Dynamic Interactions Between Users and Information in a Co-existence Space

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By exploring interactions between users and information, this paper intends to propose a co-existence framework for companying physical space with virtual space. Based on this framework, we implement an information structure for users to interact with information space interactively, which includes information nodes, hyperlinks and interplays through i-Room system (Chang and Lai, 2003). Furthermore, the information structure of representation is also tested and re-evaluated in representing ten historical significant civic buildings in Taiwan.

Keywords: co-existence, digital media, information space, virtual space

Introduction

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 representation itself is an arguable issue. Recently, thanks to the developments of digital media technology, many researchers have attempted to use digital media to virtually reconstruct existing buildings. The researches addressed such issues are: 1) Simulation: by bringing the building as real as possible under your fingerprint, 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 approach provides an important base, the visual feedback, for this research. 2) Digital media representation: by finding the suitable techniques for representing the abstract information of buildings, such as (Wan, Liu and Lee, 2001; Novak, 1988) share an insight of how virtual media can be used as a representation. 3) Augmented reality: by providing virtual experience physically, such as (Donath et al., 2001; Anders and Livingstone, 2001) argue that the interaction between physical and virtual space should be touchable and ubiquitous. 4) Information access: by providing 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.

As discussed above, digital media provides a powerful advantage that physical experience cannot express or not without intention or understanding is the visualization of complex information and accessibility. However, in this research, the basic
problem we concern is when you can experience the real building, why will you want to see it in virtual space. 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? Therefore, by investigating the interactions between users and information in virtual space, we propose a co-existence framework for companying physical space with virtual space. In addition, the information structure of representation has been also tested in representing eleven historical significant civic buildings in Taiwan.

**Interactions between users and information**

Interactions between users and information play an important role in the co-existence approach. Shneiderman (1987) and Pressman (1992) have categorized users as novices, intermittent users and frequent users based on applicable knowledge and visiting frequency. Furthermore, two additional factors are considered for our analysis: on/off-site (when the users 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 users are analyzed based on the three factors. The classes of users are shown in (Figure 1).

In addition, there are four common interactions between users and information. They are collecting, interpreting, integrating, and communicating information. These interactions along with their analysis are described in the next sessions.

**Collecting information**

Basically, two folds of dimensional space for the need of collecting information are provided: standard 2D space and dynamic 3D space. In standard 2D space, knowledgeable users and novices can easily collect information by a sequent linkage order. In dynamic 3D space, knowledgeable users 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. Besides, users might have the different approaches to collect information on different location: on-site or off-site. Users 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.

<table>
<thead>
<tr>
<th>Users</th>
<th>Information</th>
<th>Standard 2D Space</th>
<th>Dynamic 3D Space</th>
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</thead>
<tbody>
<tr>
<td>Novices</td>
<td>on site</td>
<td>on site</td>
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<tr>
<td></td>
<td>off site</td>
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<td>Knowledgeable, intermittent users</td>
<td>on site</td>
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*Figure 1*

Different classes of users based on the above information conditions.
Interpreting information

Users always interpret information based on their individual backgrounds. 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 users 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 users 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 users can integrate with real experience of physical space to make the interpretation realizable. Contrarily, off-site users can have more potential to make the interpretation imaginable than on-site ones.

Integrating information

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, users can easily and rapidly integrate with other information by hyper-linking different websites, where provides users multi-layer and diverse information. On-site users usually hyper-link the relevant websites according to their own visiting process in physical space. Contrarily, off-site users 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, users approach a multidimensional information exploration, where information can be non-fixed and multi-layer organization to connect related objects and scenes.

Communicating information

Information is dynamic and fluid in virtual space. Users can communicate information with their individual mental space, as well as the experience of different users such as Chat, Net-meeting, E-mail, download and upload information in virtual space. This interactive relationship always happens in the situation where users are off site. Knowledgeable users can skillfully utilize dynamic 3D space to communicate information with others. Novices follow the typical process to communicate information based on standard 2D space. Therefore, the insight for this behavior is that users 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.

