

<u>Title:</u> Digital Archiving of Perceptual Experiences of an Architectural Space with Computer-Aided Methods

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Introduction:

Digital archiving of architectural heritage has been focusing on the recording of the physical configuration of architectural construction in digital formats that can be preserved permanently and distributed more easily. Based on the conceptual representational drawings of plans, sections, and elevations, along with documentations of materials, construction, and assembly methods, the main purpose of the archiving is to ensure that the knowledge required by reconstructing architectural heritage can become available to future generations [4]. Photography utilizes films or sensors to capture light reflected from the environment through a camera lens to create images. This process is similar to the human vision process and thus constitutes a type of perceptual representation. However, in the archiving of architectural heritage, photographs are more often used as supplements to conceptual information, such as the appearance of the materials, or the details of craftsmanship; and to a lesser extent for the documentation on how an architectural space is intended to be experienced by visitors.

The goal of this study is to develop a framework to incorporate the perceptual viewing experience into the digital archiving of architectural heritages. The established methods of behavioral mapping and the newly developed digital tool Space Syntax were used to investigate how to identify views that can best represent the perceptual experiences of an architectural space. Perceptual studies were conducted to identify the types of architectural scenes that can be most representative for a particular architectural space. To conclude this study, the methods used were compared, and a framework was developed for the determination of the appropriate point-of-view for scene recording or the appropriate perspective for photograph acquisition for the archiving of the perceptual experience of historical architecture.

Main Ideas:

One of the intentions in architectural design is to configure the physical construction to create a particular spatial experience for an architectural space. For instance, the planning of the circulation often determines the point of stay, and thus creates design opportunities to frame the view with architectural elements. Given our own human visual perception of the world, the exact contribution to our memory regarding an architectural space relies on what we have seen. As a result, recording the perceptual experience of architectural scenes presented based on the architectural construction should be as important as the recording of the physical construction of historical buildings and monuments. However, an architectural space can be presented using unlimited point of views. Accordingly, the determination of viewpoints and the recording of their corresponding scene is the first question that needs to be addressed in this study.

Canonical View

A three-dimensional object can be viewed from many different perspectives. Object recognition studies have suggested that an object can be most easily identified from a particular view. This view is termed as the canonical perspective or the canonical object view [2],[5]. Many studies were conducted to develop systematic methods to identify a canonical view of a 3D object, and they generally agree that the frequency and maximal information hypotheses can derive the canonical view of an object under investigation. The hypothesis of the maximal information implies that a view that reveals most of the information of the object is preferred as its canonical view. Conversely, the hypothesis of frequency suggests that the canonical view requires the minimum amount of time for the recognition of the object because it is imprinted in our memory given that we have seen it many times in our lives [2],[5]. It is possible that both hypotheses contribute to the formation of a canonical view of a 3D object. However, an architectural space is an immersive environment that we cannot be viewed in its entirety from within. Accordingly, the canonical view of an architectural space may be more relevant to the hypothesis of frequency.

To determine the canonical view of an architectural space based on most frequently seen views, we experimented with two different approaches of behavioral mapping and Space Syntax. Perceptual studies were conducted to investigate whether a canonical view could invoke one's mental image of a particular historical architectural space, and to identify the method which is more reliable for the determination of the canonical view of the architectural space.

Selected Cases for Study

Two traditional temples located in Tamsui of Taiwan were selected for the study. Both Longshan and Fuyou temples were built and devoted to the folk religion of the goddess of Sea. The historical Taiwanese folk religion temple was selected for three reasons: first, they are the major architectural heritages in the country and many of them have undergone dramatic remodeling changes and some have even been demolished. The digital archiving of these heritages thus becomes imperative. Second, there is specific route associated with the ritual ceremony performed within the temple, and hence predetermines the points-of-view of the believers. Third, it has a simple and open layout that allows the unobtrusive observation of human behaviors. In addition, the two temples have similar configurations of the front and main halls with a courtyard in the middle, but their current preservation conditions are different. The Fuyou temple is located on a busy main street, and has been remodeled with the use of a roof to cover the courtyard, while the Longshan temple is hidden in a traditional market and has been preserved in a state that closely matches its original construction. The comparisons of the two selected temples can also reveal differences owing to their currently preserved conditions.

