured and distributed in similar forms for entertainment. This epoch is an addition to the history of visual recording that started with the introduction of commercial photography in 1839 through the invention of Daguerreotype process as well as the first public screening of motion pictures in 1895 by the Lumiere Brothers in Paris. The advent of photography and subsequent motion pictures is the reference point for this discussion because it marks the use of technology to capture the visual physical world via scientific means − i.e. light waves focused onto chemical recording media − without the need of direct intervention. "Capture" is an appropriate term as a process that absorbs light waves and records data, which is distinct from representational methods where the artist is the critical agent in the representational process.

For architects in the last century, photographic and motion picture media provided a new way for spatial designs to be presented and consumed by the audience without being on the site of the real built environment. The photo-realism of these media had a profound appeal to the audience in satisfying the desire to see the reality of the built form, as demonstrated by the success of Walter Ruttmann's 1927 film, "Berlin: Symphony of a Metropolis," composed of numerous location shots that depict the space and livelihood of the city at a time when global mobility was limited. However, the static frame introduced by these media brought an unexpected consequence; it promoted a framed architecture in place of architectural design as a built, immersive environment. The "frame," separating what is within the view and what is outside of view, certainly existed throughout all history of depiction, from the oldest drawings of cave people and animals to high renaissance painted scenes. The realism of captured 'reality' brought this aspect to the fore.

Andre Bazin, a prominent film critic, wrote that the film screen's frame is "the edges of a piece of masking that shows only a portion of reality" [Bazin 1967]. Photographers and filmmakers alike use this frame for directing the attention of the viewer to a small limited section of the sphere of the environment around the camera at will. Bazin explains that a filmmaker further edits these framed shots together on the timeline and creates a sequence that constructs a sense of reality in the minds of the viewers that may or may not have any resemblance to the real location where these shots are recorded. The audience is consuming Ruttmann's construction of Berlin out of the fragments Ruttmann sliced from the real city, and it is his design of the Berlin experience that was made through framing and montage, not a copy of the experience of the city in 1927. Likewise, when we see architecture published in magazines today, it is often hard to imagine the whole immersive experience of being on the site despite the convincing graphic appeal of the photographs. Visiting the real site after looking at its photographs often leaves us with an impression of the inadequacy of photography. Some places are only photogenic; others, like Louis Kahn's projects, usually give a much stronger impression on the real site than in photographs.

In an essay on Mies van de Rohe's architectural projects and his idea of panorama, Stan Allen (2000) wrote about the paradoxical nature of built forms. "Buildings are presumably more tangible and physically present than drawings, yet it is only in the experience of the building that the most intangible aspects of reality can be made visible." (p. 75) He includes the play of light, shadow, and atmosphere as well as parallax effects produced by the spectator's movement and peripheral vision as examples of the intangible aspects. The building itself is essential for intangible reality, but the

reverse is true about drawings. Allen argues that "Drawing, as Mies understood very well, always stands in for that which cannot be present… It works in the interval between thought and thing, provoked as much by architecture's absence as by its presence." (p.73) Allen's point about the role of drawing as complimentary to the presence of the reality is probably applicable to other forms of representations of architecture and urban designs. For instance, when we visit Berlin, we still need to look at a map while standing on the streets of Berlin. We often need a floor map to navigate through a building we visit. Photographs and videos help to understand the forms of places, but do not serve as replacements of the real experience in them. In comparison to other forms of creation, such as sculpture, spatial designs can be complex and require multiple collaborating forms of representations. In the same essay, Allen also mentions pictorial panorama as a form of spatial representation gaining popularity in Europe and America in the 1790s: "… unlike the fixed viewpoint of classical perspective, the panorama allowed – in fact, necessitated – the movement of the observer. The continuous band of painted scenery could not be scanned from a single station point; the movement of the viewer was the necessary counterpart to the encompassing spectacle." (p. 77) Pictorial panorama puts the audience in the center of 360-degree scene location and provides an immersive environment for them to look around, and thus "map the laws of vision and compass of the spectator." (p. 77).

The significance of the "frame" in this context is to identify new degrees of freedom created by successive technological advances, from (a) photography, to (b) moving pictures, to (c) panoramic photography, and (d) panoramic video. From the still photograph, the moving picture introduces motion over time. The panoramic photograph captures a view from all directions (a 360-spherical view), and can, therefore, be considered "unframed." The 360-panoramic video adds sequential time motion to this "unframed" view at any point in a motion picture. A viewer of a 360 video can change the direction of what is viewed as if turning one's head up/down/left/right, as the motion picture progresses.

Today, the contemporary panoramic technology such as virtual reality HMD can combine the realism of photography and video with an immersive sense of pictorial panorama. For instance, a spherical view around a static camera point can be stored in an equirectangular format and displayed in the headset or a browser on a computer monitor. The resulting product is usually made by recording the scene with multiple cameras and stitching them together with the help of software. The view is still framed within the headset screen or browser window, but turning his head or scrolling inside the window lets the viewer interactively observe the desired direction in the scene. This gives a user a frameless sense just like a pictorial panorama. Stitching together videos simultaneously recorded by multiple camcorders can create an equirectangular video file, which, when played, allows a viewer to look around as the camera circulates in a space, as recorded. A more sophisticated system can deploy a 3D model in place of a video recording, where the viewer can not only look around but also interactively move about in the model in any direction. Using scanning technology or photogrammetric modeling, the 3D model can look as photorealistic as a video recording.

