COMPANYING PHYSICAL SPACE WITH VIRTUAL SPACE
A CO-EXISTENCE APPROACH

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Abstract. This paper presents a kind of co-existence relationship: companying physical space with virtual space with a case study. The fundamental approach is to investigate the interactive relationship between navigators and information in virtual space, including collecting, interpreting, integrating, and communicating. Based on these relationships, we propose an information structure, which elaborates the information of our co-existence representation. The infrastructure composed with two processes of data representation based on an individual spatial structure is tested in representing eleven historical significant civic building in Taiwan.

1. Introduction

Representing building digitally is a wide-discussed research topic. However, how to represent an existing and well-maintained building in virtual space is a hard problem. Not just the complexity of information, but also the information itself is an arguable issue. What kind of information, thus its representation, is required when you can both access virtual space and physical space of an existing building? Will there be differences for different knowledgeable users? Furthermore, who are the users? For the question, the straightforward solution is a co-existence approach by companying the physical space with virtual space/information. By studying the both ends: virtual and physical spaces, the co-existence approach shows an potential to balance the relationship between virtual and physical spaces, and furthermore, to create a new type of spaces.

By viewing virtual representation of buildings as a companion role, this research provides an understanding of the characteristics of virtual space and its impacts within co-existence approach. Therefore, the representation issue described above becomes the information requirements for the users who are
accessing the co-existence spaces, especially virtual space. The main criteria for information representing by such approach is that it has to be impossibly represented by the physical space.

1.2. INFORMATION AS A COMPANY TO CO-EXISTENCE SPACES

One and the most clear advantage that physical experience cannot express or not without intention or understanding is the visualization of complex information and accessibility.

The researches addressed such issues are: 1) Simulation: by bringing the building as real as possible under your fingerprint, this group of researches (such as Clayton et al., 1999; Sanchez et al., 1997; Braithwaite et al., 1997) simulate the building using photo-realistic rendering techniques or virtual reality techniques. This group of researches provides an important base, the visual feedback, for our research. 2) Digital media representation: find the suitable technique for representing the abstract information of buildings (Wan, Liu and Lee, 2001; Bridge and Charitos, 1997; Datta, Chang, and Woodbury, 1997; Novak, 1988). This group of researches share an insight of how virtual media, thus, digital media can be used as a representation for our purpose, and the possible co-existing relationship. 3) Augmented reality: provide virtual experience physically (Donath et al., 2001; Anders and Livingstone, 2001). This group of researches thus argues that the interaction between physical and virtual space should be touchable and ubiquitous. 4) Information access: provide the possible and individual filter for accessing the numerous data of building (Inanc, 2000; Fukai, 1996). The main concept within this camp is to provide a mechanism for dealing with the complexity of the information.

1.2. INFORMATION AND INTERACTION

Most of views described above have invoked two research issues—the interaction between users and the information; and the information required for that interaction. This is to say that information in virtual space should not just replicate the spatial sense of physical space. In addition, via interaction, information should provide a way to enhance the knowledge and to amplify the imagination of users. Therefore, 2D information visualization such as Web pages cannot satisfy the need for spatial experience in our spaces. However, as the nature of desktop metaphor, 2D information visualization has its own value that cannot be totally dismissed by 3D environment. Therefore, the interaction among virtual spaces has to be hybrid dimensional spaces.

By analyzing the information requirements from virtual space and physical space, we propose an information structure based on two processes of data representation and the user interaction. In addition, the structure of
representation has been also tested in representing ten historical significant civic buildings in Taiwan. The result is also reported in this paper.

2. Virtual Space as an Interaction between Navigators and Information

Interaction between users (navigators) and information plays an important role in the co-existence approach. Some researchers have categorized navigators as novices, intermittent users and frequent users based on applicable knowledge and visiting frequency (Shneiderman, 1987; Pressman, 1992). Furthermore, two additional factors are considered for our analysis: on/off-site (when the navigators are visiting the virtual information when they are on or off the building site) and also 2D/3D information (as described above, 2D standard websites as long as 3D virtual worlds are needed for the experiment). This is to say that twelve different conditions of navigators are analyzed based on the three factors. The relevant information is shown in [Figure 1].

![Figure 1. Different kinds of navigators are based on the above information conditions such as applicable knowledge, visiting frequency, site relations and spatial dimension.](image)

These navigators have the common interactive behaviors with information, which includes collecting, interpreting, integrating, and communicating. The behaviors along with their analysis are described as following sessions.

