INTERACTIVE USABILITY FRAMEWORK DESIGN AND SCENARIO IN VIRTUAL ARCHITECTURE

A ubiquitous virtual workplace case study

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Abstract. In virtual workplace, two-dimensional system with desktop metaphor can provide only limited functions and interactions. It is indispensable to create a framework that can change traditional computer generated 3D model into interactive virtual architecture exploited by end users. However, such framework cannot be established without fundamental understanding of the new virtual architecture. The aim of this research emphasizes on how to design a virtual working place supporting actual office activities to extend the boundary of the conventional office through 'Digital Space Lab' case study. To achieve our goals, potential usability of virtual architecture is investigated. The next step is to design the virtual working place. After that, a set of scenarios indicating how the end users will utilize our interactive workplace is demonstrated. Eventually, the result serves as basis knowledge to construct a usability framework for the novel virtual architecture.

1. Introduction

Spatial Convergence, the new integration between real and virtual space, reveals the new possibilities and the new relationships between human and space so called 'Human-Space Interaction'. Consequently, this requires new interactive abilities in both spaces. Meanwhile, ubiquitous computing technology (UbiComp) has been widespread exploited to create such interactive and smart physical environment. The virtual environment, nevertheless, still be limited to two-dimensional or simple three-dimensional web interface running on the cyberspace. In other words, contemporary virtual space cannot deliver full interaction supporting real activities performed by end users to interact with the real world. In addition, the current purpose of utilizing virtual environment is entirely distinct from real world in terms of place, function and activity. There is no dominant connection between real and virtual worlds.

Likewise, contemporary office space has been being altered because of the emergence of virtual office. The first shift has been found through a number of created virtual studio using intranet-based web services. However, two-dimensional system together with desktop metaphor can provide only

limited functions and interactions. Moreover, many of social and management aspects are ignored through such works. With the state-of-the-art CAD standard and virtual reality technology, virtual world has gradually become more potential to create a new kind of virtual architecture interacted with real space. Instead of using 3D models to built real space, we intend to find out how to use the model to create a new type of virtual architecture.

Therefore, in long term, it is indispensable to create a framework that can change traditional computer generated 3D model into interactive virtual architecture exploited by end users. However, such framework cannot be established without fundamental understanding of the new virtual architecture. The aim of this research, thus, emphasizes on how to design and apply a virtual working place supporting actual office activities to extend the usability and the boundary of the conventional physical office. In fact, this research focuses on the interactivity between real space and virtual model. Due to constraints in human resource, budget, and time, the physical space must be compact, flexible to install and remove equipments as well as possible to evaluate the result with minimum resources. The study model, thus, is bound to the author's working place so called 'Digital Space Lab', a CAD & GIS research center in Korea, is selected as the study case.

To achieve our goals, information from related works, case studies, and literature review are investigated in the first step to predict the new usability of virtual architecture due to the emergence of cyber space, virtual reality and ubiquitous computing environment. Second, programming of the virtual digital space lab is defined based on users' requirement and new potential of virtual architecture. The following step is to design the virtual working place according to research constraints and boundaries. After that, a set of scenarios indicating how end users will utilize our interactive workplace is demonstrated. Eventually, the result of this paper serves as basis knowledge to construct a usability framework for virtual architecture capable of supporting real activities and services.

2. Related Works

Prior to in-depths investigation, it is necessary to understand what virtual architecture is from the start. Elaborated by avant-gardes in the field of digital architecture, a number of recent architectural projects and theories reveal the similarities and the overlaps of virtual architecture towards dynamic and immaterial state. This section describes state-of-the-art technology related to current virtual architecture and virtual workplace.

2.1. VIRTUAL ARCHITECTURE

In 1990, the notion of *'Virtual Architecture'* emerged after 'Guggenheim Virtual Museum' (GVM) was launched and functioned as an internet-based museum for the Solomon R. Guggenheim Museum[1]. The project provided new methods to exhibit, collect and use of digital art. This evoked the new interesting and understanding for the role of architecture in Cyberspace not attempt to mimic any aspect of "real" building (Couture and Rashid, 2002).