Allen talked about pictorial panorama in relation to architectural designs such as Shinkel's planning of central Berlin and Mies van der Rohe's New National Gallery in Berlin. It became an essential mode of representation and source of spatial ideas for them to make spatial designs although the method was not widely adopted by other architects. Contemporary technology of these immersive or

interactive panoramas has yet to penetrate the daily operations of architects. However, Bjarke Ingels, one of the most eminent architects of the new generation, recently published his promotional video of VIA 57 West in panoramic video format on YouTube (Lynch 2016). The project in New York received the International Highrise Award in 2016.

2.   TESTING THE NEW TOOLS

What do these new panoramic technologies uniquely provide to users for understanding the heritage sites that are too remote to visit or inaccessible for the sake of their protection or for other reasons? Can they be used to stand in for other representational media less suited to depiction of the built environment, or can they convey some of what Allen says are the most intangible aspects of reality?

This paper identifies 3 concepts of note: (1) the advent of 360 panoramic photography and video provides new degrees of visual freedom, in a "unframed" manner; (2) 360 panoramic media may affect how we perceive and understand architecture; and (3) the use of 360 panoramic techniques for capturing digital heritage is a new exciting tool for all those who study architecture [Nagakura 2015].

Previous studies have been made about human cognition of spatial design in terms of the effectiveness of virtual 360 environments in place of physical space; these studies have included different types of media, testing methods, and hardware. For instance, a test conducted by Heydarian et al. used a HMD and 3D models of office space in a building, and showed that a virtual space can be provided to simulate a physical space sufficiently, to the degree that subjects are able to perform simple cognitive tasks such as object identification in virtual space just as they do in physical space [Heydarian et al. 2015].

This paper is similarly concerned with spatial cognition in immersive media, but with regard to implicit human perception of formal environments and their attributes instead of explicit task performance by the subjects. In particular, to assess the possibilities of the panoramic technologies, two sets of experiments with subjects were designed and conducted: one with the purpose of measuring the sense of scale and proportion, and the other to evaluate the recognition of formal compositions.

2.1   Test on Scale and Proportion

As part of a Master's thesis at MIT [Choi 2016], a test was conducted to evaluate a low-cost consumer HMD for its effectiveness in allowing a user to acquire a spatial sense of scale and proportion similar to that achieved by the physical environment (Fig. 1). The HMD used was the GearVR developed and released by Samsung Electronics at the end of 2015. The simple but responsive motion tracking system built into this system only detects rotational movement of the head and not its lateral movement. However, the HMD also has a small touchpad on its side, which is convenient for the user to adjust the image contents. The experiment took place in a Japanese tea room constructed in the Boston Children's Museum. The room was deemed appropriate for this test because its size and style are different from the common rooms our subjects from Boston area are familiar with, which makes it difficult for them to guess from their life experience. For instance, the sliding doors of the room

have a low height of 1730 mm (5′8″), and the room has no western furniture such as chairs and tables, that could give clues to the subjects about dimensions.

To display in the HMD, two digital models were prepared. One is a photogrammetric capture of the room with fully photographic texture on all surfaces. The other one is a white geometric model reconstructed from the photogrammetric model without any details such as the sliding door, lattice or floor mat patterns. All default settings of the HMD device were used including the inter-oculus distance, and the model was adjusted so that the measurement unit is correct and the virtual cameras are placed at the same height as the subject's eyes in the physical space. Stereographic imaging mode was used to display one image per subject's eye with parallax.
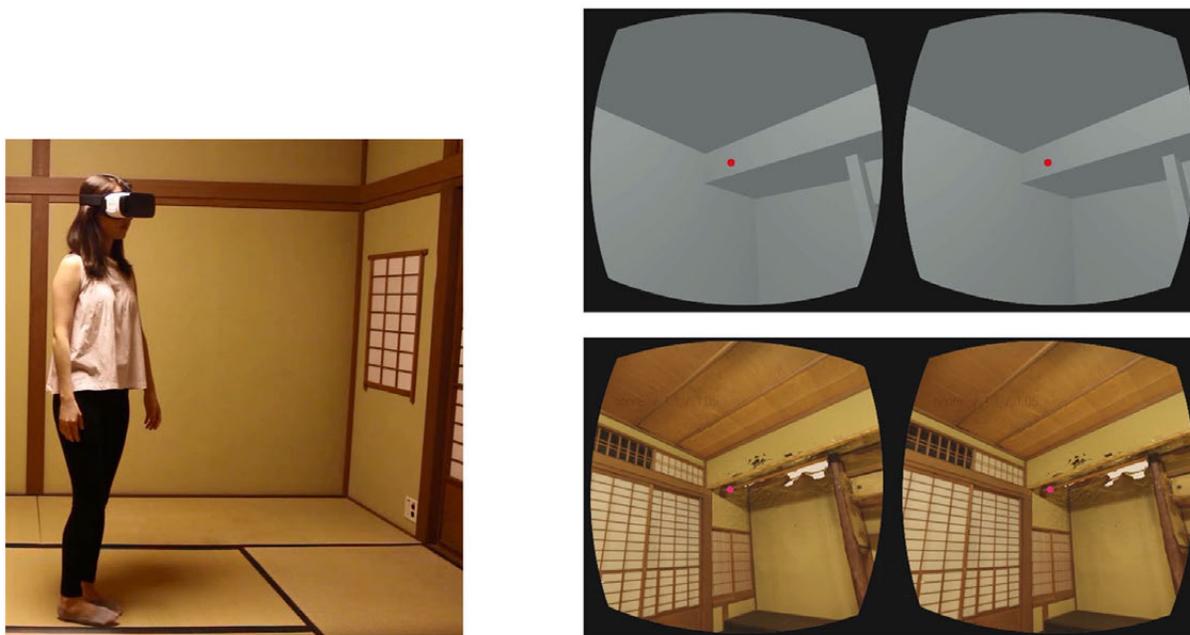

