NAVIGATION IN 3D INFORMATION LANDSCAPE—A 3D MUSEUM FOR CIVIC BUILDINGS

TENG-WEN CHANG, IH-CHENG LAI
Graduate Institute of Architecture, National Chiao Tung University, Hsinchu, Taiwan, R.O.C.
tengwen@arch.nctu.edu.tw, ihcheng@arch.nctu.edu.tw

Abstract. Navigation is about information that requires visual feedback and spatial orientation in both information representation and user-interaction. Among those, spatial orientation is the primary research question for navigating in 3D information landscape. By inspired by Ware's three control loops, 'spatial metaphors' and 'visual components" are proposed as the fundamental concepts of a navigation framework called '*i*-Room'. *i*-Room is comprised of four constituents—*handles, i-Bag, i-Map* and *Focus/scale*. An information landscape based on a repository of diverse digital media of 11 significant civic buildings in Taiwan is designed for testing this navigation framework. An implementation of *i*-Room based on *Muse* of navigation realization and their interaction behaviors with spatial metaphors/visual components is also reported in this paper.

1. Introduction

Navigation is about information. No matter gaining expected or un-expected information, navigation is a reflective activity involving the fun of discovery and exploration mechanism. While information space using 3D space as a metaphor for visualizing the relation and dynamic of information, the concept of navigation becomes an important factor for its success. In order to provide a successful navigation process, visual feedback and spatial orientation in both information representation and user-interaction are two key research issues.

Many researches have attempted to address these issues, notably are information visualization (Spence, 2001; Pereira 2001), data-mining (Bimbo, 1999; Fayyad, 2001), human computer interface (HCI) researches (Shneiderman, 1998; Hix and Schulman, 1991) and interaction with virtual space in design (Chang and Huang, 2002; Chiu, 2000; Chien, 1998).

However, most of researches are only related to two-dimensional representation. The effective navigation in 3D information space remains further exploration. While without a working realization in both visual feedback and spatial orientation, the issues in 3D navigation cannot be fully explored. For this purpose, a virtual space (Lai and Chang 2003) based a repository of diverse digital media such as text, image, animation and sound is created as a test-bed.

For building up an effective navigation for 3D information landscape, it should begin with an understanding of navigators' awareness of environmental information. Even information space is not a real space, physical experience should provide a great insight for understanding the model of navigation.

1.1. THE PHYSICAL EXPERIENCE

As identified from design researches, people use to confront the 'lost in space' issue while navigating in a complex 3D physical space such as urban environment. Researchers, particularly Lynch (1960) and Passini (1984), provide some individual metaphors, that we called them *spatial metaphors*, to reflect human spatial orientation in physical environment. The examples of such spatial metaphors are Lynch's paths, edges, districts, nodes, and landmarks, and Passini's signs, organization, and maps. These spatial metaphors in physical space provide a significant role for understanding or wayfinding in 3D space. Thus, similar approach in virtual space should provide additional mechanism for realizing an effective navigation.

1.2. THE VIRTUAL EXPERIENCE

In virtual space, navigation is another story while sharing some common grounds with physical experience. One main argument is virtual space should not replicate the physical space completely since 'virtual is not real'. This concept is clear in the 3D game-design. However, the concept of spatial metaphors should be the way to build up navigation system. Several approaches including (Lai and Chang 2003) have endeavored to provide a workable user analysis for 3D virtual space navigation. Additionally, similar 'lost in space' symptom is worse in virtual space due to the nature of 2D visual display device. As well, the non-gravity characteristic of 3D virtual world adds another significant but difficult task for navigation.

Therefore, while exploring the users' intend to transform the spatial experience "orientation" from physical space into virtual space metaphorically, we investigate the potential of realizing process from a theory called spatial metaphor to its realization, and illustrate its realization in an example—3D civic buildings museum.

2. Information Orientation

As information orientation is the key for visualizing the 3D information landscape for effective navigation. The main issues of navigation are 1) discovering information with orientation and 2) interactive visual feedback, which involves the transformation between data manipulation and navigation in virtual space. Inspired by Ware's three interlocking feedback loops (Ware 2000): data manipulation loop, navigation loop and problem-solving loop, we argue that navigation is to use the appropriate spatial metaphor to have the information orientation in virtual space. Regarding of Ware's theory, interactive visualization is a process made up of a number of loops that fall into three broad classes. Therefore, there are two fundamental issues, including spatial metaphors and visual components, are analyzed in the following sessions.