Space Syntax

Space Syntax is a scientific approach of theories and techniques used to analyze the spatial layout in relation to the various scales of human interactions and social effects [1]. One of its analyses tools is the visibility graph that can reveal different perceptual aspects related to the views and visibilities. The visibility graph analysis can be performed with the open-source software of DepthmapX, thus allowing a computational framework to derive the analyses of the visual integration of an architectural heritage based on the CAD drawings of its floor plans. Fig. 1 illustrates the visibility graph analyses conducted by DepthmapX for the traditional temples of Longshan and Fuyou. The colored grid map represents the visibility connectivity, whereby the red-colored regions are those that are more likely to be seen and can view more of the surrounding space. The two temples have similar layouts that result from their traditional patterns. The space is enclosed by solid walls with multiple rows of columns. The center of the open courtyard and the open space in the front hall are therefore most easily visible when someone wonders in this area. However, this analysis can only identify the place that is most frequently seen but falls short from identifying which specific scenes are most frequently viewed by visitors. This is because human behaviors are often directed by purpose, such as the ritual ceremony. Therefore, the computational methods of Space Syntax cannot account for the identification of the canonical view of this particular type of architectural space.



Fig. 1: Floor plan and visibility graph analysis of the temples of Longshan and Fuyou.

Behavioral Mapping

Behavioral mapping is a research technique that has been commonly used to study how a space is used by participants. It is based on the analyses of the records of tracking movements and behavioral patterns of participants in the studied space [3]. For studies conducted to investigate human behavioral patterns in an architectural space, the behavioral maps are often produced at sites with manually drawn symbols on floor plans which are printed on paper. At the site, researchers pick one person who enters through the entrance, and use a symbol (e.g., a circle on the floor plan) to track the person's locations every 10 s. A circle with a line indicates the direction toward which the person is looking at, an arrow means that the person is looking up in that direction, while a circle without a line and an arrow indicate that the person was not viewing the space but was rather chatting with other persons or was reading relevant information. A total of 30 people were recorded in a single day for both temples. Each manually drawn tracking record sheet was redrawn on the same file of the vectorgraphic computer program on different layers. This allowed further analyses of the records based on different categories by turning on and off the layers. Fig. 2 illustrates one example of tracking records and the summary of the overlapped behavioral maps of the temples of Longshan and Fuyou. As illustrated in Fig. 3, three views (LS2, LS3, and LS1) that faced toward the worshiped deity in the front and main halls and at the entrance of the temple, are the most common views for the Longshan temple. In the case of the Fuyou temple, views gazing the worshiped deity in the front and main halls are also the two most frequently encountered views (FY1, FY2), while the third view (FY3) is the one that faces the incense burner.



Fig. 2: Individual and summarized behavioral mappings of the Longshan and Fuyou temples.

Perceptual Studies

Seventeen volunteers were invited to participate the study. Temple images were presented on digital devices to allow viewers to make perceptual judgments. There were three types of images. The first types of images include the most frequently viewed scenes based on the behavioral mappings. The second and third types are significant architectural elements. Three views are close range views of

architectural details and assemblies, and another three views are distance views of structural configurations or decorations. These six views were acquired on site with reference to the published survey of the two temples. Accordingly, they represent the photographs that are commonly used as supplements to the conceptual drawings in digital archiving. Fig. 3 illustrates the two sets comprising nine images each for each temple used for the perceptual studies.



Fig. 3: Images used for the perceptual studies.

