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## **SPATIAL REPRESENTATION OF DESIGN THINKING IN VIRTUAL SPACE**

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**Abstract.** “Space” has long been an important concept in architecture; and architectural spaces and forms have been continuously evolved due to the appearance of new concepts of space. Since the invention of Internet, new spaces have been created through the computer. To understand how human beings in the digital age experience these new virtual spaces, and to discover the implications of the possible new concepts of space into the physical architectural world, this paper discusses the nature of virtual spaces by examining the verbal and visual elements involved in the creation of a sense of virtual spaces. All the verbal and visual elements of virtual spaces discovered through our experiments and interviews are presented. It is found that the three core elements of both verbally and visually constructed virtual spaces are: movements, interactions, and acoustic effects. In addition, a comparison between verbally and visually constructed spaces, and between physical and virtual spaces are explored. Finally, further studies related to the role of digital media in the construction of a sense of space are suggested at the end of this paper.

### **1. Introduction**

Architecture has long been regarded as a combination of solid mass and void space. On the one hand, architectural form has been continuously evolved due to any significant progress of materials and construction/design methods, such as arches in Roman age, pendentives in early Christian, buttresses in Gothic, and glasses and steels in modern. On the other hand, architectural space has also been continuously evolved due to the emergence of new concept of spaces, such as timeless spaces in Greek and Roman, dynamic spaces in Baroque, void spaces in Tao of Chinese literature, and inside-out spaces in modern. Therefore, any mechanisms that could make a change of either the design/construction process of

solid forms or the concept of void spaces, in some sense, provide great opportunities to define where future architecture would go.

Digital media including the Internet have already influenced both design/construction process and the concept of spaces (Mitchell, 1995, 1999; Liu, 2001). Since 1990, the digital design process and its corresponding construction procedure have been implemented by several pioneering architects, such as Peter Eisenman and Frank Gehry. What is needed to explore and to discuss at present is the new concept of space, especially the so-called virtual space, and the implications of virtual spaces to physical spaces. On the other hand, cognitively speaking, in real and physical space, people and designers experience the space through sensory perceptions. Human perception is constituted by both visual and verbal codes (Bahrick and Boucher, 1968; Glanzner and Clark, 1964; Reed, 1974; Simon, 1972). Since design knowledge representation rely mainly on both verbal and visual representation (Mitchell, 1990), this study focuses on the verbal and visual aspects of virtual spaces.

## **2. Background and Problems**

In addition to the field of architecture, the concept of space has also attracted interest of researchers from various academic disciplines in recent years (Agnew, 1993; Benko & Strohmayr, 1996; Chang, 1999; Foucault, 1982; Gould, 1998). Researchers from disciplines such as anthropology, geography, sociology, philosophy, and linguistics regard it as the base of the discussion of various theories in social sciences and humanities (Chen, 1999).

On the other hand, since the invention of Internet, Internet users have been experiencing a new and magic “world.” According to the definitions in traditional architecture theories, “space” is generated whenever people define a finite void by some physical elements (Zevi, 1985). However, although Internet is a virtual, immense, invisible and intangible world, navigating in it, we can still sense the very presence of ourselves and others in a wonderland. As Bertol (1997, p. 59) puts, Internet is “an infinite artificial world where humans navigate in information-based *space*” This sense that Internet is a space could be even more obviously testified by the use of *Cyberspace* -- an exotic kind of space -- as an alternative naming of it. In addition, Novak (1991, p. 226) further indicates that “cyberspace is architecture; cyberspace has an architecture, and contains architecture.” As more and more people now spending more and more time dwelling in this new virtual space, we could predict that this new spatial experience will ultimately change (actually, it has been changing) our concept of space as human actors in the digital world. In order to understand this potential

influence, it is important for us architects and architecture scholars to ask how a sense of space is constructed and negotiated in the cyberspace, how this virtual space co-exists with the physical space and what is the nature of this virtual space.

To join the current interdisciplinary discussion on the issue of space, and to obtain new definition as well as insightful understanding of “space”, this study explores the spatial phenomena in Internet, i.e. the virtual space. I hope that the findings of this study would ultimately be also helpful for contemporary architectural designers and scholars in their designs in the real world. As a preliminary exploration, the main objectives of this study are to discover the verbal and visual elements involved in the creation/construction of a sense of space in the Internet and to examine the differences between virtual spaces created by verbal and visual elements.

