Digital Architecture: Theory, Media and Design

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**Keywords:** cognition, computing, digital design media  
**Abstract:** Computers, the new digital media, liberate the duality of concepts of space in human civilization. The construction and simulation powers of digital media trigger all kinds of unlimited imagination. The new space of this kind may be called digital space or virtual space. This new space is between mental and physical spaces because it provides designers with not only unlimited imaginality of mental space but also live-inside perception of physical space. A new concept of space of mankind is thus generated.

## 1 INTRODUCTION

The history of architecture could be regarded, in some sense, a history of developments of form and space (Liu 1998). Initially, designers manipulated space by using architectural methods in order to interpret what they observed from lines and shapes in the natural environments, which are basically and mostly free-curved. Although what they saw and what they could imagine was unlimitedly free, the architectural forms that they could create were unfortunately limited. Due to the limitations of design representation, architectural materials, structural and construction technology, what they could do was simply producing limited geometric lines to reflect the unlimited free-forms observed from the natural environment. The fruitfulness generated during the process from observation to imagination and the limitation facing the human architect in the process from imagination to creation are the cognitive and biological sadness of human architects. There is no difference in this regard in the Eastern and Western history. Architectural design sometimes develops based on this kind of limitation and spontaneous sadness; and architectural theory consequently evolves philosophically and phenomenally in order to interpret the distinction between artefacts and nature. On the other hand, artists do not need to be limited by the use of any representation techniques and architectural technology, the freedom of art is thus far beyond the freedom of architecture. This becomes critical distinction between pure arts and architecture (Liu 2002).
A COGNITIVE/ COMPUTATIONAL STUDY ON SPATIALITY

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, research papers on spatiality discuss the nature of virtual spaces by examining the verbal and visual elements involved in the creation of a sense of virtual spaces (Liu 2001; Huang et al. 2002; Chang et al. 2002).

To synthesize the findings mentioned 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.

All the verbal and visual elements of virtual spaces discovered through various
experiments and interviews are preliminarily 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. Further studies related to the role of digital media in the construction of a sense of space are suggested.

3 PHYSICAL AND VIRTUAL DEVELOPMENTS ON DIGITAL MEDIA

Digital media including the CAD/CAM technology, rapid-prototyping, Internet, VR-cave, motion capture, 3-D body scanner, and blue-screen have already influenced both design/ construction process and the concept of spaces (Mitchell 1999; Liu 2001; Liu and Bai 2001; Tan et al. 2002). Since 1990, the digital design process and its corresponding construction procedure have been implemented by several pioneering architects, such as Peter Eisenmen and Frank Gehry (Figure 1). 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 (Agnew 1993; Gould 1998; Chang 1999; Maher1999; Strate 1999; Chen et al. 2002).

Figure 1 Headquarter Office of GreatLink Corporation (Shenzhen, China, 2002-2003, AleppoZONE)
3.1 The Identity in Physical and Virtual Spaces

In the new digital age, the most pressing issues facing our society is the question of identity, both in terms of how we conduct our daily lives and in terms of our sense of individuality. In the real world, each person’s character is shaped according to his or her culture, society, knowledge, economics, etc. And each individual, in turn, must interact with a pool of other individuals. For example, think of how an intellectual would choose to express himself. A man must conform to the expected image of a “man” created by society; A “Punk-Rock” teenager is expected to be rebellious; a thirty-year old woman is expected to be elegant; a child is expected to be innocent; a senior citizen is expected to be kind and gentle. These frameworks for identification are both innate to the individual and are also acquired traits, which have, in a sense, become irremovable shackles, pigeonholing individuals according to prescribed categories.

3.2 The Compromise of Architecture in Physical and Virtual Spaces

In the digital age, both the field of architecture and architects themselves must face the myriad of developmental conundrums and restrictions outlined above. In the real world, not only is architecture shackled by concepts such as culture, economics, and politics, but also by restrictions on construction materials, construction methods, gravity, the laws of physics, etc. Thus, in the real world, architects must make significant compromises to their abstract visions so as to conform to the restrictions outlined above.