2.1. SPATIAL METAPHOR

Spatial metaphors present a conceptual abstraction for realizing navigation. The examples of spatial metaphors in 3D information landscape are *locomotion*, *viewpoint control*, and *map orientation*. Each metaphor plays an important role during the navigation process with different aspect. Meanwhile, they correspond to the *visual spatial maps,* such as *focus, context* and *scale*, to search information.

2.1.1. Locomotion and Viewpoint Control

In 3D information landscape, locomotion provides navigators information orientation through data represented environment, where can harness their real-world spatial interpretation and navigation skills. Besides, locomotion involves viewpoint control for search information. According to Gibson (1986), locomotion is largely about perceiving and using the affordances offered for navigation by the environment.

Ware classifies four types of locomotion metaphor (world-in-hand, eyeball-in-hand, walking and flying) employed in the problem of controlling the viewpoint in virtual 3D space. Insights from them as the navigation are 1) World-in-hand: the navigators metaphorically grab some part of the 3D environment and move it; 2) Eyeball-in-hand: the navigators imagines that they are directly manipulating their viewpoint, much as they might control a camera by pointing it and positioning it with respect to an imaginary landscape; 3) Walking: one-way of allowing navigators of a 3D virtual environment to navigate is simply to let them walk about; 4) Flying: this metaphor having aircraft-like control enables navigators to smoothly create an animated sequence of views of the 3D environment.

21.2. Map Orientation

Map orientation indicates the navigators' location and direction. When information space is large and complex, map can provide information orientation, which can help navigators exploring a 3D information landscape and reduce the cognitive load. In term of control compatibility, there is two alternatives have been studied. They are 1) the track-up map: this map is oriented so that the straight-ahead direction, from the point of view of navigators, is the up direction on the map; 2) the north-up map: the map display that the north is always up, at the top of the map.

Insights from this metaphor are 1) to show where you are in 3D space that is comprised of level of details based on the domain of interest; 2) the direction of a map has to be fixed that is similar to the control panel of desktop environment. Besides, map orientation should provide procedural instructions when the task itself requires navigating from one site to other sites in virtual space.

2.1.3. Focus, Context, and Scale

In addition to locomotion, viewpoint control, and map orientation, there are a number of successful spatial navigation techniques that involve interactive visual display such as distortion, zooming, elision and multiple windows. These techniques make navigators easy to move rapidly and explore information between views at different scales for the domain of interest. Besides, they provide a kind of spatial metaphor: focus-context for navigators in 3D information landscape. The basic insight of this metaphor is such techniques relying on analysis of the user interactive behavior. As well, this metaphor will depend on the platform of implementation and the interaction between the users with the information.

2.2. VISUAL COMPONENTS

The visualization process and their structures are the prominent concept for navigation in 3D information landscape. At the same time, these involve interaction with visual components. To the users, such functionality provides the basic common sense skills of eye-hand coordination for direct manipulation over information. Therefore, using visual components to be interactive with spatial metaphor provides the information orientation in 3D virtual environment. The main visual components are form, color, motion and spatial position. Their characters and definitions are 1) Form as "*spatial figure representation*" of information landscape, including spatial grouping, line characters, size and added mark, 2) Color as "*interaction* *representation"* of information landscape, including hue, intensity and transparence, 3) Motion as *"movement representation"* of information landscape, including flicker and direction of motion, 4) Spatial position as *"coordinate representation"* of information landscape, including 2D position and stereoscopic depth.

2.3. SUMMARY

We summarize that information orientation is fundamental for navigators to involve navigating behaviors such as collecting, interpreting, integrating and communicating information in 3D virtual environment. Therefore, our approach is to take advantage of the characteristics of spatial metaphors to provide information orientation. By integrating with visual components, we propose a navigating framework called "*i*-Room", which is comprised of 4 constitutes—*i*-map, *i*-bag, handles, and focus/scale.

3. *i*-Room Framework

According to the above treatise, we propose a framework "*i*-Room", which provides navigators to have information orientation in a 3D information landscape. This system is composed with orientation constituents including *handles*, *i-bag*, *i-map*, and *focus/scale*. Each constituent has own combination of visual components. In addition, each constituent is related to the individual spatial metaphor such as locomotion and viewpoint control, map orientation, focus, context, and scale. The relations are shown in [Figure 1].