### **3. Methodology**

As a preliminary exploration, in order to achieve a more comprehensive understanding of the spatial phenomena in Internet, the research design of this study was divided into two stages. At the first stage, my research team adopted a commonly used research method in social sciences – participant observation (Milroy, 1987) – to start our systematic navigation of different spaces in Internet, such as BBS, homepages, chatrooms, MUDs, MOOs, and online games. In addition to being silent observers, my research assistants also tried to initiate informal discussions on the issue of “space” in their verbal interactions with the many Internet hangouts from various places in the real world. After two months of observation and participation in various Internet spaces, we selected several target websites to collect data for a thorough and systematic analysis at the later stage. The data collected include the verbal records (mainly in Chinese) of the interactions (i.e., verbal communications) in three chatrooms and one MUD and the visual presentations of 13 business homepages as graphical data (Please see Appendix).

At the second stage of this study, we recruited 8 Internet regular users to approach this topic from different point of views, These 8 subjects are currently graduate students at National Chiao-Tung University in Taiwan. They are from four academic disciplines: linguistics, visual communications, industrial design, and architectural design (two subjects from each discipline). We first invited them to navigate different websites which we selected at the first stage. As they were navigating, we begun to ask questions and observe their reactions. After they logged out, we conducted another systematic and thorough interview with each of the subject. They were then asked to conduct a text and a graphics analysis. In

this procedure, the subjects were asked to highlight all the words in the textual data and all the elements in the visual data which prompt a sense of space to them.

## 4. Results and Discussions

### 4.1 VERBAL ELEMENTS

To synthesize the findings obtained from different research stages, the results reveal that verbal elements involved in the creation of a sense of space cover a wide range of linguistic strategies, and can be divided into the following categories (Table 1):

#### 4.1.1 *Explicit Space Description*

- a. naming of specific virtual places
- b. use of common spatial terms
- c. description of the functions of virtual locations/places
- d. description of space orientation

Strategies used to explicitly construct a virtual space include (a) specifically naming the background of a conversational activity as "KTV", "University chatroom", "residential area" or "Main Plaza;" (b) using common nouns which contain a sense of space, such as "house", "room", "wall" and "casino;" (c) describing the function of a virtual space, such as "...a banquet is going to be held here;" and (d) expressing a sense of space orientation, such as "You're wandering at the south east corner of Penacles Central Plaza. The statues of the great heroes are put here ..."

All the participants in this study identified this category as cues of spatial sense formation. Chatrooms or MUD groups of which the textual data include more of these linguistic features are connected with a stronger sense of space. This is probably because these linguistic features are the most obvious cues which can trigger direct experience mapping to the participants' spatial experiences in the physical world.

#### 4.1.2 *Description of Movements*

- a. movements from one space to another
- b. individual body movements at a fixed point (i.e., description of participant actions and gestures)
- c. physical interactions (description of actions to other participants)

For all the subject, descriptions of a sense of movement are also considered crucial cues to stimulate a sense of space. Descriptions of movement from

one space to another, either from a virtual to a physical space or to a different virtual space imply a transition from one space to another. For example, in the sentence "you go to the residential area and wait for me there," a movement from one Internet channel to another in the same website imply that different channels are different places, hence different spaces. Another sentence "Nelvi, where do you come from?" (meaning "Nelvi, where are you now in the physical world") implies that "from which physical space (i.e., location in the real world) do you come to this virtual space (i.e., this digital chatroom)?"

Another kind of movement is individual body movement (e.g., "Nelvi is dancing") Descriptions of this kind could evoke a sense of presence of participants. Finally, physical interactions refer to actions to other participants (e.g., "bibi shakes vibra's hands). The description of physical interaction in the above sentence implies a sense of proximity between these two users, hence their presence in the same space. Additionally, this kind of verbal description makes the participants feel a high degree of participant interaction. In our interviews, it was found that "interaction" and "movement" is two of the most crucial factors of spatial sense formation.

TABLE 1. Verbal elements of virtual space formation

Subject	space description	movement	implicit reference	space condition	identity participant	graphical expression	voice/odor
A	v	v	v	v	v	v	v
B	v	v	v	v	v		
C	v	v	v	v	v	v	v
D	v	v	v		v	v	
E	v	v	v	v			v
F	v	v	v	v		v	
G	v	v	v	v	v	v	v
H	v	v	v	v	v	v	v

4.1.3 *Implicit Spatial References*

In addition to the more obvious verbal elements presented above, there are some verbal elements of spatial construction which appear to be more implicit. The linguistic items marked most often are words such as "here/there", and "front/back". However, even though they are less explicit, all the subjects marked them as one of the important verbal elements evoking a sense of space. For example:

A: Let's go to /es.