Figure 1. Test on the Cognition of Scale and Proportion Using HMD. (Copyright: J. Choi)

In one test, the subject was helped to enter the real tea room blind, and then wore the HMD at the center of the room, experiencing the virtual tea room, either the textured or the white model, while looking around in it for a while. Then the subject's HMD was taken off, and the physical tea room was observed in the same manner. Finally, the subject was asked the question "Is the virtual room in HMD smaller or bigger than the physical tea room?"

In another test, the virtual tea room model was digitally prepared to be stretched horizontally or vertically to create a wrong proportion. The subject was invited into the real tea room, asked to look around and to study the space. Then the subject put the HMD on and was presented with the stretched version of the virtual tea room, and asked to correct its proportions by using the touchpad on the side of the HMD. Its interface was programmed to allow changing the horizontal and vertical proportions of the digital model simply by sliding the finger on it laterally or vertically.

The third test was similar to the second one, except that the tea room model was prepared proportionally scaled instead of stretched. The subject was asked to adjust the scale of the virtual model to match the actual tea room. Each subject was tested twice, once with a virtual model prepared larger than the real item and the other prepared smaller.

Five MIT students participated in the test as subjects. In the first qualitative test, four out the five subjects reported that the virtual room felt slightly smaller than real one, while one reported it as slightly larger. In the quantitative test of the scale, the average result of the adjusted virtual tea room came out to be about 10% larger than the actual tea room. This is reasonable since most subjects reported the virtual tea room to look smaller in the qualitative test. There was an insignificant difference (only about 3%) between the textured model and the white one with respect to the adjustment of the scale of the virtual tea room. However, four of the five subjects reported that texture gave them more information to work with, and made the comparison easier between the virtual and actual tea room. In addition, the response time needed was shorter for adjustment. Finally, the results of the second experiment, adjusting the stretched model, were very similar to those of the third experiment, adjusting the scaled model. The difference between the two adjusted models averaged about 2%, which is not very noticeable.

This experiment was small in sampling size. Only one location of about 3.6m square was used. Only one HMD product was tested with its default hardware properties, such as lens FOV and inter-oculus distance, which are critical factors for sensing depth in binocular parallax viewing. However, the test indicates that a low-cost HMD product can have good potential for conveying the spatial design with respect to the sense of scale and proportions. Further tests with larger sample sizes and test conditions would illuminate HMD efficacy and improve designs.

2.2 Test on spatial composition

As part of a research methods class at MIT [Nagakura 2015], a test was conducted to compare conventional framed video and panoramic video for its effectiveness in allowing a user to understand spatial composition on an architectural site (Fig. 2). Panoramic video of a walk-through sequence recorded on the site of the Villa Foscari was used as the example. The sequence started inside the main hall on the piano nobile level, where the camera was moved out through the main entrance to the terrace, down the exterior stairs to the ground level, and finished in front of the façade of the building by the waterway. From this panoramic video, a regular framed video was created by always aiming the camera in the direction of the movement such that the view always looks forward. This 80-second video sequence included three angular turns, movement from interior to exterior space, and vertical movement on the stairs with a constant development of the scene. The hypothesis of the test was that panoramic video would provide viewers with a better sense of the three-dimensional composition of the complex architectural form in comparison to the conventional framed video.

