DUAL INTERFACE BETWEEN PHYSICAL AND DIGITAL CITIES

Cyberspatial Cognitive Approach to Thread Digital City in Physical City

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Abstract. Today, digital cities are being developed all over the world. By using a city metaphor, digital cities integrate urban information and create public spaces. However, human how to entry into the new emerging digital cities, to percept themselves in around cities, and then taking shape the recognition of digital city forms? This paper studied by the viewpoint of cognition in order to explore the structure of the new style spatiality as cyberspace. By exploring the factors of human spatial cognition in physical space to interpret that human how to image and percept the spatial form of digital cities by the spatial experience in physical space, to construct the dual interface of spatial cognition of interaction between digital cities and physical cities.

1. Introduction

Recently, more and more researches attempted to well define and interpret the spatiality of cyberspace (Chang et al., 2002; Huang, 2001; Huang et al., 2002; Liu, 2001).The most researches studied the interactive processes between the physical city form and cyberspace to draw an analogy of the spatiality, to imply a new style emergence of spatiality, ex. The varied definition: digital cities, virtual cities, information cities, cyber cities, telecities and so on. The relationships of city forms between digital and physical by using a city metaphor integrate urban information and create public spaces for people living in the cities, in which reveal the significance of information flow and interactive service transforming between real and digital cities on line (Ishida, 2000; Light, 1999).

However, human how to entry into the new emerging digital cities, to percept themselves in around cities, and then taking shape the recognition of

digital city forms? This issue must be studied by the viewpoint of cognition in order to explore the structure of the new style spatiality as cyberspace. The cyberspatial phenomena in our research have been studied from the viewpoint of cognition to explore the factors of human spatial cognition in physical space. In order to study that human how to image and percept the spatial form of digital cities by the spatial experience in physical space, to construct the interface of spatial cognition of interaction between digital cities and physical cities (Figure1).

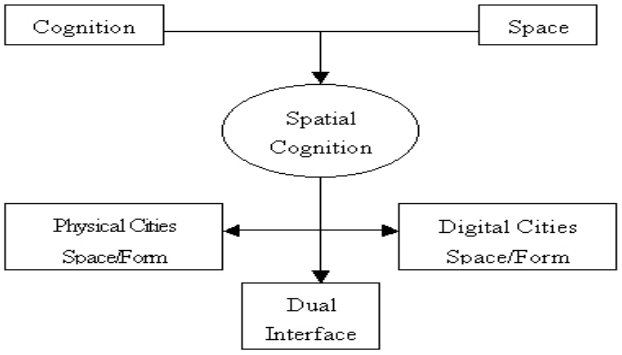

Figure1. *The spatial cognition of interaction.*

1.1. THE PERSPECTIVE OF SPATIAL COGNITION

The cyberspatial cognition approach in studying spatial structures of cyberspace and digital cities is an important access. Interestingly, the most studies of cyberspace and digital cities were influenced by the spatial knowledge of cognitive mapping(Al-Kodmany, 2001; Dodge and Kitchin, 2001), which has developed by Lynch (1960).

Lynch's analysis of the city rested on five different elements: paths, edges, landmarks, nodes, and districts, to image the physical city form as the mental map, as cognitive processes of spatial knowledge. Lynch provided a theoretical framework for studying cognitive maps, urban form, and the spatial relationships of cities. This included an exploration of how regular citizens use and visualize city spaces. With regard to Lynch's mental map, the researches of cognitive psychology consider it as mental representation of spatial knowledge, referring to memory area and visual information processes. Because of the limitation of memory capacity, human use the simple strategy to abstract the information of landmarks, not clear visual symbol, to remember the spatial information(Solso, 1995). Siegel and White, 1975, state that the developmental progression of a mental map is from landmarks to survey map (P'eruch et al., 2000)？Based on the Spatial Cognition Triangle -- sensory, spatial knowledge and behavior, Krieg-

Bruckner et al. (1998) state that the mental map of human is formed from the hierarchical relationships of spatial knowledge, dividing by navigational behavior. According to processes of navigation, the hierarchical taxonomy of a mental map involved three sub-processes to perform the Visual coding and Whole-Body coding of spatial information: working memory of egocentric coordinate, long-term memory of landmark and long-term memory of position.