B: We can get something to eat there .

“There” in the above sentence refers to another channel in the same website and thus implies another place as opposed to where they are in the virtual space.

#### *4.1.4 Description of Spatial Condition*

Description of spatial condition (such as crowdedness, noisiness/quietness, friendliness, hostility) is considered by all the subjects, except for one, as another kind of important linguistic expression which could stimulate a sense of space. Examples are like "everybody, quiet please" and "wow, it's so crowded here!" This feature is highly connected with the temporal dimension in that the change of time could cause changes of spatial condition in synchronous modes of computer-mediated communication such as chatroom conversations and MUDs observed in this study. For example, about at 11:00pm at a Friday night, we could see a conversation like the following:

A: oh, god so many people here

B: It's a surprise to see so many people today.

A: yes, indeed

The above conversation implies that normally the number of participants is smaller than that of this weekend night. In general, during weekends, or everyday after 10:00pm, the number of chatroom participants is larger. At the late night when more and more participants are logging into the chatroom, the speed of turn taking become faster and faster. And as the words appear on the computer screen at a faster speed, participants can feel a higher and higher degree of vividness in their interactions. In contrast, as time goes on, when the participants begin to log out one after one, the verbal interactions decrease gradually -- sometimes to a degree that the words on the screen simply become frozen. This change of atmosphere from high to low can sometimes cause uneasiness of the participants still online, as illustrated by the following expressions:

“ZZZZZZZZZZZZ, I'm so bored.....falling asleep

“The air is getting so cold here.....

The above examples illustrate a phenomenon: As the chatroom participants sense different speeds and different atmospheres of the chatroom interaction, they also sense a change of the spatial condition in that virtual room.

#### *4.1.5 Identity of Participants*

- a. nicknames of participants
- b. description of facial expressions

c. description of virtual appearances

Linguistic expressions of participant identity could create a sense of participant presence in the computer-mediated communication. These expressions include participant nicknames, description of virtual appearances, and facial expressions (both verbal descriptions and emoticons such as ";-p", "@@", and";-))". The facial expressions make the participants feel that they are face-to-face in the same space (Curtis, 1997). Six of the eight subjects marked these linguistic devices as cues of sense of space. An example to illustrate how participants define a space based on participant nicknames is shown below:

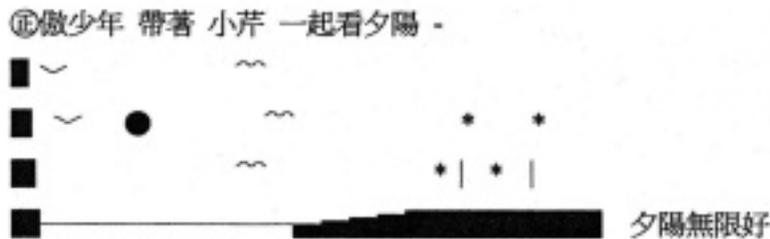
A: @@  
 A: a bunch of people whom I can't recognize  
 A leaves this chatroom

Participant A entered into a chatroom, obviously astonished with two eyes wide-open @@ because most of the nicknames on the computer screen, that is, most of the participants in this chatroom were not familiar to him. The place was thus no longer the one familiar to him and such a space made him uncomfortable. Therefore, he left the room very quickly.

4.1.6 Graphical Expressions

In the text-based chatroom communications that are constituted mainly by verbal symbols, a 2D abstract sketch can sometimes be regarded as a cue of a sense of space. Since this visual presentation is somewhat abstract, a sense of space is prompted through visual imagery and experience mapping, rather than direct mapping. Six of the eight subjects indicate that in the verbal environment, the appearance of 2D visual presentation can enhance a sense of space triggered by the verbal elements. The following is an example:

Arrogant young man takes Shiao-Xien to see the sunset together.



4.1.7 Description of Voice, Sound or Odor

The verbal elements mentioned above evoke a conceptual and imaginary space all through visual imagery and then experience mapping (Strate,

1999). However, a sense of virtual space could also be constructed through visual perceptions of symbolized or verbalized acoustic and olfactory effects, and through acoustic and olfactory imagery and then experience mapping. Examples are as the following:

- (((((((wow)))))))
- Oh, the smell is so bad here. The whole chatroom is full of Monkey's gas.

