COMPARATIVE NAVIGATION SYSTEM FOR COLLABORATIVE ARCHITECTURAL DESIGN

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Abstract

As information technology continues to evolve, it is affecting all creative art forms by providing new tools and surroundings, such as virtual environments. 3D real-time simulation environments strongly support communication and navigation, enabling users to collaborate on designs using centralized or distributed environments. The persons concerned must understand the proposed design. Systems that help them gain this understanding are therefore required. An effective concept for gaining understanding is comparison. However, comparing one design proposal with another using existing systems is difficult because the users must consider their viewpoints separately. In this paper, we describe the concepts, strategies, and functions of a 3D virtual design environment for collaborative, real-time architectural design that is based on our 3D comparative navigation system and real-time simulation technology. We also evaluate the advantages and disadvantages of using this design environment to support collaborative architectural design.

1. Introduction

The opportunities for 3DCG to be utilized as a tool by specialists in considering architectural designs have been increasing in recent years. Consciousness about design has been increasing and it is essential for efficient architectural rendering and agreement between persons concerned. The role of 3DCG is abundantly clear for specialists and non-specialists alike who want to effectively understand design.

The examination of designs by persons concerned and the demand for presentations are high. Various viewpoints need to be considered in collaborative design, not just the viewpoints assumed by an enterprise body or a designer.

There is also an increasing demand for designs to be able to respond immediately to demands in presentations.

Collaboration up till now has involved the creation of still pictures or animations from a viewpoint which has been assumed in advance. However, it is actually difficult to guess all the assumptions for all the needs that the persons concerned. Moreover, with collaborations, immediate responses cannot be made to spontaneous needs.

We need to focus our attention on a 3D real-time simulation engine as a tool in the design process to solve these problems immediately. A 3D real-time simulation engine would provide an effective, interactive, and rapid platform for design. It could be applied to all stages of the design process and we could check our designs at any time, anywhere and at any stage inside that platform. Visualization and interactivity enable good communication between the customer and designer to reduce misunderstandings. Real-time interactive previews are expected to become major processes in design studies in the future.

Recently, personal computing power has been increasing very rapidly. Low price and high performance are the main reasons for the popularity of PCs. Visual simulation and computer animation are moving from expensive workstations to inexpensive PCs. We can now obtain faster rendering speeds and higher quality results from PCs. 3D real-time simulation is another mainstream force for visual simulation rendering high-speed, high-quality images.

Architectural design involves two major components, i.e., photo realistic and scenario scripting, which enable participants to feel a greater sense of realism: however, in the field of entertainment, movie makers and video-game programmers are investing a great deal of economic and human resources in developing a good interactive interface, i.e., 3D real-time simulation engine. This field is expanding very quickly but depends on the benefits it can bring to the entertainment market. It has grown considerably over the past few years and hardware and software developers are focusing on this field and gradually approaching perfection.

A good interactive 3D development platform was the aim of our research, and we had an urgent need to use 3D real-time simulation techniques for architectural design to enable us to produce better designs. We therefore focused on applying a real-time simulation engine to architectural design.

1.1. Comparison for collaborative design

The persons concerned in design must understand the proposal on which they are working. Systems that help them gain this understanding are therefore required. We propose comparison as an effective method of assisting understanding. People may be compared with other objects to help them understand a certain object. By considering the difference, a person can recognize and understand an object. That is, by comparing and uniting, areas with similarities and differences are clarified and users can recognize each of these. Therefore, we put considerable emphasis on comparison. A person can clarify the correlation, the influence, and the causal relation of objects by multilaterally comparing these objects. In addition, a person can deepen his or her recognition of each feature of the object by comparison, and is guided toward understanding.

However, comparing one type of content to another using existing systems is difficult because users have to locate and observe them from separate viewpoints. We therefore created a prototype system that displays different content simultaneously while controlling the viewpoints automatically to facilitate comparison of content. Such a comparative navigation system enables comparison between design proposals by displaying related parts of the proposals automatically. Our 3D comparative navigation system is semantically a 3D extension of such a system. People can walk through only one space in reality, but in virtual space, the user can walk through many spaces at the same time. This is a key concept of the system, and it is intuitive and effective.