Cyberspatal researches had indicated that human behavior in cyberspace bases on certain similarities with spatial behavior in the physical world(Kwan, 2001). Many above-mention theories about spatial learning, cognitive mapping, and way-finding behavior are helpful for understanding the cognitive experience of human in cyberspace and physical space. When cyberspace attempt to replace the real world(Ronald T. Azuma, 2001), we want to ask the problems between both if have any differences on spatial cognition, if has the dual interface of spatial cognition to transform the differences of the spatiality.

1.2. THE CONCEPTUAL MODEL OF CYBERSPATIAL COGNITION

We examined our mental representations of spatial knowledge include information about spatial relationships and about how to navigate in our environment. The main types of spatial knowledge, spatio-cognitive ability, have two: survey knowledge, learned from maps, and route knowledge, gained from navigating through the environment (Medin et al., 2001).

Cyberspace, as a cognitive objective, is the map itself that defines and becomes the space(Kwan, 2001). Thus, we can deal with cyberspace as a large-scale environment of spatial knowledge in which its entire landscape is like human mental map. The studies of cognitive cyberspace emphasize on three aspects: orientation, way-finding (or navigational aids) and map, just like the mental map of physical environment by Lynch's perspective(Al-Kodmany, 2001; Chiu et al., 2000; Kwan, 2001; Lin and Chiu, 2002). When we perceive the world, the external-input stimulate the sensory memory and decompose into verbal and visual elements to convey to working memory, then to select from there elements to save into long-term memory and perform the mental map of spatial knowledge(Atkinson and Shiffrin, 1968). With this background on spatial knowledge and cognitive cyberspace, we described a pre-conceptual model to understand cyberspatial cognition before discussing different cognition between physical and digital city (figure2). We drew this theoretical and conceptual model from the researches between cognition and space. It still be revised and examined by the spatial experience and observation.

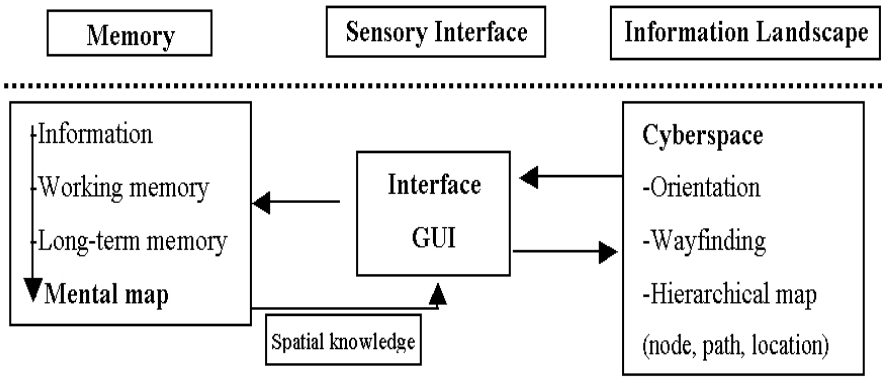

Figure 2. *The pre-conceptual model of cyberspatial cognition.(After Kwan and Medin)*

The first step of this research is to construct the pre-conceptual model of cyberspatial cognition from the researches between cognition and space. The second step will revise and examine the pre-conceptual model of cyberspatial cognition into dual interface of cognition and space by the spatial experience and observation. In the end, we figure the dual interface of space and cognition between digital and physical cities, to provide the spatial elements to describe the prototype of digital city form spatial cognition.

2. Methodology

In order to revise the pre-conceptual model of cyberspatial cognition, we conduct an experience about the spatial cognition. We will refer to more spatial elements to figure out a dual interface between different spatiality.