The different sets of images were paired to display to participants. Before the trial, participants were prompted with a question such as "Which image do you feel comes to you mind when you think of the space of Longshan temple?" Each pair was displayed in a sequence twice with the location swapped. The procedure was repeated two times for each set. Table 1 illustrates the results. Images were arranged based on the total numbers of preferred picks and formed a preference scale. In the case of the Longshan temple, the two frequently viewed scenes upon entering the temple and the front hall occupied the first two picks followed by the two distant views of the structural configurations or decorations. The three close views that show details are the least preferred. The third view of the group of the most frequently viewed scene is a view gazing the goddess of Sea at a limited visual field. The fact that this view falls behind the two views of the spatial configuration in the preference scale suggest that the two hypotheses of frequency and maximal information can both have influences on the canonical view. Additionally, the hypothesis of frequency may be more effective than that for maximum information in our particular case study. Statistical analyses of the three types of views also confirm that the group of the three most frequently viewed scenes was significantly preferred over the other two ($F_{2,32}$ = 94.588, p < 0.005; Post hoc analyses were significant between all three pairwise comparisons). In the case of the Fuyou temple, a similar trend can also be observed. The two interior views that are based on the most frequently viewed scenes are the most preferred views. However, the third view of the most frequently viewed scene is listed as the fifth in the order of preference. This can be attributed to the fact that this view is facing outside the temple and contains limited visual information of the space.

Number of Preferred									
Longshan Temple	236	229	170	165	145	104	73	54	48
Scene	LS1	LS2	LS8	LS9	LS3	LS7	LS6	LS4	LS5
Fuyou Temple	239	203	170	169	157	121	74	60	31
Scene	FY1	FY2	FY8	FY9	FY3	FY7	FY5	FY4	FY6

Tab. 1: Preference scale for the temples of Longshan and Fuyou.

Conclusions:

The results of the perceptual studies indicate that views from the more frequent perspective are selected compared to the views of the architectural detail elements when people are asked to recall the historical architectural space. This result is in agreement with the hypothesis that the most frequently viewed scene can be considered to be the canonical view of the space. However, the results also show that the most frequent views that include more spatial information are preferred compared to the ones that only have limited visual focus. This can be attributed to the other canonical view based on the hypothesis of maximal information. Therefore, we conclude that the most frequently viewed scene with wide visual fields of interior space can be a preferred representative image stored in our memory for that particular space. Studies also showed that the most frequently viewed scene can be more precisely identified by the behavioral mapping method. Given that the most frequently viewed scene involves human behavioral patterns, visibility analyses conducted using DepthmapX were based solely on the physical configuration, and can only identify the most frequently viewed spot. Although the identified spot cannot provide the most frequently viewed scene associated with the stored perception of the architectural space, it does imply that there is an ideal location to capture a panoramic view or 360° image to document the maximal amount of visual information in a single image. As illustrated in Fig. 4, a 360° spherical image can be used post process to restore all the available sight of viewed scenes from that particular location.



Fig. 4: A 360° image to record the maximal visual information based on the point of view identified by Space Syntax; and one of the possible viewed scenes restored from the 360° image.

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References:

- [1] Al-Sayed, K.: Space Syntax Methodology. London, UK: Bartlett School of Architecture, UCL, 2014.
- [2] Enns, J.: The Thinking Eye, the Seeing Brain: Explorations in Visual Cognition, 1st ed., W.W. Norton, New York, 2004.
- [3] Ittelson, W. H.; Proshansky, H. M.; Rivlin, L. G.: The Use of Behavioural Maps in Environmental Psychology, in Environmental Psychology: Man and His Physical Setting, Proshansky, H. M.; Ittelson, W. H.; Rivlin, L. G.; Eds., Holt, Rinehart and Winston, New York, 1970, pp. 658–668.
- [4] Letellier, R.: Recording, Documentation and Information Management for the Conservation of Heritage Places. Routledge, 2015. <u>https://doi.org/10.4324/9781315793917</u>
- [5] Palmer, S. E.; Vision Science: Photons to Phenomenology, 1st ed., MIT Press, Cambridge, MA, 1999.