At the same time, architects often have new and exciting ideas, but because they are expected to conform to the way society expects architects to be, their true nature or true imagination is bound up and silenced. In such an environment, the concept of identity keeps architects from releasing their true imagination as one could, say, in designing an intense and active world to be sued in a video game. Similarly, since real world building construction requires following a multitude of guidelines and restrictions, not to mention the restrictions placed on the architect himself in terms of conforming to a particular identity, it is easy to see how extremely constrictive and limiting the entire process can be.

In cyberspace, however, all of these restrictions are removed and imagination can flourish; the laws of nature can be suspended; things can be changed at will; building costs are irrelevant; construction methods are irrelevant; the concept of personal identify hindering one’s actions no longer applies. In cyberspace, an architect’s multifaceted identity can be released. Thus physical space and virtual space are to be equally important developmental arenas for architects as we move forward.
3.3 The Coexistence of Physical and Virtual Spaces

It can be said then that both physical and virtual spaces have been particularly affected by the new developments in digital technology (Figure 2). Digital technology can allow designing efforts for both physical and virtual spaces to thrive, with both worlds able to survive. Accordingly, one can move easily and instantly between physical and virtual spaces, making the integration of both realms and important concept for architecture in the coming years.

Figure 2 Motion-capture in Virtual Chung'Ann (Taipei, 2002, AleppoZONE)

4 DIGITAL IMPACTS ON ARCHITECTURAL DESIGN

It can be said then that both physical and virtual spaces have been particularly affected by the new developments in digital media. Digital media can allow designing efforts for both physical and virtual spaces to thrive, with both worlds able to survive. Accordingly, one can move easily and instantly between physical and virtual spaces, making the integration of both realms and important concept for architecture in the coming years (Liu 2002; Liu et al. 2002). Two practical projects which applied various digital media in the beginning of the design processes had been constructed in order to implement the idea of coexistence of physical and virtual spaces. In the first project, CAD/CAM, 3-dimensional scanning and rapid-prototyping had been efficiently used. The design team had mentioned (Figure 3):

*After the design phase, various free-form elements were tested and fabricated. Actually from this time, we entered into a much more challenging phase. There were no any modular or standardized frame or surface in the design. In fact, there was no module at all! We should be able to control a high degree of accuracy and efficiency for producing all different angles and curves. Because in Taiwan, the technological quality of architectural industry is still insufficient and unfamiliar with these kinds of digital processes and requirements, the design team searched for assistance from high-tech industrial design companies and even car design companies, to test accurate laser-cutting and rapid-prototyping technologies. All free-angled folded*
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frames and surfaces as well as all free-curved plastic surfaces were pre-fabricated by February 13, 2001. From then on, the challenge and goal during the site assembly phase were to guide the labours how to assemble these digital elements to the level of 0.5mm accuracy. Both supervisors of the contractor and the design team discussed (with occasional arguments) back and forth numerous times for solving all kinds of problems we wouldn’t imagine in regular design projects. The project was completed on June 15, 2001. It took us six months and 20 days. (Liu et al. 2002, p. 48-49)

Figure 3 Reception Lobby of Bcom Corporation (Taipei, 2000-2001, AleppoZONE)

In the second project, in addition to the fore-mentioned digital media, VR-cave, head-mounted displays and tactile gloves, are further used to increase the “real” space. The design team had mentioned (Figure 4):

How big is enough for a museum? In the history of architecture, even though people wished to construct their buildings as big as possible, they failed due to human limits on materials, structure, gravity, and even human perception as well as vision. A museum is never big enough if it is a physical one. In terms of physical media, all the physical elements of architecture are limited in increasing the spatiality of buildings. Physical space, even it is huge, is finite. In contrast, virtual elements of architecture are able to augment human perception of spatiality in terms of digital media and technology. In other words, virtual space, even it is tiny, is relatively infinite. The statement here is not yet complete: is virtual space big enough for a museum, even it is relatively and almost infinite? The answer is rather clear. The virtual space is still limited when compared with human imagination. Therefore the coexistence of physical and virtual spaces is so far the only direction to try the idea.
of “boundless space”. (Liu et al. 2002, p. 13-14)

