Abstract

The purpose of this Short Paper is to describe my research interest, think over how it can be related to the research projects of the Design Machine Group (DMG), University of Washington, and discuss what kinds of methods and possibilities can arise when I commence on this research. In this paper, Virtual Reality (VR) based Design Methodology has been proposed in support of my research interests. The methodology is composed with three components: representation, tool, and process. Moreover, These components are focused at constructing the Collaborative Virtual Environment (CVE). I described the features of the three components concerning my prior research for the purpose of making a good beginning to find and play my part of a number of research projects of DMG.

Introduction

The process of designing buildings has become increasingly more difficult, reflecting the growing complexity of the buildings themselves and the processes leading to their design. To solve these difficulties, the primary uses of computers in the architectural design have been shifting from the evaluation of proposed design solutions, to their graphical (and other) representation, and more recently to facilitating collaboration among the various professionals who are involved in the design process.

Currently, each of the research related to design computing and VR has advantages with respect to its ability to support collaboration. However, taken individually, as they have been, they have some limitations to meet the goal of developing and maintaining the initial design ideas between parties, from colleagues to clients progressing the collaborative design process. [1]

My approach to effective collaboration can be considered a combination of design computing and VR research. To combine them into one, I propose a VR-based Design Methodology composed with three components:

(a) representation : a spatial, graphical or verbal representation for communicating the design
(b) tool : a manual or automated way of making the representation
(c) process : a ‘how to’ steps for gathering, managing, designing, and developing the concepts

It is essentially, a careful collection and composition of several design computing researches, with many adaptations and enhancements. Furthermore, I add VR approach to the methodology to create a CVE and easy-to-use and sharable design tool across disciplinary boundaries. Using this CVE, each participant to the design project could see the VR-like representations of the building differently from their point of view. In other words, architects, engineers, construction managers, building owners, and end-users all worked with modeling and communication each other in their own environment or sharable environment.

In this paper, it is not my intention to suggest any one specific methodology in great detail. I just want you to have the knowledge with which you can choose and develop your own hybrid approach by mixing and matching the processes, representation, and tool(s) from various methodologies that make the most sense for collaborative design.
Design Methodology in VR

Merriam-Webster’s dictionary defines the term methodology as: ‘A set of procedures used by a discipline to achieve a particular desired outcome’. In recent years, there have been some pushes in Design Computing to meld the best ideas of competing methodologies into a single case approach. However, in terms of VR, it is possible to make a useable, flexible, maintainable and reliable methodology including a general discussion of CAAD pros and cons.

VR makes the presentation better for the architect because his/her intentions can be made clearer that through sketches, drawings and models which only can transform an idea of architecture. Kalawsky defines VR as the term for an area in which computer generated virtual environments is used to communicate physical and abstract components to a human operator. [2] These operators are actors in an artificial model of an environment and by interacting with this simulation they can obtain a feeling of immersion, according to Kalawsky.

According to the immersion, VR can be generally categorized into three sections: Immersive and Semi-Immersive, and Non-Immersive VR. However, regardless of the types of VR, the rapid advances in computing and communications are dramatically changing all aspects of our lives. In particular, sophisticated 3D visualization, display, and interaction technologies are being used to complement our familiar physical world with computer-generated augmentations. These new interaction and display technologies are expected to make our work, learning, and leisure environments vastly more efficient and appealing. Within different application areas, variants of these technologies are currently being pursued in research and development efforts: Augmented Reality (AR), Augmented Virtuality (AV) and Virtual Reality (VR), which span the so-called mixed reality (MR) continuum. [3, 16]

In consideration of Collaborative Architectural Design, these issues must be focused on collaboration that recognizes the new communication ways and simulation including the new ways of representation. To confirm these technical innovations, the development of general design methodology is required to support the design and the design knowledge between the different areas. Design methodology has to accept the design possibilities deduced from the technical innovations regardless of time and location.

Representation in VR

The first step in facilitating collaboration is recognition of different interests of participants. This means that design representation, of the kind used by each one of professions, must be inclusive of the information used by the other professions. Hence, a more comprehensive representation than currently in use is needed. Design representation is not only used to document the final design for construction; it is essential for the development and communication of design ideas. To be used in VR, how could architectural information be represented? There are two types of representations: the representation of designs and the representation of design knowledge in architectural information. [4]

The representation of design itself in VR is used for stimulation in consideration of the types of immersion. For example, immersive and semi-immersive VR systems allow the user to be intuitively in the Virtual World (VW) and get impulses and visualizations which their experience as real before construction. Moreover, to manipulate and create objects in VR, designer can interact directly with the virtual objects using gestures similar to those that one would use to manipulate real objects: turning around, throwing, picking up, and so on. [5]

The representation of design knowledge can be achieved with 2D and 3D diagrams constructing the metaphorical design space. The space can be used for managing the design information through navigation. The geometric properties such as distance, location, and scale in this type of representation show what the information presents, which information is more important, how we can use the information, which information is related to, etc. Dimensional-Information (figure 1) has been suggested as Collaborative Architectural Information Management Tool in FEIDAD2001. In this system, I’ve abstracted several types, such as axis, box, event, text, image, link and path from architectural information to represent and construct the hierarchy of the information. [11]

To carry the initial design concept through the design process, the two types of representation in VR are considered together through design process and design tool.
Design Tools

To support architectural design in VR for collaboration, three design tools are available for the creation and distribution of 3D objects: knowledge-based tool, network-based tool and model-based tool.