2. Navigation function by content for comparison

To gain an understanding by comparison, we need to consider the original purpose and object first. The content changes according to the comparative purpose and comparative object.

We have been examining various comparisons in the design project over many years using various media, such as real-time simulation, animation, and still pictures. A function required for comparison navigation was extracted through an example from the examination of comparison for the design project. Therefore, the main content for comparison done in the design was arranged according to the following two viewpoints necessary for generalizing and sharing with the comparison technique.

- Comparing the differences between existence, form, and size reveals the identity, similarities, heterogeneity, and features of 3D structures.

- Comparing changes in the object over time reveals similarities and differences and the process of change, which occurred at each stage.

The function of comparison navigation was considered based on these two viewpoints required for generalizing and sharing with the comparison technique. The function was arranged according to the comparison purpose, object content, viewpoint setup, viewpoint movement, screen separation, and expression of content. Consequently, the following ten items were extracted to provide a function to enable general comparison navigation. They are screen division comparison, photograph/ model comparison, transparency change comparison, superposition comparison, model change comparison, camera viewing angle change, shadow display, comparison object insertion, measurement function, and guide map display.

We developed a comparison navigation system that uses real-time simulation technology to facilitate interactive comparative studies in 3D architectural design based on these items.

The technology required for the system is described below.

3. Technology

Various tools, including existing modeling tools and image-editing tools, were utilized in developing this system. The main technology used was real-time simulation.

In this study, the interface for a real-time simulation system was developed and added to the graphical user interface (GUI) using the Microsoft© DirectX Graphics®-Application Programming Interface(API) based Virtools®, an authoring tool utilized in the game development environment. Producing architectural simulation is an impossible task for non-professional programmers. Architectural designers basically have no idea on how to produce a 3D scene. Virtools's building block system was specifically designed to meet the needs of cutting-edge interactive 3D development, and is the only interactive 3D authoring tool accessible to non-programmers. Building block is a subprogram packaged in DLL. We assigned building blocks in the scene as object behaviors through the visual authoring interface. After this we could modify our scene by linking building blocks (another subprogram). The building block system is a powerful behavior-based interactive 3D development tool for the PC. Specifically designed to meet production needs of cutting-edge architectural simulation, the building block system provides the groundwork and tools to allow users to unleash their creativity and harness the full potential of the 3D real-time simulation engine. They can import industry-standard media files to the building block system as 3D models, textures, characters, sets, and sounds. They can attach behaviors to these entities to create interactions. Graphically assembled, they can control and tweak the behaviors to a higher-level element that forms the foundation for interactivity or simulation. The building block system's intuitive graphic user interface lets us design and instantly experience-sophisticated interactivity in real-time 3D environments. We can collect behaviors from a multitude of sources, existing libraries, and other projects or exchange them on the Web. This system's open architecture makes them all compatible so we can recombine them with existing modules.

The interface was made using internal scripts, as we can see from Figure 1.

Figure 1: Scripts for real-time simulation interface on Virtools®

Specifically, this was used in rendering at a speed of 10 frames per second (FPS) in an architectural design project that contained 800,000 polygons of data. Thus, a high-performance machine was needed to achieve smoother movements in real time. We used a notebook computer with a 3.2GHz CPU, 2GB RAM, and an ATI

RADEON 9800 GPU for real-time rendering.

4. Prototype system

This system was designed for comparative navigation in collaborative architectural design. We first established the conditions for the system so that it could use real-time simulation technology as a base.