Two groups of 16 subjects each, with half comprised of architects and the other of novices, participated in this test. One group was asked to watch the conventional framed video sequence. The other group was asked to watch the panoramic video in a browser and encouraged to scroll the view to study the location around the camera while watching the video.
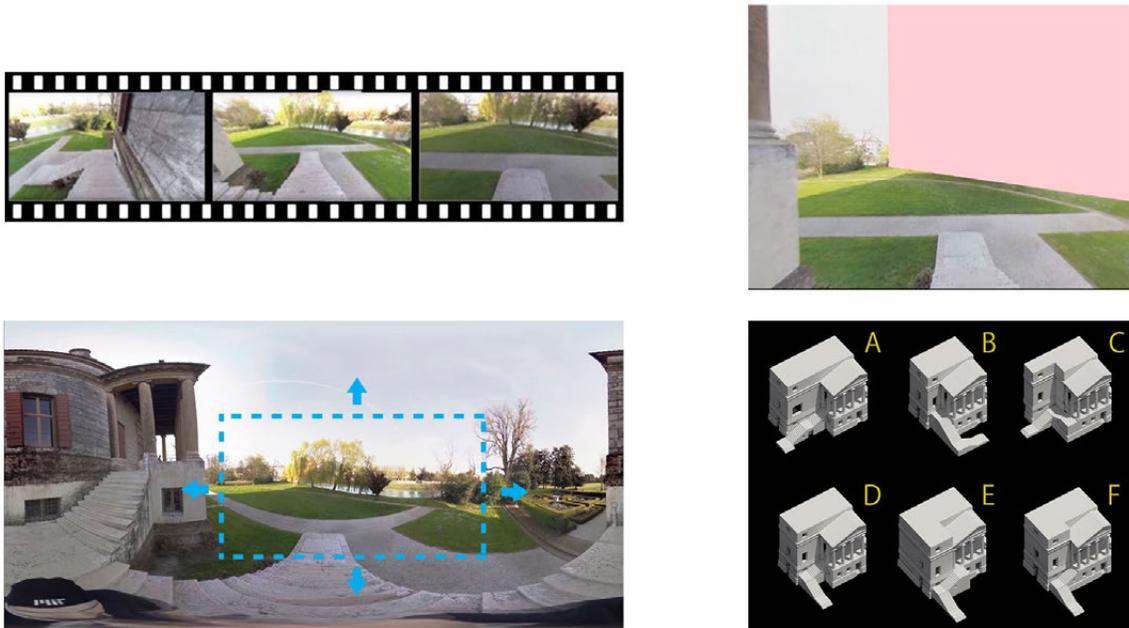
Figure 2. Test on the Cognition of Objects and Composition in Panoramic Video and Conventional Frame Video (Copyright: T. Nagakura). One group of subjects watched a regular walk-through video (top left), while the other group browsed its panoramic version (bottom left). Each of the first three questions (top right) asked what was in the concealed area (masked in pink) of a frame. The last test (bottom right) was to select a correct architectural composition of the location in the video.

After watching the video, each subject was asked four questions. The first three questions were memory tests, each with a still from the framed video sequence. It is an image of the villa scene but with a part of the scene masked out. The subject was given 20 seconds to identify what was in the mask by selecting an answer from the list of five options. For instance, an interior wall portion covered with fresco painting was masked, and the subject was asked to answer if the masked area has a window, white surface, wall with painting, sculpture or stained glass. The second image masked a small table on the side of the main door, and the options to select from were bench, plant box, backpack, table, and sculpture. The third image was a still made from a video frame at the end of the framed sequence that has the nearby waterway surface masked, and the question was to choose from water, building, street, green field and brown soil. The last question was different. The subject was presented with a set of six axonometric drawings, each showing a slightly different composition of the stairways, terrace and front façade similar to that of Villa Foscari. The subject was asked to select the correct drawing that described Villa Foscari. The correct axonometric drawing shows the portion of the villa through which the camera in the video traversed.

The test result was completely inconclusive, quite contrary to the expectation. (Table 1) Between the two groups, there was no statistical difference in identifying the correct answer for the masked image as well as axonometric composition. In all questions, about 40-50% of subjects answered correctly. The only somewhat noticeable difference was between the architects and the novices.

More architects correctly answered all of the questions except when asked about the wall with the mask hiding the painting on it.

The observation of the subjects watching the panoramic video indicates some reasons for this result. By allowing the subject to scroll the view, each subject looks at a different, often very arbitrary point of interest in the scene. For instance, near the end of the sequence, one subject was looking in the direction of the waterway, while another subject was looking at the façade of the villa with the waterway out of the view. One subject was even looking straight down most of the time to watch the footsteps of the cameraman on the terrace floor and the stairways. Therefore, the freedom of viewing direction for the subject served both as an advantage and a disadvantage. While it allowed more environments to be potentially scanned in the sphere around the camera, the view might become fixed on an obscure target that happened to catch the attention of the subject and the subject might miss a good portion of the rest of the sphere.

Table 1. Results of the Test on the Cognition of Objects and Composition in Panoramic Video and Conventional Frame Video (Copyright: T. Nagakura)

		Number of Subjects	Memory Test			Axon Test
			1. Fresco	2. Table	3. Water	
Panorama	Architect	8	44%	56%	67%	56%
	Novice	8	63%	25%	38%	50%
	Average		55%	38%	50%	52%
Frame video	Architect	8	50%	63%	75%	63%
	Novice	8	56%	22%	33%	44%
	Average		53%	42%	54%	53%

This is not only a lesson for the design of this test but also a testimony of the way panoramic videos are watched, and how this factor contributes to or blocks the cognition of the spatial design. In other words, the framed video is a time-tested way of narrating a story that filmmakers use to have the audience focus on what they are supposed to see, while the panoramic video works without curation, just like a visitor to an architectural site explores and looks around to make a personal experience.

3.   PANORAMIC VIDEO: APPLICATION EXAMPLES

The two kinds of tests introduced in the previous section suggested that panoramic media with immersive sensation can be helpful to convey the scale, proportion, and potentially other attributes of built environment that are not easily represented otherwise. At the same time, these media let the audience explore on their own, which makes curating the content a challenge. This section discusses digital heritage presentations using panoramic content, especially in the video format. It shows a few examples developed at MIT of raw video materials crafted into a derivative version through the

process of editing and combining with a goal to demonstrate effective uses of panoramic videos in the context of spatial design exhibits.