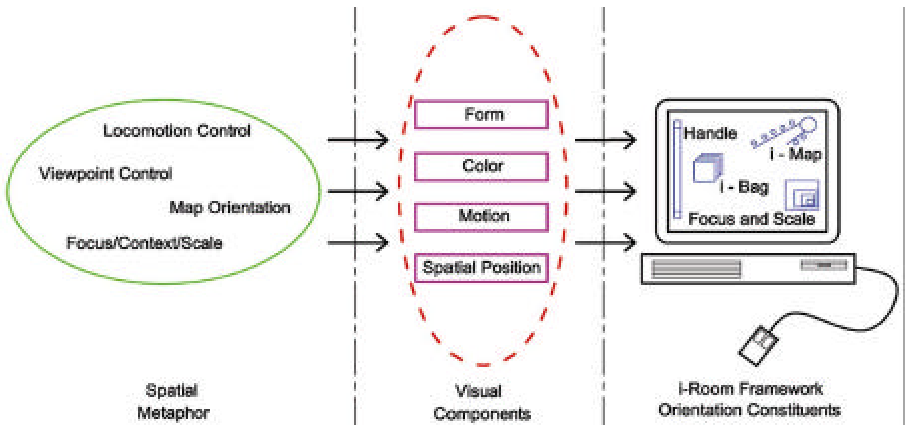

Figure 1: The diagram shows a sequent transformation from spatial metaphor, visualization components to *i*-Room framework.

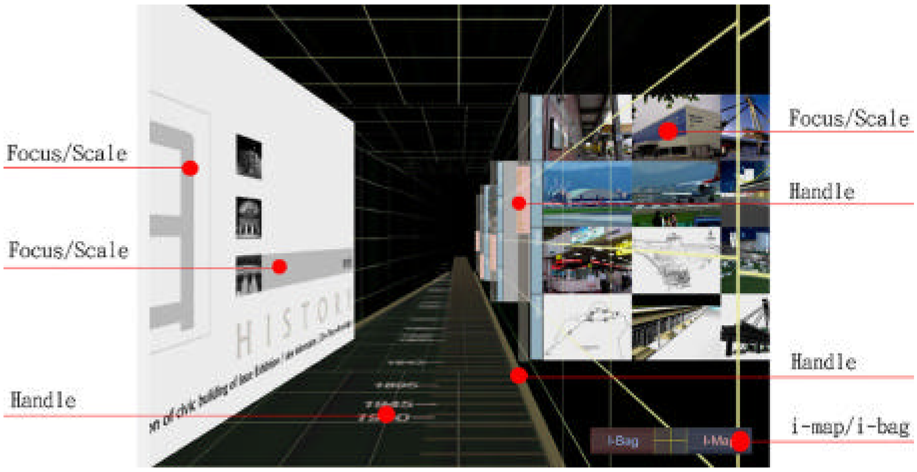

Figure 2: The image shows the spatial constituents in a 3D information landscape.

3.1. I-MAP

In the 3D virtual space, *i*-map and *i*-bag (shown in [Figure3]) is co-existence and ubiquitous in any display by different control of locomotion and viewpoint. *i*-Map is related to the spatial metaphor "map orientation", which provides information orientation for navigators to discovery information in two folds of spatial orientation: global and local orientation. Global map represents the context. Local map then shows in the location of domain of interest. As well, visual components such as form and color described before are integrated with this constituent [Figure 2].

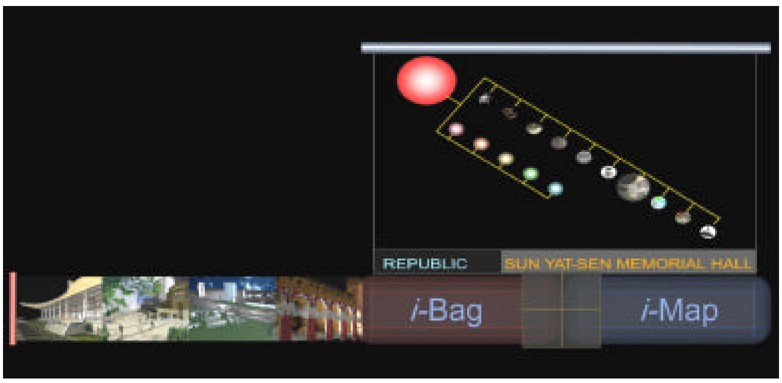

Figure 4. The images show two spatial constituents: i-Map and i-Bag.