[1] http://www.guggenheim.org/new_york_index.shtml

In addition, Marcos Novak has appended another notion for virtual architecture in his *'Liquid Architecture'* as an architecture whose form is contingent on the interests of the beholders (Novak, 1997). This architecture, as seen in Parasurf and 4D Paris-N projects, has been defined as algorithms capable of changing according to data and time axis. Unlike liquid architecture located only in the virtual territory, *'Hyperarchitecture'* defined by Ole Bouman (2002) is the result from the mergence between physical and virtual domains. It is a matter of crossing the analog and digital worlds, of hybrid environments that can no longer be classified as one thing or the other. Such architecture can be found in 'Trans-ports', an interactive pavilion for Venice Biennale 2000 developed jointly by the architect Kas Oosterhuis and Bouman. Regardless of the variety in its notions, this paper considers virtual architecture as the architecture exists in cyberspace practically utilized by end users thus causes consequences to the real world.

2.2. VIRTUAL WORKPLACE

Virtual workplace (Crandell and Wallace, 1998) is a world in which networks of people work in new ways, assisted by technology and being free from the traditional limitations of time and space. Working for a business, yet out of the office, is the cresting wave in workplace trends (Greenlee, 2003). Despite the fact that more and more companies are allowing their employees to work from home, the popularity of telecommuting has leveled off (Carpenter, 1998). A number of researches reveal the essence of social interaction in a virtual workplace. To assist people celebrate successes, companies have created web pages to acknowledge workers' efforts. Some organizations have "virtual water coolers" or chat rooms where they routinely go online and interact (Dempster, 2005). Those tradition web pages and chat rooms, however, could deliver limited quality of social interaction. The best way for companies to do this is by recognizing that Internet technology is not merely a communication device; it is also a very real space, repleted with possibilities for social interaction (Carpenter, 1998) This new possibilities, thus, will be investigated and discovered in this paper.

2.3. ROLE OF VIRTUAL ARCHITECTURE TO INTERACT WITH THE REAL WORLD

According to the research goals exploring the interaction between the real world and its counterpart, some relevant works have been examined in this section. Analogous to a physical place, one can use a virtual place to interact with its real place in different ways. At the most common level, a web interface with three-dimensional graphics is generated to function as a place to visit virtually. Digital Kyoto City[2] is an example constructed to provide the city information to public. Hence, there is no real interaction with the real city opposite to D-Tower[3]. Regardless a simple interface on the web, the virtual and the real bodies of D-Tower are merged expressing the mind status of Doetinchem citizen in real-time. Another possibility has been found

[2] http://www.digitalcity.gr.jp/index-e.html

[3] http://www.d-toren.nl/

in Virtual New York Stock Exchange Trading floor[4] in which users can perform real transactions in a virtual environment with datascape metaphor. More advanced concept has been applied in Cyberhelvetia Pavilion[5]. Remote users can interact with the interactive pavilion and its visitors using web pages. In the project, both physical and virtual pavilions were planned simultaneously since the design development process. In fact, remote users cannot only interact with users on site but also use a virtual model to control a real place as found in many remote home control systems such as Telefónica's Home-based Health Services[6].

Despite various interaction models mentioned above, our research approach is unique in that the proposed virtual architecture is applied to a workplace domain of which users can actually collaborate regardless of different time and place. In addition, in order to provide practical uses, a novel type of usability framework must be applied to our virtual architecture.

3. Digital Space Lab: virtual workplace design

Equivalent to physical place design, the design process of our virtual workplace begins with users' requirement collection and programming. The next step is to design the virtual place setting in three-dimensional cyberspace embodying space, time and interaction. The section explains the holistic design process in details.