## 4.2 VISUAL ELEMENTS

As shown in Table 2, the visual elements which can prompt a sense of space include the following graphical and digital techniques:

TABLE 2: Visual elements of virtual space formation

Subject	movement	acoustic music	simulations	human computer	volumetric	change viewing	referential
A	v	v	v	v			
B	v	v	v	v			
C	v	v	v	v	v		
D	v	v	v	v	v	v	
E	v	v	v	v	v	v	v
F	v	v	v	v	v	v	v
G	v	v	v	v	v		
H	v	v	v	v	v		

### 4.2.1 Movements

- a. object movements
- b. human figure movements

The visual targets under this category include specific 3D objects or human figures either moving forward and backward, turning around, or flashing on the screen. A two-dimensional object moving from one side of the screen to the other side is also covered in this category. All the eight subjects considered “movements” as one of the most important visual elements of a sense of virtual space.

### 4.2.2 Acoustic Effects and Background Music

All the eight subjects pointed out the importance of acoustic effects and appropriate background music in the formation of a sense of space. Acoustic effects here refer to all kinds of (quasi-)authentic sounds such as human voices and footstep sounds. In addition, well-designed background music, especially music with appropriate rhythm, is also crucial. This finding is very interesting because while we asked the subjects what *visual* elements in the computer screen make them felt that there is a space in

front of their eyes or even for them to immerse within, one of the answers they gave was *acoustic* elements. This phenomenon can be easily explained, however. As Strate (1999) indicates, “visual space situates the individual on the outside looking”, while acoustic space places the individual “in the center of the action, surrounded by an aural environment that is heard holistically.” Because of this reason, the sounds our subjects heard immediately made them immerse into the environment presented on the screen, but for some of them, only aurally not visually. Further, as presented in the previous section (Table 1), although these subjects did not really hear any sounds from the verbal descriptions, because of the same reason, five of them, also marked the verbal descriptions of voice/odor as important elements for a sense of virtual spaces. But apparently, this spatial sense is formed through imagination and experience mapping, rather than direct immersion.

#### 4.2.3 Simulations

- a. static simulation
- b. dynamic simulation

Static simulation includes using the familiar images and drawings to design the web-sites (e.g., use the concepts of maps, roads, and building forms). These static simulations are produced by both conventional and computing media such as sketch, hand drafting, physical models, video, computer images, 2D drafting, and 3D modeling techniques. Dynamic simulation refers to the use of animation and virtual reality (VR) techniques to show the concepts and real scenes of various spaces. Because of their dynamic nature, to the subjects, animation and VR can easily capture continuous spatial experiences.

All of the eight subjects reported that both static and dynamic simulations are visual elements for constructing virtual spaces (Table 2). However, like all the other visual elements discovered in this study, the virtual spaces constructed by most visual simulations, although visually seen by the subjects, are not experienced as real as physical spaces except for those simulation including photos or videos from real scenes.

#### 4.2.4 Human-Computer Interaction

- a. interactive interface
- b. well-organized and user-friendly web-site environment

As we reported in the previous section, “interaction” is one of the most crucial factors in the verbal construction of a sense of space. In the visual presentations, we find again that it also plays an important role. However, the “interaction” here is not between/among the computer users but between computers and human users. Seven of the eight subjects marked features under this category as visual elements of spatial formation. For

them, well-organized and user-friendly web-site environment provides a better sense of orientation, so that its users will not be lost easily. A good sense of orientation is thus crucial for them to form a sense of space. In addition, to push a visual button, to open something, to move an object/human figure by clicking the mouse, or any other kinds of human-computer interaction all help them generate a better sense of space.

#### *4.2.5 Volumetric Presentation*

- a. 3D objects
- b. perspectives
- c. shadow/lighting
- d. layer/depth presentation

On all 2D computer screens, it is easy for designers to present a 3D space by showing any volumetric characteristics such as 3D objects, perspectives from different angles, shadow/lighting effects, and layer/depth presentation. It is interesting to find that all the subjects with design background marked all the three volumetric elements as visual elements to form a space. However, the two subjects with linguistics background did not consider this as a kind of spatial presentation.