We base on the model of cyberspatial cognition to examine the cognitive deference among physical city space, physical VR space and VR space as a system of a perceptive process by combining a mix of technologies, including virtual reality, movies, static pictures, panoramic views, 3D model. According to the spatial experiment of cognitive deference, we will revise the theoretical and conceptual model of cyberspatial cognition. With this result, we figure the dual interface of space and cognition between digital and physical cities, to provide the spatial elements of spatial cognition to describe the prototype of digital city forms thread the physical city, which establishes a platform to package different pieces of information of spatial cognition in an associative process. This associative platform supports human cognition, as it more closely resembles the way in which humans actually process information. Linking digital city to the specific physical city on the VR system simulates human cognition and memory in that the human mind continuously geo-references images.

Method

Subjects. 40 subjects (25 architectural students, 15 visual students) participated in the experiment.

Four environments. A place, Tainan's Confucian temple area in Taiwan, been performed by four digital media (figure3).

Figure3. *Four digital media*

Experimental room. The experiment took place in a darkened room (5m*7m). The subject sat in front of the monitor screen (21"). (figure4)

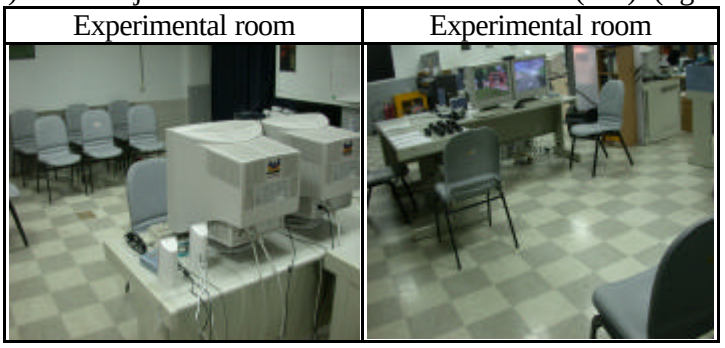

Figure4. Apparatus and Experimental room.

Apparatus. The hardware involves one infrared cable, 3D stereo glass (40), one 3D stereo camera, two speakers and two PC (P4 1.8G, 512ram, nvidia geforce3 ti500). The software involves virtool2.1, max4.0 and upmost.(figure5)

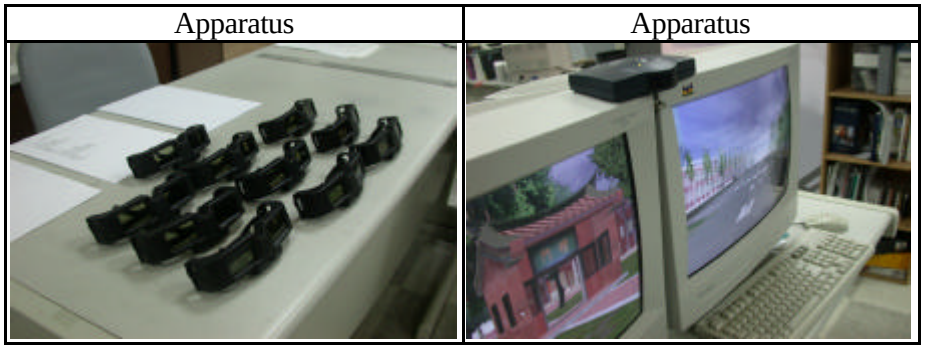

Figure5. Apparatus.

Procedure. Before staring the experiment the task of digital media was explained to the subjects and they were allow to practice on the device for about 15 minutes. The environments used for practice were not used in the experimental trails.

The experiment consisted of 4 different display for a place presented in order, physical video, physical VR video, 3D animation and 3D VR system. The four displays had performed the same visual tracks in the Tainan's Confucian temple area (figure6). The subjects were reminded to percept the spatial difference among them, in order to figure out four mental maps in them memory after the ending of this experiment. The total time of the process was 20 minutes.

Figure 6. The tracks of visual processes

3. Results and Discussion

Results

The following table showed the results of the experiment (table1). A is the group of architectural students. B is the group of non-architectural students.

Table1. The statistics of the experimental results.