Figure 4 Virtual Space in the Quanta Virtual Museum (Kuei-Shan, Taiwan 2002-2004, AleppoZONE)

5 CONCLUSION: TOWARDS A MACRO DIGITAL THEORY OF ARCHITECTURE

The history of architecture, to some extend, could then be regarded a history for developing concepts of space. Therefore, architecture would dramatically evolve whenever the concepts of space of mankind crucially evolve. Human beings possess spontaneous spatial capacity; we may call the space of this kind mental space. For instance, we realize the ideas of heaven and hell to be called theological space in religion; we follow symbols and taboos to define ritual space in anthropology; and social space in sociology, psychological space in psychology, text space in literature, expression space in music. These mental spaces almost have no boundaries and consequently provide designers with unlimited imagination for thinking. However, the only limitation is that mental space fails to form the lived-in perception. In other words, mental space enables people to imagine unlimitedly, but it is too abstract to
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feel inside the space.

5.1 Dual Concept of Space

In contrast to mental space construct by human mental capacity, on the other hand, we construct physical space by artefacts. Although we always expect that the creation of physical space is unlimited, actually it is limited in many ways. For instance, in the developments of architectural space, the physical space had been evolved from solid mass in Egyptian pyramids, void space in Tao, in-between space, inside-out spaces and so on. In the developments of building construction and materials, we had invented numerous technologies which enables designers to build from small to big, from low- to high-rise, and from solid to light constructions. Moreover, due to the digital technology, totally free spaces and buildings like Gehry’s Bilbao Museum could be born by the end of 20th century. In the developments of design thinking media, we had represented design thinking through architectural plans, elevations, and sections since Egyptian period. In order to capture spatial and constructional complexity, in Renaissance, architects had begun to use physical models in all ranges of scales. Finally we developed totally unlimited free-form thinking thanks to digital media. In summary, we expect that physical space could be unlimited for design thinking driving by the unlimited capacity of mental space, but it is limited by nature. However, due to the evolution of construction, materials, and media, the boundaries of physical space evolved a bit in history. Therefore, although physical space could not enables people to imagine unlimitedly, it is very concrete to feel inside the space.

In the long run, architects had struggled between the conflicts “imaginable and unimaginable” and “ inside or not inside”. The complimentary concepts of physical and mental spaces had led architecture for thousands years. Designers eager to possess endless imagination in association with in-side spatial perception, but we eventually fail. Only the paper architecture could bridge the gap slightly because of its concretion and unlimited imaginality; but the live-inside capacity remains poor.

5.2 Trine Concept of Space

Computers, the new digital media, liberate the duality of concepts of space in human civilization. The construction and simulation powers of digital media trigger all kinds of unlimited imagination. People could feel vividly inside the space we create in the virtual reality cave simulator. Moreover, many people already spend hours a day or even longer to “live in” a virtual place called cyberspace where the spatial experience, human-environment interaction, and human-human interaction differ heavily from those in physical space. People could arbitrarily hyper-link to other places like in scenarios of sci-fi novels; the organisation of cyberspace extends the current rigid adjacency of space. The new space of this kind may be called digital space or virtual space. This new space is between mental and physical spaces because it provides designers with not only unlimited imaginality of mental space but also live-inside perception of physical space. A new concept of space of
mankind is thus generated (Liu et al. 2002; Wan et al. 2002).

The initial dual concept of space in architectural history has liberated. A new trine concept of space is evolving due to digital design media. From now on, people are able to walk back and forth in mental, physical, and digital-virtual space as they want. New media create new spaces; new spaces in turns create new architecture.

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