To summarize, the interactions between users and information plays the most important role for representing information in virtual space by companying physical space. Therefore, the information in virtual space is not just replicate the experience and phenomena of physical space, but the space where users can interactively collect, interpret, integrate and communicate information.

The Co-existence Information Space

Information represented by data of buildings is the information space. Therefore, the meaningfulness of domain data and its representation is the crucial part for implementing information representation in virtual space. We represent data of these existing buildings following two processes -decomposition and assemblage. Furthermore, by integrating the interactions between users and information, we propose a co-existence framework to companying physical space with virtual space.
**Decomposition and assemblage**

Decomposition and assemblage are the foremost information processes for classifying data in virtual space. Such processes composed of their associated structure represent the information space for the virtual co-existence space. Also, the information processes stimulate the interplays between users and information. 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.

**A co-existence framework**

Our co-existence framework show in (Figure 2) is basically composed with two constituents. They are 1) two information processes: decomposition and assemblage representing the information space for the virtual space to interact physical space; 2) four interplays: four interplays (collecting, interpreting, integrating and communicating) provide different interactive conditions for users to interplay with information. These two constituents constitute the co-existence approach for companying physical space with virtual space. Under this framework, we implement the information structure using ten historical significant civic buildings in Taipei as an example. The outcomes as well as the possible impacts of these case studies are documented in the following sessions.

**An information space of existing civic buildings**

The selection criteria of information space 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 the co-existence framework, we implement such co-existing space with 3D navigation and representation based on a 3D virtual platform called *Muse* (Muse 2003). Basically, the information structure includes information nodes represented by multimedia, hyperlinks within space and time axes and interplays through i-Room system (Chang and Lai, 2003).
Information nodes represented by multimedia

Figure 3
Standard 2D information space.

Figure 4
Dynamic 3D information space.

Figure 5
Hyperlinks within space and time axes: symbols (1-5) represent five spatial issues, and symbols (A-J) represent ten civic buildings.
3D information space (Figure 4) in Muse sites.

Hyperlinks within space and time axes
The interacting of co-existing space within i-Room is to interact with the dynamic information landscape built by lots of the diverse components. In addition, the 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 5). 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, i-lobby, i-metric cube, and i-corridor. Besides, the relationships among these virtual sites of civic buildings are connected by two other spatial metaphors i-paths.

Interplays within i-Room system
In the information structure, users can dynamically interplay (collecting, interpreting, integrating, and communicating) with these decomposed components to reflect a way of thinking about the reorganization content of buildings through i-Room system (Chang and Lai, 2003). Through navigation tools (such as handle, focus, scale), i-Room system provides i-Bag for collecting information, i-Map for interpreting information, and i-Cell for integrating and communicating information (Figure, 6). For example, in i-Cell, users can exchange personal information with others, and integrate (such as assemblage) information in real-time by communicating with others. Therefore, users not only interplay with information, but also interplay with other users in virtual space.

Some findings
By evaluating the interactions in the information structure, there are some findings addressed here. In standard 2D information space, most of users can easily navigate information by following the hierarchical linkages. Also, it enhances users more easily for understanding the relationship between information. Such interaction is suitable for novice and on-site users. However, the 2D information space is limited and passive to interplay between users and information, and not humane for users to interact with information. Within this space, such interaction more focuses on collecting information than interpreting, integrating and communicating.

3D dynamic information space provides dynamic and active interactions. Most of users tend to explore information by interpreting, integrating and communicating besides collecting. In particular, it inspires off-site and knowledgeable users to play with information. However, most of users always get lost in 3D information space. Also, there are complex operations to interact between users and information. Therefore, orientation and humane interface are the keys for interplaying within 3D information space.

Conclusion
In conclusion, this paper provides a basic understanding of how to interact with users and information to highlight the co-existence relationship between physical space and virtual space, especially on the virtual space. The interactive relationships between users and information are four behaviors—collecting, interpreting, integrating and communicating. Each behavior presents different meanings to users in virtual space. Therefore, information is decomposed and reassembled to combine with the specific interests of users, 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 users 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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