3.1   Raw material

Panoramic video is the most economical and convenient raw material to deploy on panoramic hardware, as only the video recording is required, meaning that generating and processing 3D models is not necessary. Many low-cost consumer systems are available today. They produce 360 videos usually from two fisheye lenses placed back to back and by quickly stitching the two videos. High-end models use six or more cameras to produce equirectangular frames in high resolution, which is necessary to play the video in decent resolution, since a panoramic video shows only a fraction of its sphere at a time to the user's viewing frame. Some models are capable of producing stereographic videos by using even more cameras for recording.

Despite a plethora of available models on the market today, they generally share some common technical issues. One problem with recording using a traveling camera rig is image stabilization. Because the panorama production requires multiple cameras, the stabilization strategy that an ordinary single camera uses is not directly applicable. Some software provides stabilization on post-stitched equirectangular frames, but its effect is often limited. Using a stabilization handle for holding cameras would also cause the bulky hardware to be observable in the panoramic video. Likewise, a classic dilemma for a walk-through sequence is the cameraman becoming a part of the panoramic video recorded. Another typical issue is the stitching artifact making a visible seam between the footage from adjacent cameras despite various remedies for blending applied by stitching software. In a high contrast scene, each camera may deploy its own exposure setting and the seam tends to be amplified. In an environment where some objects become close to the cameras, the parallax caused by the displacement of the adjacent cameras is likely to cause double vision near the seam. While good preparation may help reduce such artifacts, seams are inevitable in certain onsite conditions.

3.2   Temporal and spatial montage

For a digital heritage exhibit, a story can be told from raw materials recorded on sites and added narratives. An example is "Palladio Burns 360," a work composed of shots on-site near Vicenza in collaboration with historian Howard Burns. An equirectangular file is a video file that encodes a number of rectangular pixel frames per second, so any regular Non-linear Editing (NLE) software can be used to perform conventional editing. Its warped 360-degree image frames require a panoramic player to appropriately view the scene, but major editing software already handles this through a built-in or plug-in tool.

On the timeline, shots from different recordings can be montaged into a story through cut and paste operations. Various effects can be applied to blend between shots for transition and to adjust image quality and other properties such as speed. As indicated by the subject memory test, a viewer using a video player can arbitrarily scroll and look around the panorama to explore the scene sphere. The viewer can find viewpoints of interests while losing the view over the rest of the frame at a given time. With this in mind, editing should consider giving enough time for the viewer's exploration and

avoiding fast changes. Another observation of the subject test is that a viewer sometimes gets stuck on watching a specific corner of the scene sphere for a long time, without exploration. Editing the video to include a horizontal pan of the scene is often an effective method to move a view out of this frozen direction. In NLE software, this can be achieved by slowly shifting the video's frame image horizontally with its portion going out from one side of the frame while adding to the other side. This autonomous horizontal pan, if built into the panoramic video, can be at odds and awkward when the viewer is scrolling the frame, and so too many of them should be avoided. This method, however, seems to be appropriate for the video director to implicitly recommend that the viewer change attention and should be an addition to the director's operational vocabulary. Another even more direct and effective method of narration is to program the 360 video player so that the scene pans to target at a specific portion of the panorama at a specific time in the video, no matter where the viewer has scrolled in previously.
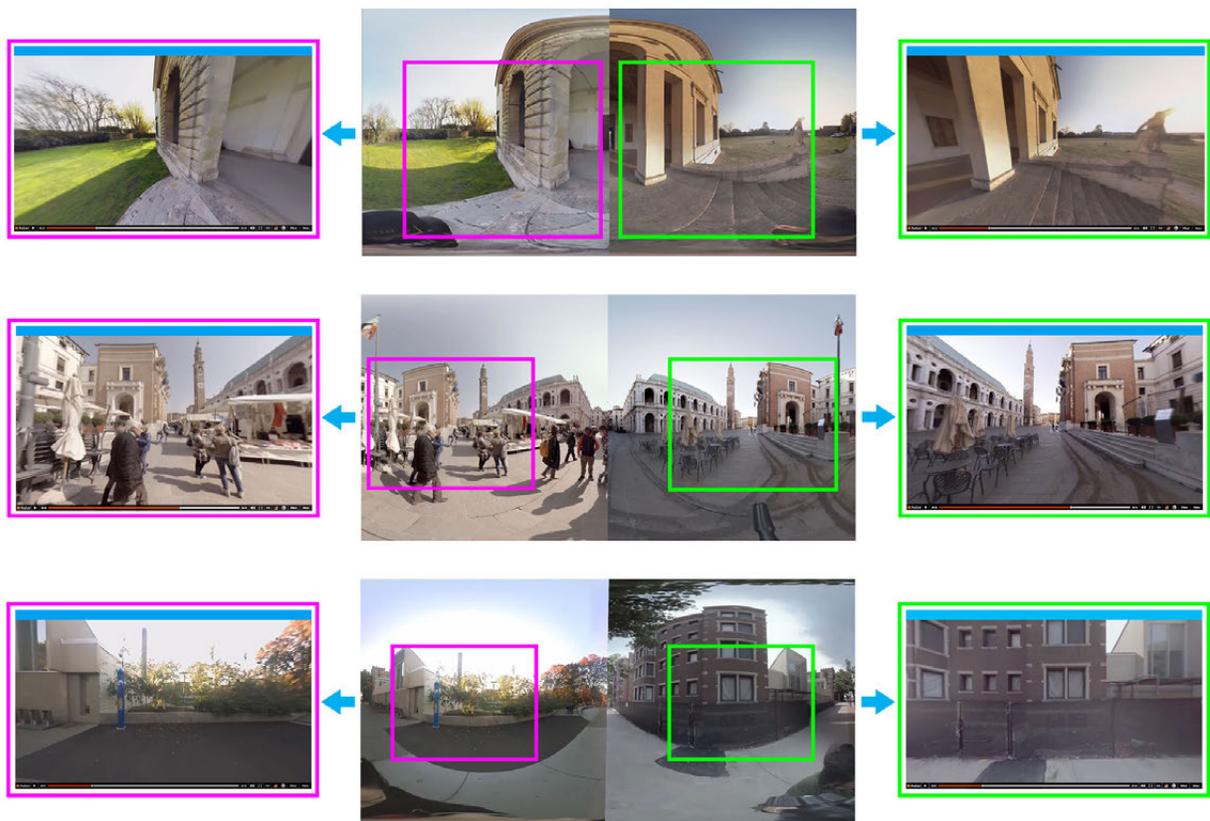