2.1. COLLECTING INFORMATION

The main behavior for navigators is collecting information. The information should be divided into two catalogues: the information helping them to understand the related knowledge of these buildings, and individual domain of interest such as archaeology, education, travel, design and so on. In our approach, we provide two folds of dimensional space for the need of
collecting information: standard 2D space and dynamic 3D space. In standard 2D space, knowledgeable navigators and novices can easily collect information by a sequent linkage order. In dynamic 3D space, knowledgeable navigators can use different navigation methods, including world-in-hand, eyeball-in-hand and flying, walking to collect information. However, novices can go through 3D space via walking or normal click-and-fly mechanism to collect information. In addition, the collecting experience navigators have been through can build up personalized knowledge/experience. The insight from this analysis is that thoughts can be ordered and placed on the personal information space to reflect a way of thinking about the organization of their content.

Beside that, navigators might have the different approaches to collect information on different location: on-site or off-site. Navigators who are on-site always collect information to supplement and compare the experience of physical space. On the contrary, off-site navigators collect information that can provide appropriate knowledge of these buildings before they visit in physical space, or on their own requirements.

2.2. INTERPRETING INFORMATION

Navigators are interpreting information based on their individual backgrounds including the profiles of their age, sex, education, motivation, goals and personalities. Standard 2D space, like usual websites, provides a typical information access by a sequent linkage order. Dynamic 3D space thus provides a no gravity environment and dynamic navigation control. For such environment, the navigators are encouraged to interpret information freely, and, with dynamic spatial experience that can’t be represented in physical space. Additional insight for this behavior is that the interpretation might inspire navigators the spatial imagination and un-expected means of spatial experience differently.

Knowledgeable navigators usually take full advantage of dynamic 3D space to interpret information combined with standard 2D space. Novices are easy to follow a sequent linkage order on the standard 2D space. Besides, another insight for this behavior is that on-site navigators can integrate with real experience of physical space to make the interpretation realizable. Contrarily, off-site navigators can have more potential to make the interpretation imaginable than on-site ones.

2.3. INTEGRATING INFORMATION

The integrating information is the essential components of Virtual space based on the nature of digital media they provide, including web-based HTML or VRML representations, or simple text-based description for individual browsing or group interaction. At the same time, navigators can
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easily and rapidly integrate with other information by hyper-linking different websites, where provides navigators multi-layer and diverse information.

However, navigators have the different approaches to integrate information for different locations. On-site navigators usually hyper-link/bookmark the relevant websites according to their own visiting process in physical space. Contrarily, off-site navigators can follow their own existing spatial experience to explore and integrate diverse information. The insight from this analysis is that dynamic 3D space provides more information space to integrate than standard 2D space regardless of knowledgeable navigators or novices. Therefore, navigators approach a multidimensional information exploration, where information can be non-fixed and multi-layer organization to connect related objects and scenes. In addition, such behavior can provide the necessarily orientation information for the navigators.

2.4. COMMUNICATING INFORMATION

Information is dynamic and fluid in virtual space. Navigators can communicate information with their individual mental space, as well as the experience of different navigators such as Chat, Net-meeting, E-mail, download and upload information in virtual space. This interactive relationship always happens in the situation where navigators are off site. Knowledgeable navigators can skillfully utilize dynamic 3D space to communicate information with other navigators. Novices follow the typical process to communicate information based on standard 2D space. Therefore, the insight for this behavior is that navigators communicate information by their own individual spatial metaphor, where experience and knowledge can be not only transited between physical and virtual spaces, but also is shared among different users in real time.

2.5. SUMMARY

We summarize that information is the space where navigators manage and present data that is generated and exchanged in the process of exploring the information, but not replicate the experience and phenomena of physical space. Our co-existence approach is to company physical space by taking full advantage of the characteristics of virtual space to represent these existing buildings in virtual space. And we propose an information infrastructure, including two mechanisms of information representation: decomposition and assemblage based on an individual spatial structure.
3. Representing Information by Decomposition and Assemblage

Data of building is information in virtual space. Information represented by data of buildings is the space. Therefore, the information space represented by the analysis described above should also respond back to the issues of navigation in virtual space. This is to say that the meaningfulness of domain data and its representation is the crucial part for implementing information representation for the navigation. However, the representation of the domain data will depend on the platform they are onto, the virtual space.

Come to the data representation for the virtual space, the available data types are still digital media such as text, 2D images, 3D models, animation, and acoustic media to represent data of building. The composition of many digital media should relate to the means of domain data, thus the design knowledge, relevant to the existing buildings. The exemplary issues are historical background, programming, spatial sense, construction technology, construction material, etc.