3.1. VIRTUAL WORKPLACE POLICY

In accordance with our research goal to create a virtual place for actual use in parallel with its real place, it is necessary to understand the fundamental disparate characteristics of our virtual workplace as follows;

3.1.1. Placeness and trans-interaction

Not only acquire the characteristics of a place but main spaces in the virtual workplace also have their actual place in the physical world. In such virtual spaces, a user can perform certain actions that alter the current context of both worlds. This interaction across two worlds is called *trans-interaction* classified into three categories as shown in figure 1. *Trans-communication* refers to the communication between local and remote users through the virtual architecture. The interaction between users and counter-spaces is called *trans-presence*. Finally, we call the process that keeps tracking and synchronizing spatial context across two worlds as *ambient context synchronization*. For example, a virtual working room is linked to a real working room in digital space lab. One can turn on a radio in either room to broadcast music in both spaces simultaneously. This kind of interaction increases social interactions among users regardless of their current location and elaborates 'sense of place' or 'placeness' in virtual architecture.

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[4] http://www.nyse.com/pdfs/3dTradingFloor.pdf

[5] http://expo-archive.ch/eng/index.html?siteSect=761&sid=4292116&cKey=1149243834000

[6] http://www.broadbandhomecentral.com/report/backissues/Report0309_pictures.html

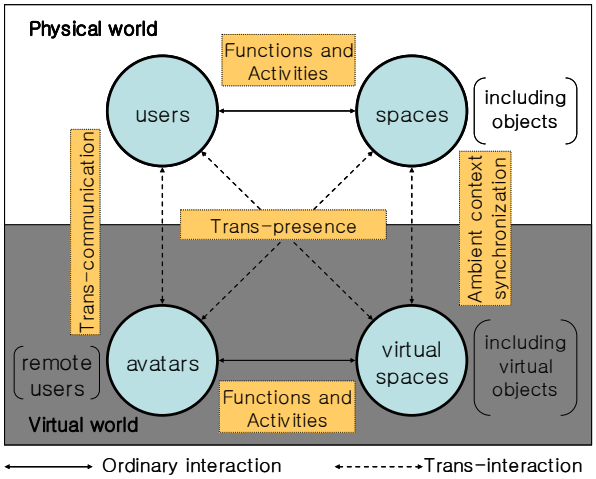

Figure 1. Interaction in virtual architecture

3.1.2. Degree of reality

The representation of virtual architecture is limited to neither realistic place metaphor like *Activeworlds*[7] nor datascape-like visualization as found in *Virtual Statistics Class* (Kalay et al., 2004). The line between 'real' and 'surreal' is a thin one. On one hand, there must be enough cues in the Cyber environment to support suspension of disbelief. On the other hand, it would be silly not to take advantage of the reality-bending affordances of Cyberspace. (Kalay and Marx, 2003) Regardless of the uncertainty in such discourse, our virtual workplace has been defined to borrow spatial characteristics from physical world as a contemporary office space. The main reason is to provide basic comprehension of a place implying how one can use the virtual place to perform real working activities.

3.2. PROGRAMMING

Fundamentally, the programming has been concluded by following existing functions of Digital Space Lab. Only selected users have privilege to use the virtual work place to simplify the system. Likewise, only essential existing spaces included in the virtual workplace composed of a meeting room, a shared working room. Nonetheless, extra areas are inserted to support supplement virtual activity as well as to increase the value of placeness and social interaction. These areas are common room, toilet and entrance hall. User identification takes place in the entrance hall. Unplanned meeting is held at the virtual room. In addition, one can manage their work and chat with colleagues simultaneously in the working room. Besides, working unit decoration is also possible to express personal identity. Common room is a casual chat room with selective background music and extra leisure activities. Toilet provides an area for dressing and make-up (changing avatar and appearance). Since only the meeting room and the working room have their real location, trans-interaction will be enabled only in both places. Table 1 summarizes the programming of virtual digital space lab.