	PHYSICAL VIDEO		PHYSICAL VR VIDEO		3D ANIMATION		3DVR SYSTEM	
Recognized the place	A	B	A	B	A	B	A	B
	19	6	19	6	19	6	19	6
A space feeling	23	9	20	11	20	12	17	8
Inside the space	9	6	14	9	7	3	15	12
Different Spatial Cognition between both	PHYSICAL VIDEO vs. PHYSICAL VR VIDEO		PHYSICAL VR VIDEO3D vs. ANIMATION		3D ANIMATION vs. 3DVRSYSTEM			
	A	B	A	B	A	B		
	17	12	19	9	20	7		
	Category of Factors among the different spatial cognition							
	Visual factors	Audio factors	Media Interface factors	Device factors	Event factors	Memory factors	Whole-body Surround factors	

Discussion

According to the results, the experiment reported here aimed at examining the pre-conceptual model of cyberspatial cognition on the basis of factors and comparing the observed performances to figure the dual interface of space and cognition between digital and physical cities (figue7). Among the differently spatial cognition, we found some phenomena to revise the pre-conceptual model.

A. An overall perspective map for survey knowledge to designate location. Like 2d and 3d map, a panoramic view for a whole scene.

B. Whole-body information for passage knowledge to percept the surrounding environments. Like VR's walking through, role-play of avatar, viewpoint changes, for immersing sensory simulation.

C. Visual information for route knowledge between long-term and sort-term memory to find orientation, egocentric coordinate and position. Like elements of landmarks, elements of routemarks.
D. Audio information for short-term memorial cues to associate a place sense or scene with the synesthesia.
E. Event information for long-term memorial cues to associate a place sense or situation with the synesthesia.
F. Media interface factors for performing the behaviors of human navigational cognition in the environments. Like text, image (2d,3d), animation, VR, hypermedia, on-line…and so on.

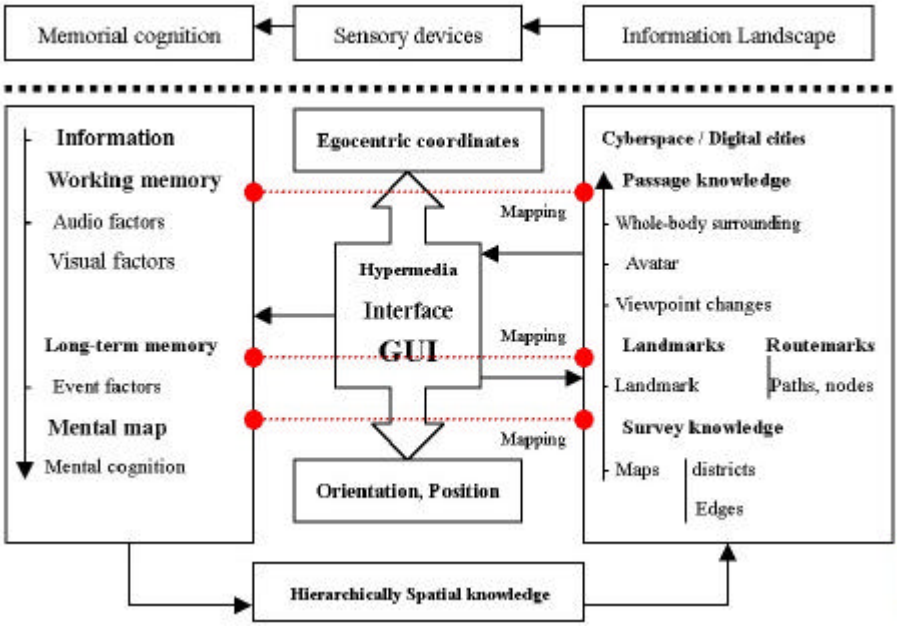

figure 7. The dual interface of space and cognition between digital and physical cities.

4. Application and observation

Application

We used the spatial prototype of the dual interface to establish a digital city by using the VR system, Digital Tainan in Taiwan, to examine the cognitive relationships of Dual Interface between the digital and physical city (figure8). The role of this VR platform is spatial perception of a city form and visual communication of planning data through 3D and VR systems (figure9). The evolution to this digital platform is seen as a critical component of spatiality in

the development of digital cities form, which will allow urban planners to visualize, percept and model the complexity of the built environment in web-based virtual reality.