We represent data of these existing buildings following two processes—decomposition and assemblage [Figure 2]. By utilizing such classification process, the data and their associated structure represent the information space for the virtual co-existence space.

Besides, the structure of information space is also important element of information representation, which is metaphorically related to individual spatial organization of physical space such as museum or gallery, as well as provides the necessary circulation and orientation.

Figure 2. The diagram shows the co-existence relationship between virtual space and physical space by two processes: decomposition and assemblage
4. Representing Existing Civic Buildings in Co-existing Virtual Space

For testing the approach of co-existing spaces and representation of information, we represent eleven historical significant civic building in Taipei. The selection criteria are based on four time periods in Taiwanese modern history, including Ching Dynasty, Republic, Japan Occupation and Modern era. Each building has attained its wholeness through years or centuries of acculturation, and still exists in its own way in the modern Taipei city. Based on an individual spatial structure, we proposed an interactive framework called i-Room (Chang and Lai, 2003) that incorporates two processes, decomposition and assemblage described above. And, we implement such co-existing space with 3D navigation and representation based on a 3D virtual platform called Muse (Muse 2003).

4.1. SPATIAL STRUCTURE BASED ON SPACE-TIME INTERACTION

The interacting of co-existing space within i-Room is to interact with the dynamic information landscape built by lots of decomposition components. In addition, the decomposition components are based on two axes of ‘space’ and ‘time’, and are hyper-linking each others based on the user analysis described above. Hence, navigators explore through the complex cross network built by co-existence of physical space and virtual space. The relation is shown in [Figure 3].

![Figure 3. The dynamic linkages are based on interaction between space and time in co-existence virtual space. Symbols (1-5) represent five spatial issues, and symbols (A-J) represent ten civic buildings.](image)

The spatial structure shown in the experiment is composed with 16 Muse sites, and each site is represented by its individual spatial metaphors such as i-entrance [Figure 4], i-lobby [Figure 5], metric cube [Figure 6], and linear corridor [Figure 7].
4.2. DECOMPOSITION BASED ON DIGITAL MEDIA

Each civic building has its own identity and specific information, which consist of several issues and their indexes in virtual space. Therefore, ten civic buildings are decomposed into diverse components, five issues and four indexes, and represented by digital media. Five classified issues are 1) historical evolution, 2) policy, 3) urban space, 4) architectural composition and 5) architectural style. Each issue composes of four indexes, including space, time, event and keyword. The classification is shown as [Figure 8]. With available information, there are over 500 decomposed components that form the co-existing information space. As well, each component combined with appropriate digital media has been representing onto two information spaces—standard 2D space and dynamic 3D Muse sites. Examples of instances are shown in [Figure 9,10].
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Figure 8. The diagram shows the decomposition process from physical building, issues, and indexes to digital media.

Figure 9, 10. The images show two kinds of dimensional space: standard 2D space and dynamic 3D space.

4.3. ASSEMBLAGE BASED ON INTERACTION BETWEEN NAVIGATORS AND INFORMATION

The other process is called *assemblage*. Navigators can assemblage these decomposed components to reflect a way of thinking about the reorganization content of buildings according to their own interesting and background. In addition, navigators can exchange personal information with the others and download the assemblage information in real-time. Therefore, the mechanism of assemblage is composed with two layers of interaction: 1) between navigator and information, and 2) between navigator and other navigators. Furthermore, each interaction can be represented by additional metaphor: *i*-Bag and *i*-Room. Details of navigation framework will be documented in (Chang and Lai, 2003).
5. Conclusion and Future Work

In conclusion, this paper provides a basic understanding of how to interact with navigators and information to highlight the co-existence relationship between physical space and virtual space, especially on the virtual space. The interactive relationships between navigators and information are four behaviors—collecting, interpreting, integrating and communicating. Each behavior presents different meanings to navigators in virtual space. Therefore, information is decomposed and reassembled to combine with the specific interests of navigators, overview the existing buildings and define their own programs. When the potential uses of virtual space in real world, the spatial experience and knowledge can be affected by the information technology quickly, and the influence will be visible.

The demonstration project provides some directions for future development in the co-existence relationship between physical space and virtual space. However, there are two issues should be more in-depth studies for our future work. They are 1) human-computer interface: enhances speed of learning and performance between navigators and information; 2) social interaction: explores new form of interaction for exchanging idea and thoughts in addition to current communication technology.

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References


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Shneiderman, B. (1987). *Designing the User Interface*. Addison-Wesley