Figure 3. Split villas: Pisani and Poiana 360 (top: YouTube video), Vicenza Piazza Mirrored: Dawn and Daytime 360 (middle: YouTube video), and MIT with and without Bexley 360 (bottom: YouTube video). (Copyright: T. Nagakura)

Doing this requires a specialized editor or use of game engine software with scripting capacity, but it has the potential of creating media with the virtues of both exploratory panoramic video and

traditional story-telling film, giving a person an experience just like that on the site with an accompanying guide periodically suggesting what to look at. However, this method would be inappropriate for HMD for an obvious reason.

In comparison to timeline montage, composing multiple video sources geometrically in a video frame is more difficult and restrictive on a conventional NLE editor. The reason is that moving the position of a part of panoramic image frame horizontally in an equirectangular format simply pans the scene in the player but moving it vertically will destroy the scene being played. The equirectangular image is basically a representation of a spherical surface projected onto a rectangular form, like a map of a globe, and vertical panning of the panoramic scene requires specialized panoramic editing software or one that can use other panorama encoding schemes such as cubic projection.

Despite this restriction, the panoramic format opens up new possibilities for digital exhibits. The following examples show a composition of two half spheres from different recordings (Fig. 3). The first one, "Split Villas: Pisani and Poiana 360" presents the comparative study of two Palladian villas, Pisani and Poiana. Palladio is known to have produced villas by applying similar compositional principles with a variety of site-specific details. In this exhibit, the camera walks through the center of the symmetrical villas, respectively, from exterior front into the main hall. The scene sphere of each building is split into half, where the left side of Pisani and the right side of Poiana are combined back into a full panoramic sphere. Throughout the walk, a viewer can look around or scroll the views to compare the two villa spaces and understand that they share the sequence of front yard, short step-up, covered porch, large entrance door, and main hall of cruciform shape with a vaulted ceiling. At the same time, the difference of details is shown in the circular and rectangular steps, rustication and its lack of the porch columns, and the extent of the fresco painting on the vault.

The second example, "Vicenza Piazza Mirrored: Dawn and Daytime 360", shows a comparison of two recordings shot at the same spot in Piazza Dei Signori in Vicenza but at different times of day. One is an early morning view of this important public space in front of Palladio's renovation of the Basilica and includes an empty square without people or activities. The other is a view in the daytime of market day, with the square completely occupied by local vendor kiosks and full of citizens and tourist activities. To command the full view of the square, the camera tripod was set on one side of the square, and an early morning view was mirrored before being split in half and combined with the other half of the daytime view. A viewer simultaneously observes the square as a purely architectural composition in one, and as a container of a peculiar social event in the other.

The third example, "MIT with and without Bexley 360", is a composition of two sequences made on the same walk-through path along the main street adjacent to the MIT campus. The two sequences were shot on two different days about a year apart. Bexley Hall dormitory was demolished during that period to make way for an open public space. As in the previous example, one of the two shots was mirrored to allow comparisons between the same halves of the scene sphere from the two shots. This video shows the transformation of the campus environment, and how a loss of one heritage structure gave birth to a new perspective for the community, especially clearing a view from the main campus entrance toward another important heritage of MIT, the Chapel designed by Eero Sarinen in 1955.