3.2. I-BAG

i-Bag (as shown in [Figure 3]) is the constituent related to a repository of data for the specific interest of navigators. This constituent not only reduces navigators' cognitive load, but also provides information orientation for navigators to collect, interpret, integrate and communicate information in 3D virtual space. Focus, context and scale are the main spatial metaphor for this constitute, which is then realized by visual components such as color and form. The details are shown in [Figure 2].

3.3. HANDLE

The handle, which provides some dynamic control cues, attracts navigators' attention for information orientation. This constituent is following the spatial metaphor "locomotion" such as walking, flying or eyeball-in-hand in every 3D information space. Furthermore, motion and spatial position play a more important role than color and form [Figure 2].

3.4. FOCUS/SCALE

Focus and scale, related to the spatial metaphor "focus/context/scale", provide the other alternative of information orientation. According to complex information in 3D virtual space, this constituent interactive with motion event (information hints as shown in [Figure 4]) provides a way of decomposing information. Particularly in 3D information space, this constituent following different viewpoint controls takes advantage of visual components: form and spatial position combined with information hints [Figure 2].

Figure 4. an information hint (as a transparent screen off the screen) when navigator focuses on certain information

4. An Example: Navigating Civic Buildings in Virtual Space

This example is to use 3D civic buildings as a device for understanding the mechanism behind the reflective navigation, especially in 3D. The Taiwanese civic buildings based on four time periods in Taiwanese modern history, including Ching Dynasty, Republic, Japan Occupation and Modern era. The information landscape of this space (as shown in [Figure 5, 6]) is comprised of more than 500 digital media components, and four different time zones. The main task for navigating civic building is able to navigate within a 3D information landscape with multiple interactive layers of space and time analysis.

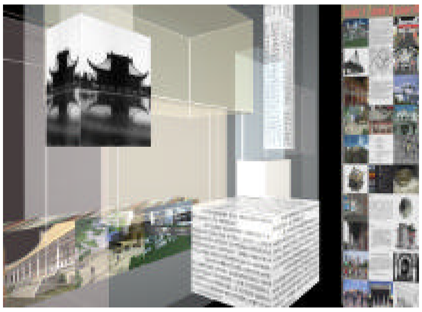


Figure5, 6. The images show two spatial representation integrated with i-Room framework: i-cell and i-cube.

In this case, the primer key for understanding the navigation with information orientation is based on a 3D navigation platform called *Muse* (Muse 2003). We simplify the spatial metaphors as a set of concepts for 3D civic buildings, then, we conduct the example using the following process: 1) assign the image of civic building to ask for meaningful metaphors; 2) analyze this set of metaphors using the elements for our spatial metaphors; 3) assign the spatial metaphors constructively back and ask for information orientation; 4) integrating visual components to achieve a pattern of navigation. Following the navigation analysis and the user-analysis (Lai and Chang 2003), we proposed an "*i*-Room" framework, which is comprised of four orientation constituents including *i*-Map, *i*-Bag, handle, and focus /scale. Each orientation constituent is integrated with four visual components including form, color, motion and spatial position. The outcome will be shown in the following images, including 3D spatial representation [Figure 2], *i*-bag and *i*-map [Figure 3], and other spatial metaphors composed within *i*-Room framework [Figure 5, 6, 7, 8, 9, 10].

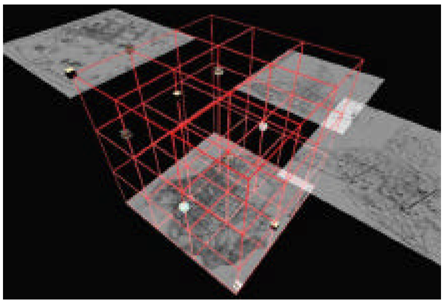
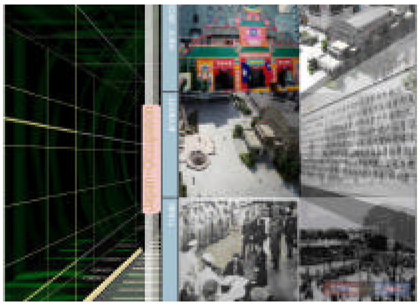

Figure 7, 8. The images show some orientation constituents: handles, scale and focus in the dynamic 3D information space.