#### *4.2.6 Change of Viewing State*

- a. color change
- b. zoom in and zoom out

Through the change of the viewing state on the screen, three of the subjects can feel a sense of space. The viewing state could be altered by fast color change of the same image. As one of the subjects reported, the fast color change, for him, could produce a visual effect similar to opening a physical door. In addition, the viewing state could also be changed by zooming in a specific image in order to go to the next screen presentation or to obtain an enlarged image in order to switch to another function or for more information.

#### *4.2.7 Referential Presentation*

- a. human figures
- b. use of wireframe

“Referential presentation” here refers to the use of some devices to define a space, such as the use of wireframe to delimit the boundaries of a space on the screen and the use of human figures to define the scale of a space. This type of visual elements is only meaningful for 2 subjects, interestingly both are architecture graduate students.

## 5. Comparison

To synthesize the findings reported above, we could find three “core elements” of virtual spaces; that is, the three elements which appear in both the verbal and visual categories: movements, interactions, and acoustic effects. Described human movements in the textual environment or object/human figure movements physically viewed on the computer screen are considered by all the subjects as one of the two most important categories of virtual space elements. Another most important category is “interactions”, including verbal interactions and verbally described physical interactions between/among participants in chatrooms and MUDs, and any kinds of human-computer interactions. The other core element type covers both music and acoustic effects of any kinds. Different from the first two categories, acoustic effects, although marked by all the subjects as one of the crucial elements of visually created virtual spaces, they were marked by only five subjects in the textual environments. This phenomenon can be explained, however, by the fact that in the textual environment, the subjects did not really hear sounds; they felt temporarily in an aural space only through imagination.

In addition, according to our interviews with the subjects in this study and our informal online conversations with other Internet users, verbally created virtual spaces are different from visually created ones. In general, for all the subjects in this study, verbally presented virtual spaces evoke a sense of space at a degree much higher than visually created virtual spaces because in the former, the space of imagination is much larger. All of our subjects pointed out that when viewing the visual presentations on the screen, the kind of spaces they felt is a space “out there”. They felt like they were watching TV, movies, or cartoons. The spaces presented in front of them are thus separated from them by the appearance of the computer. Just as Strate (1999) states, they are “on the outside looking in”; they don’t feel that they are “in” those virtual spaces. Only in one condition, they could begin to feel like being in a space, that is, in situations where the animation and simulation presentations are visually as real as the physical world.

On the other hand, verbally created virtual spaces are not physically seen, they are spaces in the mind; they are spaces of imagination; and they are spaces of uncertainty. However, although invisible, as our subjects testify, once they log in and enter, say a chatroom, they feel that they are in a space already. The feeling of being in a space is so real, although the shape of the space is vague.

## 6. Conclusion

Architecture, in a professional sense, deals with spaces in terms of spatial elements including floors, walls, columns, beams, and roofs, etc. Mostly, in the physical world, the sense of space is constructed by these so-called architectural elements, and this has become common understanding of designers. However, the results of the verbal and visual analysis by the subjects in this study seem to be very different from what designers would normally think. All subjects pointed out that movements, interactions, and acoustic effects are the major elements for them to sense a space, not formal and volumetric elements as architects would expect. This unexpected finding might reconstruct our understandings of the sense of space learned from our architecture history class. Further research with more cautious research design is needed to verify this finding.

In addition, the implications of this study are related to the use of media in architectural design processes. In order to express the idea of space in designers' mind, during the design process, conventionally, designers use normal media (sketches, hand drawings, and physical models), to express traditional spatial elements in an exact coordination system. However, from the result of this study, we understand that the major three core spatial elements could not be expressed via these traditional media. Two serious questions are raised then. First, how can we express the three major and some other spatial elements by traditional media that are incapable to express them? Do we designers have missed these core spatial elements for a long time? Or, do we have alternative ways to do it? Second, what kinds of media should we use in order to capture the major spatial elements more easily, effectively, and expressively? Do current digital media serve these purposes better than traditional media? If, yes, that might explain why digital media are becoming popular and well accepted in architecture even though we don't quite understand why previously.

The findings of this study, though preliminary, seem to add new information to our understanding of virtual spaces. But these findings seem at the same time pose more serious questions. It would be interesting for future studies to investigate all questions raised above. In short, all the above questions are related to how the understanding of newly emergent virtual spaces influences architectural designers in their real-world practices in the digital age. Finally, to obtain a fuller picture and an even more appropriate understanding of virtual spaces, further research is needed to study the same issue by examining more Internet participants with various educational backgrounds.

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