[7] www.activeworlds.com

TABLE 1. Programming of virtual digital space lab.

Space	Meeting room	Working room	Toilet	Common room	Entrance hall
Description	Meeting area	Providing personal working unit for each user	Dressing area	Recreation area	Identification area
Real location	Meeting room	Each working unit linked to each user's desk	None	None	None
User	All users	All users	All users	All users	All users
Activities	Brainstorm VDO conference	Personal chat Schedule management Output posting uploading Music listening Personal working unit decoration Message posting	Dressing Make-up	Personal chat Group chat Play chess Music listening	Login Logout
Tools	Meeting table Chairs Whiteboard Projector	Mail box Radio Bulletin board, Calendar Decoration Stuffs: picture frame, cactus, etc. Pool file drawer (file server) Post-it	Clothing Avatars	Water cooler Chess Radio	Key
Zone	Formal	Semi formal	Personal	Informal	Security
Trans-interaction	Trans-communication Ambient Synchronizatic Trans-presence	Trans-communication Ambient Synchronization Trans-presence	None	None	None

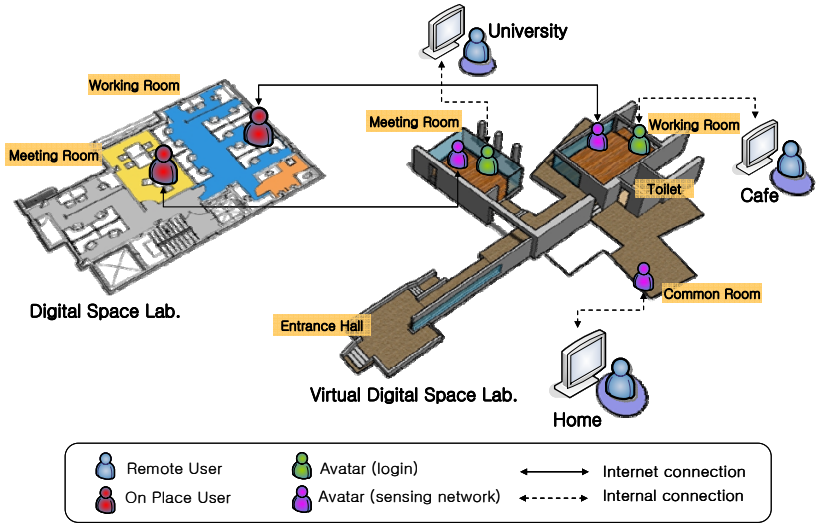

Figure 2. *The design of virtual digital space lab*

3.3. DESIGN

As mentioned in the previous section, the design of virtual digital space lab follows a place metaphor borrowing spatial characteristic of contemporary architecture regardless of freedom in free-form modeling. In addition, the layout topology has been kept whereas the dimension, the shape and the furniture have been altered. Some features are also added to compensate existing constraints in the real place such as expanding the room size, improving the atmosphere, etc.

Figure 2 illustrates the holistic view of our virtual digital space lab design and connection. The virtual workplace serves as a collaborative platform among users located from different places such as home, university or even café according to one's working routine. On one hand, the remote users can use available internet connection to access virtual digital space lab. On the other hand, sensing network in physical digital space lab detects the presence

of ‘on place’ users and project their location into the virtual workplace using their predefined avatar. In this way, remote users can communicate with ‘on place’ users through the virtual platform (trans-communication). Furthermore, as mentioned in the previous section, the presence of remote users in the virtual workplace can also alters the physical environment in terms of visual and sound effects (trans-presence). The mentioned trans-interactions are maintained by means of ambient context synchronization between the virtual and the physical rooms. Table 2 shows trans-interaction list in details.

TABLE 2. List of trans-interaction between virtual and real digital space lab.