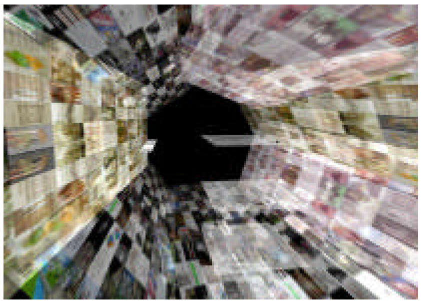

Figure 9, 10. The images of 3D information space.

5. Conclusion and Future Work

In this research, an *i*-Room framework successfully provides a test-bed for understanding the issues of information orientation. In addition, *I*-Room provides a way of interaction between navigators and the information space. Thus it will allow navigators to easily catch up their own information in 3D virtual space. This result also demonstrates how the spatial metaphors integrated with visual components and where it should play an important role for navigating in 3D information landscape.

Furthermore, this research invokes some future directions for development of navigation in 3D information landscape. First of all, a new form of viewpoint control, particularly world-in-hand should be more in-depth studies. As well, the interaction of using our navigation framework requires a further exploration. One of the usages of our framework is utilizing the nature device such as body motion and sensors. By using embodied gestures in physical world, ones might be able to interact with information navigation freely without any limitation. This reflective navigation enhances navigators to collect, interpret, integrate and communicate information.

Acknowledgements

We sincerely appreciate the time and energy our team (3dCOBs) expended in support and sustain of this research: Chao-Chin Chien and Jun-Horg Lin for carrying out the experiments; Shih-Wei Tsao and Kai-Tzu Lu for programming Muse; Wei-Yeng Shao and Ssu-Kuang Lee for collecting data; and all participating students. With all their assistance, we are able to complete this paper successfully.

References

Bimbo, Alberto Del (1999). *Visual Information Retrieval*, Morgan Kaufmann Publishers.

Chang, Teng-Wen and Huang, Jessica H. (2002). A pilot study of role-interplay in Web-based learning environment, *Educational Media International*, Taylor and Francis. 39(1):75-85.

Chien, Sheng-Fen (1998). Supporting Information Navigation in Generative Design Systems, Dissertation, School of Architecture Carnegie Mellon University press

Chiu, Mao-Lin (2000). Museum of Interface-Designing the Virtual Environment, in Tan, B-K, Tan, M. and Wong, Y-C (eds), *the Proceedings of 5th Conference on Computer Aided Architectural Design Research (CAADRIA)*, Singapore, pp 471-480.

Fayyad, Usama (2001). *Information Visualization in Data Mining and Knowledge Discovery*, Morgan Kaufmann Publishers

Gibson, J.J. (1986). *The Ecological Approach to Visual Perception*. Lawrence Erlbaum Associates, Hillsdale, NJ.

Hix, Deborah and Schulman, Robert S. (1991). Human-Computer Interface Development Tools : A Methodology for Their Evaluation. *Communications of the ACM*. March, 1991. 34:75-87

Lai, Ih-Cheng and Chang, Teng-Wen (2003). Companying Physical Space with Virtual Space—A Co-existence Approach, *the Proceedings of 8th Conference on Computer Aided Architectural Design Research (CAADRIA)*, Thailand.

Lynch, Kevin (1960). *The Image Of The City*, MIT press

Muse (2003). http://www.musecorp.com/.

Passini, Romedi (1984), *Wayfinding in Architecture*, Van Nostrand Reinhold press

Pereira, Gilberto Corso (2001). Urban Information Visualization - The Salvador project. Architectural Information Management, in *the proceedings of 19th eCAADe Conference*, Helsinki (Finland) 29-31 August 2001, pp. 517-521

Shneiderman, Ben (1998). *Designing the User Interface-Strategies for Effective Human-Computer*, 3rd Edition, Addison-Wesley press.

Spence, Robert (2001). *Information Visualization*, Addison –Wesley press

Ware, Colin (2000). *Information Visualization-Perception for Design*/ Morgan Kaufmann Publishers press