- High-speed rendering system : A high sense of reality and high-speed rendering are a trade-off. If the system tries to fulfill both functions, it may not have sufficient performance for both. Priority is given to rendering at high speeds to achieve real-time simulation. Simultaneously, a system that can ensure the highest sense of reality is needed.
- Lightweight 3D data : Maintaining sufficient rendering speed can be achieved with weight saving of data. It is necessary to find out how to archive sufficient data speed while maintaining the required reality. Further, it is necessary to minimize stress for the user when using the system through the Internet. Therefore, the system needs to complete reading 3D data within 10-90 seconds at least. This can be changed by selecting suitable hardware and software.
- Easy operation interface : It is necessary to offer an interface that can be operated easily. When there is a situation where operation does not complete drawing, the performance of the high-speed rendering system will decrease. Moreover, it is necessary to offer an interface that can be used immediately, even if a user has only just seen the system for the first time.

4.1. System outline

This system enables a general user to arrange a building in virtual space.
The internal and external design models of the building are first recorded on the modeling server. If the name of a building that a user wants to access and use for the server for network distribution is chosen, the interior and exterior space models suitable for it will be retrieved from the modeling server. Moreover, if a design proposal to use it is chosen, the model will be loaded from the modeling server and it will be sent to the user. The user can design the proposal while manipulating the model in virtual space. The user can also record the data on the server using his/her ID.
The system consists of the following elements (Figure 2).

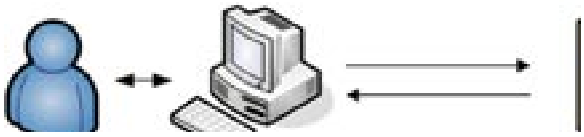

Figure 2: System configuration.

- Server for network distribution : This registers the user's personal information through a general user-oriented interface that is easy to use.
- 3D model server : This has the internal and external design models of the building, records various kinds of model data in a database, and is connected with the network for distribution.
- Personal computer : This is a device for viewing distributed information. It is for general users, and it is necessary to install the software for data distributed from the system.

We then designed the GUI, which included a fundamental operation function, as shown in Figure 3. We optimized the comparison navigation function, which is the most important concept of this system, so that it could be fully utilized. For example, to enable many types of content to be compared, we designed the screen switch for one-screen comparison and two-screens comparison.

4.2. Main functions for comparison

First, we explain concurrent comparison navigation function briefly. Users can compare many types of content on the same screen. For example, they can make a comparison between one design proposal and another design proposal on the same screen. A new design proposal can also be compared with the existing building on the same screen. Also, when the examination with

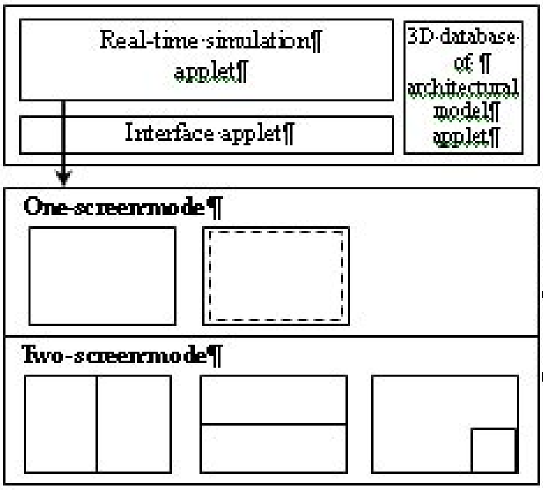

Figure 3: Graphical User Interface (GUI) flow

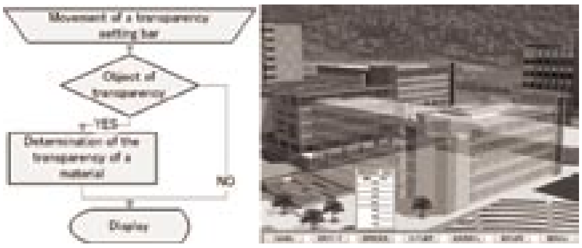

Figure 4: Procedure using the superposition comparison function (left) and snapshot (right).