<table>
<tr><td rowspan="2">Space</td><td colspan="2">Meeting room</td><td colspan="2">Working room</td></tr>
<tr><td>Physical place</td><td>Virtual place</td><td>Physical place</td><td>Virtual place</td></tr>
<tr><td rowspan="5">Trans–communication</td><td colspan="2">talk across the worlds using speaker and mic.</td><td colspan="2">talk across the worlds using speaker and mic.</td></tr>
<tr><td>digital whiteboard</td><td>virtual whiteboard</td><td></td><td></td></tr>
<tr><td colspan="2">video conference</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Trans–presence</td><td>a LCD panel on a wall indicating the presence of remote users in the virtual meeting room</td><td>Representation of ‘on place’ users using avatars in the virtual meeting room</td><td>a LCD panel on one’s desk indicating the presence of the remote user at the virtual working unit</td><td>representation of an ‘on place’ user using an avatar at one’s virtual desk</td></tr>
<tr><td></td><td></td><td>a LCD panel on one’s desk showing bulletin board, calendar, message posted by remote users</td><td>a virtual bulletin board, calendar, message box on one’s virtual desk</td></tr>
<tr><td></td><td></td><td colspan="2">music control and broadcast</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Ambient Synchronization</td><td colspan="2">visual and audio</td><td colspan="2">visual and audio</td></tr>
<tr><td colspan="2">lighting</td><td colspan="2">lighting</td></tr>
<tr><td colspan="2">location tracking</td><td colspan="2">location tracking</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
</table>

3.4. SCENARIO

The utilization method of virtual digital space lab is demonstrated through a scenario. It describes how to exploit the virtual space and serves as a basis frame for further implementation. The scenario background takes place on Saturday morning. Unexpectedly, an unplanned meeting about an on-going project is set up while some members are outside the office. A professor is working at digital space lab while John is working at home. Simultaneously, Anna is on the way to the office. After login on the virtual workplace platform, John goes to the virtual meeting room using his avatar and sees his professor’s avatar there. Note that a sensor network in the office recognizes the presence of the professor in the real meeting room and places his avatar in the virtual room automatically. On one hand, the professor communicates with John using a digital whiteboard, a web camera bundled with voice transmission features in the meeting room. On the other hand, John cans discuss the project using virtual devices including a whiteboard and a video conference tool provided in the virtual meeting room. After the meeting, the professor leaves the office and John goes to his virtual desk to modify the project plan. He updates the schedule, uploads a document and sends a message to Ann. Meanwhile, Ann arrives at the office and goes to her desk. She passes John’s desk and sees his avatar working in the virtual working room through a LCD panel on his desk. At her desk, Ann sits down and sees a message icon on her LCD panel. John sees Ann’s avatar on her virtual desk. Using a provided voice chatting tool, John tells Ann to check the mailbox and review the meeting content. Ann hears his voice through speakers and has short conversation with him. Then, John logouts and his avatar disappear. On the LCD panel, Ann checks the renewed schedule, reviews John’s message and downloads his document.

4. Future works and discussion

The processes beyond virtual workplace design stage belong to construction process. Unlike creating a typical virtual architecture, the proposed virtual architecture framework covers how to convert traditional three-dimensional model into interactive virtual place embedded with usability framework. The solutions to integrate users, interactions and real space with the virtual place need to be investigated. Nonetheless, these processes are not included in this paper and will be covered in the next phase.

In order to create the new virtual architecture towards the concept of spatial convergence, new characteristics of CAAD model must be applied. The key issues are to enhance spatial interactivity as well as to maintain social interaction among users with actual-place metaphor. By means of trans-interaction, this brings about the sense of 'working or being together' in virtual architecture. This paper provides a design framework and point out the new potential of virtual place. After all, the designed virtual workplace will enable users not only to interact with the virtual architecture but also to influence the physical environment, thus, extending the boundary of architecture and changing the way we perceive it.

Acknowledgements

This research was partially supported by the MIC (Ministry of Information and Communication), Korea, under the ITRC (Information Technology Research Center) support program supervised by the IITA (Institute of Information Technology Assessment).

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