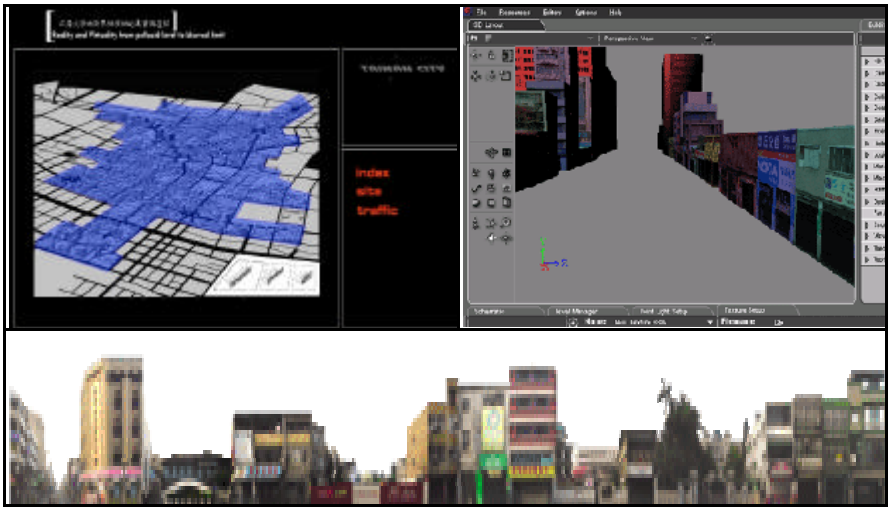

Figure 8. The VR model of the Digital Tainan city.

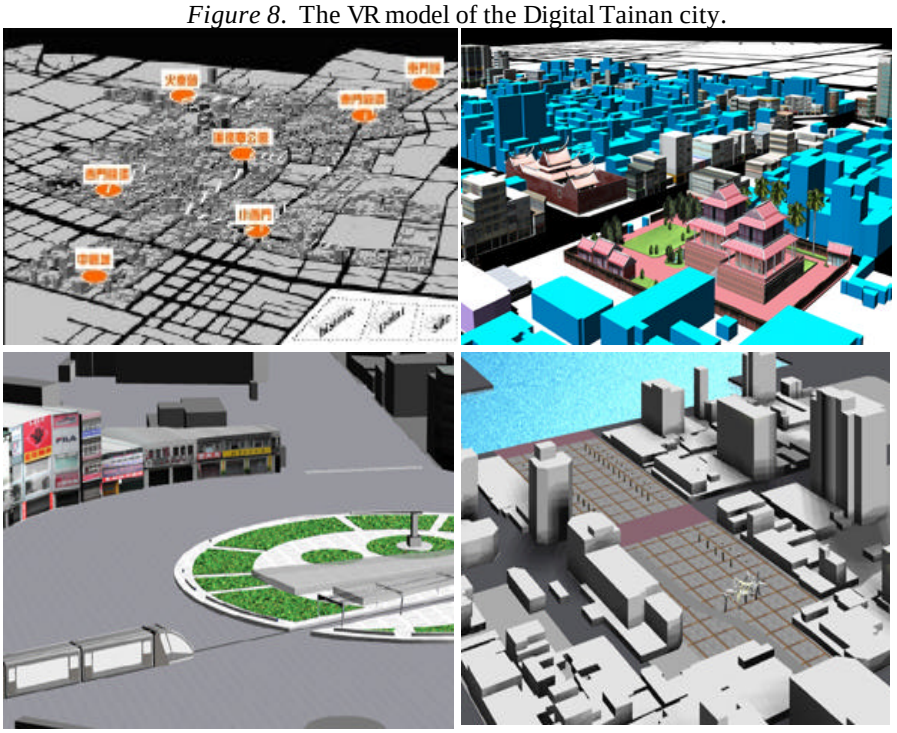

Figure9. The co-construction of the digital duality in The Digital City Tainan.

The Digital City Tainan had proposed a concept of virtual city to co-construct the digital duality from physical and virtual cities to perform the integrating of the both spatial knowledge between physical and cyber environments.