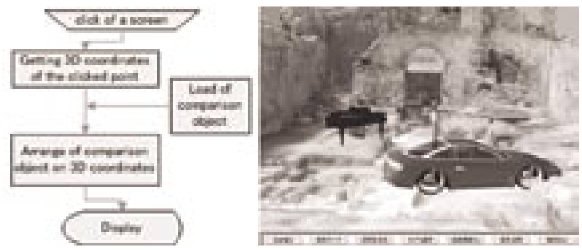

Figure 5: Procedure using the comparison function for comparison object (left) and snapshot (right).

circumference environment is performed, comparisons can be made in various screen modes between the present situation and that when the building has just been constructed.

The following items are the main functions for comparison.

Comparison navigation on one-screen

- Superposition comparison : A comparison of position and size is possible by layering two types of content and changing the transparency for one or the other.
- Putting in comparison object : The size and scale of content can easily be understood because anyone can insert and display a 3D model of known size.

Comparison navigation on two screens

- Vertical/Horizontal screen division mode: It is possible to compare content while walking in virtual space by displaying two types of content on the same screen simultaneously. This function enables the composition of space to be understood through two cameras and this information is displayed either on the left/right or top/bottom of the screen. A controller that operates one camera is shown on both screens. Also, there is a controller that operates the camera of both screens simultaneously in the center of a screen. And, users can walk along the same route on both screens, each screen displaying different content.
- Guide screen mode: The screen is divided into two sections of identical size that can be compared. Moreover, another proposal can also be displayed on a small guide screen, concentrating on one proposal in great detail and focusing on it in depth. Here, it is also possible to change the screen.

5. Conclusion

We proposed a system that promotes the use of architectural 3D models using a software program that allows users to interact with them. Thus, the base technology for experiencing construction space by quickly examining design through the Internet could be prepared. Thanks to the comparison system equipped with the 3D database, it is now possible to reuse such 3D data and functions for varied purposes in architectural design. Furthermore, the interactive interface built into the real-time rendering system enabled a knowledge-exchange architectural design system to be developed,

Figure 6: Procedure using the comparison function for two-screen division mode (left) and snapshot (right).

Figure 7: Procedure using the comparison function for guide screen mode (left) and snapshot (right)

thus providing alternatives to traditional architectural design systems.

However, we need to verify further how the experience of presence in a 3D virtual space could be achieved through the easy operation of the interface, which is one of our development concepts. We are also considering enlarging the range of projects that can be analyzed, increasing the amount of data used to set up the model, and speeding up rendering during real-time simulation. It is necessary to build a structure that only displays the required data set needed to provide an adequate explanation to avoid having to handle too much data and an overly complicated interface. This should enable more effective presentations for specific purposes, which depend on processing efficiency.

We intend to develop tools for an expression technique that has sufficient reality to suppress the increase in the amount of data, and a system that enable smooth cooperation with the database.

References

R.Sagawa, K.Nishino, M.D.Wheeler, and K.Ikeuchi. 2001. Parallel processing of range data merging. *IEEE/RSJ International Conference on Intelligent Robots and System*, Vol.1, 577-583

Knight,M,W., and Brown,A,G,P. 2003. Navrgate X, Naturalistic Navigation Metaphor for Large Scale Virtual Environments. *Proceedings of the 8th CAADRIA*. 625-629. Bangkok: Conference on Computer Aided Architectural Design Research in Asia.

Yeo,W., Yuda,Y., Oh,S., Kaga,A.,and Sasada,T. 2004. The Development of an Environmental Design Helping System Using Real-time Simulationuide. *Proceedings of the 8th CAADRIA*. 947-955. Seoul: Conference on Computer Aided Architectural Design Research in Asia.

S.Oh, R.Kodobayashi, T.Sasada, and K.Tanaka. 2005. Collaborative project to conserve and personalize the 3d digital archives of historical architecture. *Proceedings of the 10th CAADRIA*. Vol.1,179-187. India: Conference on Computer Aided Architectural Design Research in Asia.

Palmon Orit, Oxman Rivka, Shahar Meir and Weiss Patrice L. 2005. Virtual environments in design and evaluation. *CAAD Futures2005 proceedings*. 145-154. Vienna: Computer Aided Architectural Design Future

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