3.3   Self-Guided Tour: Panorama with annotation

One subtle method to curate the exploratory nature of panoramic video for digital heritage exhibition is to assist the viewer's exploration with annotations while the video is played. The idea is to produce a situation resembling a self-guided tour on a tourist site or in a museum exhibition. For example, when a camera approaches Thomas Jefferson's bedroom in Monticello, a narrative can start and explain how the President used this unusual alcove style bed that is open on both sides, situated between his bedroom and the office space. Use of game engine or specialized software allows this audio annotation to start in relation to the viewing direction. The annotation can also be provided in the form of graphics or text embedded in the scene sphere. For a walk-through panorama, attaching annotations to the moving image of a target object such as column or fresco painting on the ceiling requires the use of the motion-tracking tool in the video editing software. Also, the annotation in graphics or text needs to be processed by an image transformation tool to map onto the spherical surface of the panoramic video.
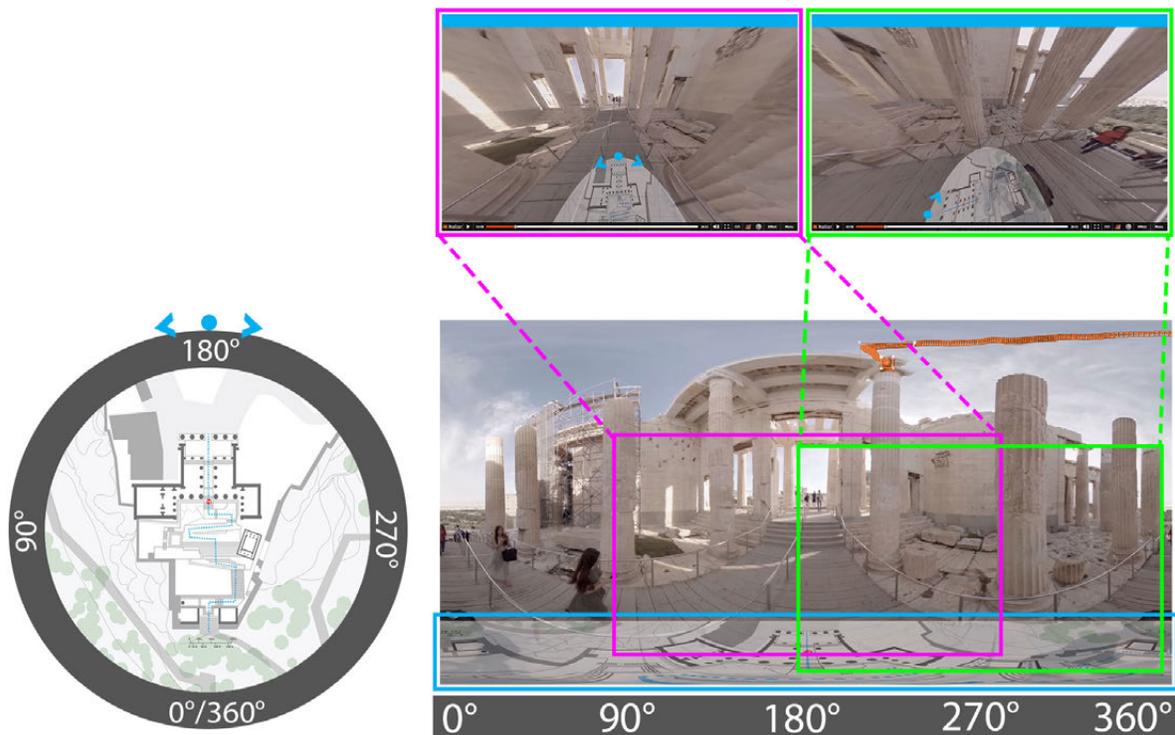

Figure 4. 360 on Plan: Acropolis Propylaea Walk(YouTube video). (Copyright: T. Nagakura)

In "360 on Plan: Acropolis Propylaea Walk", the plan of the entrance gate and the first structure behind it is placed at the bottom of the panoramic video to assist the viewer to understand the location of the camera making a walk-through (Fig. 4). Its position is identified by a moving dot on the plan. As with a GPS navigator assisting a car driver, the view direction rotates as the viewer looks around. This visual annotation was added to the raw panoramic video by tracking the lateral movement of a

target object in the equirectangular video frame, while shifting the projected image of the plan placed at the bottom of the frame by the same amount as the target object.