Observation

The Digital City Kyoto (figure10) performed a city metaphorical form: a 2D map and a 3D virtual space. A large number of WEB pages (2600 in September 1999) are being collected and linked to the 2D/3D city (Toru Ishida, 2000). Real-time mapping data from the physical city were also mapped to the digital city. As the human interface, a whole Shijo street (2Km long) has been implemented to simulate the city environment in a 3D virtual space. Citizens or visitors can get information related to the physical city such as traffic, weather, parking, shopping, and sightseeing. Digital City Kyoto had the social interaction among residents and tourists. For oversea visitors via the Internet, Digital City Kyoto had provided a digital bus tour with a guide agent that supports cross-cultural communication.

Figure 10. Digital City Kyoto http://www.digitalcity.gr.jp/.

The cyberspatial concepts of The Digital City Kyoto have the components of hierarchical nodes, paths, landmarks, edges and districts by two or three dimensional maps images (figure11). The Digital City Kyoto performed the digital concept which making simulate and virtual Kyoto city to create the duality of Kyoto city. Attempting to create a new spatial cognitive

image of urban space and life. By the dual interface model of spatial cognition on different nodes, hierarchy and paths, she has changing and forming a new cognition of the city and spatial structure to let residents perceive the meaning of urban space in digital era, as a new spatial knowledge.

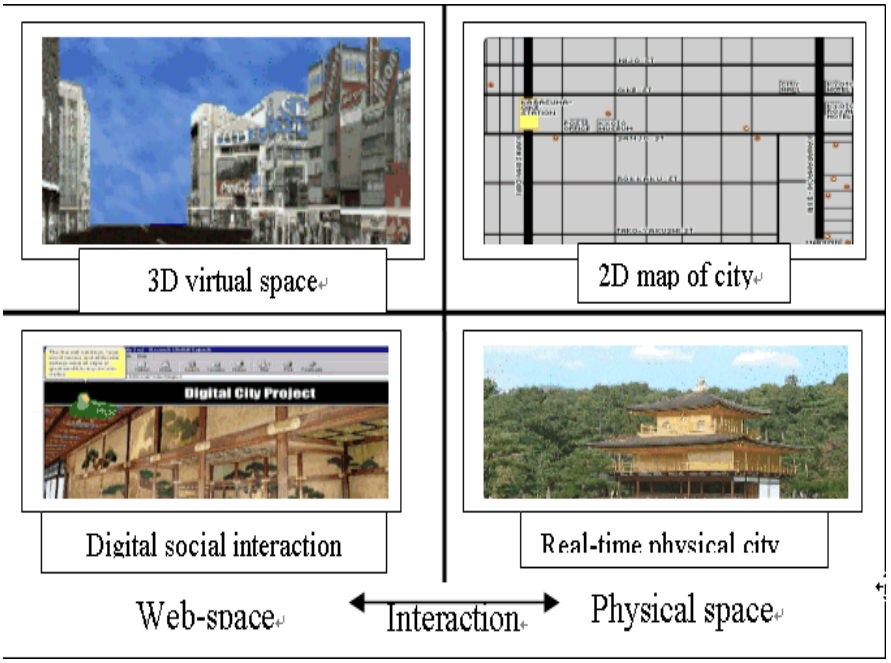

Figure11. The metaphors of the Digital City Kyoto.

5. Conclusion

Finally, the results of this research conduct the Dual Interface Model between digital and physical cities, to indicate that the perceptive and liking relationships between digital and physical cities extend the definition and boundary of city space by interacting and constructing of spatial cognition in each other. At the same time, a viewpoint is put forward of the digital city, linking the physical city with cyberspatial cognition. There are constraints on how far the spatiality of digital cities can be developed, but a view is provided on how these cyberspatial cognitions are developing to aid perceptive and visual communication in urban design. The VR mediums can provide urban designers might benefit from the platform of the digital Tainan city. In addition, a theoretical discussion among the mental map, human spatial perception, VR mediums are explored for thread the digital city form in the physical city.

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