Knowledge-based tool deals with the processing of knowledge. [4] In order to represent the design knowledge in VR, there must exist ways to construct the design knowledge with the initial information through the design process. Concerning the two types of representation in VR, it is needed to consider design models to abstract design knowledge and architectural design itself together. As mentioned above, Dimensional Information can be used as a start point to model design knowledge. In case of handling a design itself, StuPLAN (figure.2) will be helpful to construct this kind of tool. This system automatically constructs and manages well-structured floor plans with minimum geometrical inputs from the designer. This system took advantage of the building data model developed from the prior research. [1, 18] The model includes hierarchical building components such as ‘building’, ‘plan’, ‘space’, ‘ring’, ‘wall skeleton’, ‘surface’, ‘column’, etc. The algorithm developed assures a semantically rich and structurally correct floor plan at any point in the design process. [9, 13]

Network-based tool provides modules to distribute the geometric information as well as their properties by the Internet. Internet provides an excellent infrastructure for the collaborative design. Web-based CAD systems, such as WebCAD (figure.3) and WebMOD (figure.4) were developed for Collaborative Design Environment (CDE) using the Java technologies such as applet, JDBC, and Java3D. In this system, my approaches are automatically to construct and manage well-structured floor plans based on a robust building data model hoping to connect the semantically rich objects to web database. It is possible to synchronously transfer designer's messages including drawings to others located at a distance. Moreover, the tool itself can be put into the web browser to be used at any time and any place because of being developed with applet. So, the knowledge of objects could be linked to the objects to contain the related architectural information. [10, 11] User can attach their additional information to the virtual objects directly through the Web.

Model-based tool is not only to make a model with library, but to also support the user’s interaction with the geometric constraints and assistant modeling functions. Interactive Building Modeler (IBM) (figure.5) developed in Center for Computer Graphics Virtual Reality (CCGVR) has some easy-to-use functions to be used to make a building on a Virtual Workbench. Basically, the 3D modeling techniques related to Navigation, Selection, and Manipulation [5] are combined and conducted into one model represented on the Virtual Table. In this system, for constructing selection and manipulation essential for architectural design in VR, I proposed a 3D interactive grid as well as extended snapping. The work plane to contain grid is freely defined according to the user’s hand movements by using three-dimensional interaction tool, such as a Prop, with an attached magnetic tracker in order to make the manipulation of work plane where the grid is located three-dimensional. Besides, it provides a control handle that displays object manipulation data and numerical handle that displays numerical data – both necessary for supplementing restrictions of data display during modeling production. Moreover, this system produces reference objects by inputting data on basic building elements, such as windows, roof, doors and walls through the Interpreter module. In addition, by providing such building values as type, direction, location and size of building elements, it enables users to select desired details of building elements from the library and reference objects of building structure, and allocate them to a precise position by automatically adjusting the size and direction. [6, 7, 8]
Architectural Design Process in VR

To facilitate the VR and Collaboration, the design process is focused at two points: constructing design-environment and developing the current design itself. The tools and representations in VR will be used in each process for completing their purposes. This process model aims at enhancing the architectural design process with a continuous information flow from concept through construction in VR. They never need to recreate information as they progress from one design phase to the next. The continuity of design with this process helps us to advance our design as well as share with others in VE from a data collection, to a massing study or a diagram, to a 3D model, to finished construction, all the while keeping their initial design vision intact.

Information Modeling (IM): has two steps; gathering architectural information and building VR space for navigation by the Web. In terms of the types of information, each appearance of objects represents its property such as model, drawing, photograph, sketch, sound, and video recording, etc. [15] IM might be used to construct a type of Virtual Architecture (VA) for architectural information. Designer can communicate and share their design ideas in this VA. Moreover, this Virtual Design Environment (VDE) supports the other modeling process to organize the design information. For example, 3D spatial information can contain other design outputs made from other modeling processes.

Conceptual Modeling (CM): The model created in accordance with the initial design idea proceeds to the next stage and transforms into a more concrete form. This is done to preserve the user’s initial design concept throughout the entire design process. The way of CM depends on the designer’s intention and available technologies around him/her regardless the physical or virtual approach. There is a need to consider what kinds of tools would best support design and how they could be integrated with the far more developed SM.

Structural Modeling (SM): provides various intelligent modules for converting the CM model to architectural model having the functional behaviors and relations. SM is available for the generation of the followings; spatial and building elements; evaluable alphanumeric properties; VR-based representation properties linked with IM. SM might include a number of research projects related the cognitive and computational models. The important thing in this stage is to determine whether to build a SM model synchronously or not and to make a design buffer zone [14] concerning the design flexibility and feedback.

Advanced Modeling (AM): here relates more closely to traditional design phase that should occur after all requirements, specification and design outlines. AM is completed by using subsidiary models, materials and colors in each VE divided with the area. Also, the VDE of AM is constructed with the designated spatial information extracted from a SM. For example, we extract individual floor space models from the SM into separate design components. We build each floor space and complete its work by adding increasing levels of detail in AM environment. Next, selecting wall styles to match our building requirements, then convert the walls, door and roof with the new wall styles. Once we have completed work on each floor space, externally reference them back into its SM to create a detailed design development model. Configure stairs and add them to its own SM.

Conclusion

This paper so far has shown that the design methodology to support Collaborative Architectural Design. The concepts of VR and Design Computing could be integrated into the three components composing the proposed methodology. The focus of this paper is to present the points to be duly considered at the each component. No doubt, the three components are suitable target for expansion and the methodology itself may radically change or be replaced. However, a number of areas of possible future research have been identified some of which are already under consideration in my prior research. My interests up to this point, was ‘how to construct a Design Environment (DE) for architectural design’. I have worked on design process, representation, and tools, considering the important problem, ‘how to utilize the DE’. I believe that the each research related to CAAD can be consistently progressed through this methodology.
Reference