3.4   Guided Tour: Narrative through Post-targeting

A different direction in the application of panoramic video footage is a simulation of a guided tour. A conventional video can be designed to guide through a heritage location by pointing the camera from one target of interest to another as it traverses the site. Since the panoramic video includes the recording of the full scene sphere, the moving panorama can easily be trimmed into a series of specific views of interest to produce a sequence similar to that of conventional video. In other words, the interactive panoramic video can be down sampled and burned into a conventional frame video that does not allow a viewer to scroll or look around.
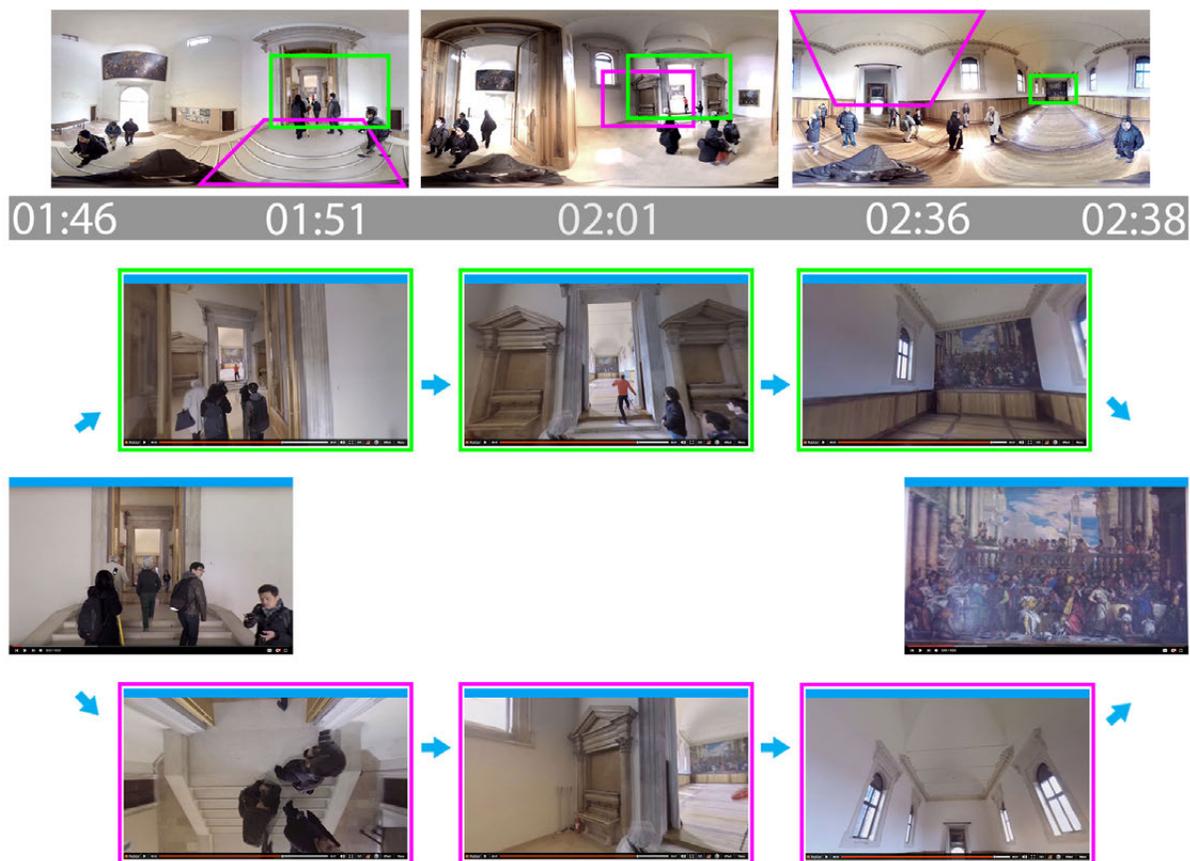

Figure 5. Double Tour: San Giorgio Maggiore Refectory (YouTube video). (Copyright: T. Nagakura)

This can be done with specialized software or by simply capturing the screen of a panoramic video player. In this case, an interesting opportunity in this process beyond just a reduction of information

is the possibility of generating different storylines from the same path of a 360 walk-through (Fig. 5). The panoramic video's camera can be oriented to any direction at any point in the sequence. So, when the camera is in the second vestibule of the Refectory of San Giorgio Maggiore in Venice, it can focus on any of the cross-vaulted ceilings, the enormous entry doors, or the replica of Paolo Vernese's painting, the Wedding at Cana, sitting at the end of the adjacent refectory hall. The selection of certain important architectural features is the curatorial decision of the guide: one storyline of the guide points at one object in this vestibule, while another storyline does at a different object.

In "Double Tour: San Giorgio Maggiore Refectory", the panoramic camera's original recording of the single path from the courtyard through the vestibules to the refectory of this magnificent space designed by Palladio was reduced and compiled into a framed video four times and then concatenated together, with each using different maneuvers of camera orientation. Out of these four reductions, one sequence was designed to accompany a story of this historic painting (Wedding At Cana), narrated by Howard Burns; another sequence focuses on various architectural details described by the same historian; and each of the two other reductions shows the sense of traversing this complex space in fast-forward speed from opposite directions, one camera looking forward and the other looking backwards.

4.   CONCLUSION

This paper places panoramic video at the intersection of two lines of historical precedents in architectural representation: photography and motion pictures, and pictorial panorama. Pictorial panorama has never gained popularity among architects, but photos and videos have become an essential tool for presenting and consuming architectural design and are broadly accepted by the public. Recently, various low-cost digital devices have become available to consumers to record and deliver panoramic viewing. The small tests with subjects indicated that use of these devices could play a unique role in capturing a part of the intangible spatial experience that is difficult to represent otherwise, such as the sense of scale and proportion. Panoramic video is also unique and different in that a viewer can select a viewing direction and actively explore the surrounding 360-degree scene. Therefore, the ordinary filmmaker's method of framing and trimming scenes to make a narrative does not readily work in this new media. On the other hand, this new environment is closer to what we know as the nature of architecture and other built environments.

As demonstrated in the examples, an interactive exhibition using panoramic video crafted with consideration of these issues has the potential to transform the way heritage sites are digitally recorded, preserved, and presented to audiences. Such an exhibit can be similar to a self-guided site tour and subtle in indicating a way to see and experience the spatial heritage; or similar to a guided site tour and articulated in reflecting a clear curatorial intention.

Architectural heritage cannot be moved. Therefore, a representation is necessary for its dislocated presence, but the view in a conventional framed method is imposing and deprives the sense visitors construct on site by moving. The video captured in 360 can encompass and record all the surrounding environment and events at a location in time, and to a limited degree, permit this sensing process to take place in a dislocated architecture. Panoramic video methods can be designed to restore the compass of representing an architectural site from the derailed course set by

photography and motion pictures that overwhelmingly promote architecture seen as framed objects. The proffered vision is towards that of an environment in which a visitor is immersed and perceives by moving and exploring.

5.   ACKNOWLEDGEMENTS

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