ISSUES OF INTERACTIVITY ON ARCHITECTURAL REPRESENTATION TOOLS

A Comparison Study between A Computer Game & A Non-Game Web3D Environment

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Abstract. This paper investigates the advantages and disadvantages in representing a building with the Virtual Reality (VR) functions of the QUAKE III game engine and the Web 3D facilities of EON Reality software. For the purpose of comparison, interactivity in architectural representation in these two environments is studied.

1. Introduction

Since 3D technology and time-based media have emerged in architecture, representation techniques now have more options. The graphic quality, details, and interactivity of 3D games and Web 3D environments have made tremendous progress in their respective areas since the first versions of Packman based games and early VRML (Virtual Reality markup language) appeared.

Nowadays 3D Computer Games are one of the leading technologies in the VR community. 3D games not only let you play in the game but also give you the option of designing your own environmental settings, called *levels*, with cost-free development tools called 'level editors'. It seems almost every 3D game these days comes with its own level editor. This extra software works like a combination of CAD and VR software that allows you to design a customized environment and add interactions as you design. Moreover, these systems are low-cost. Its easy navigation and high quality

yet real-time rendering capability are attractive to architects. Now, the question is how can we use these game engines as an interactive representation tool for architecture? What can we expect besides a real-time walkthrough?

On the other hand, non-game Web 3D environments such as EON Reality, or Cult 3D can be considered as a better tool for architects with more powerful interactivities that allow sharing options over the Internet. Companies like Dell computers, Lexmark, etc., use 3D visualizations using these Web 3D environments not only to train their technicians, sales representatives, and even customers, but also to provide a virtual experience on their products.

This paper investigates the advantages and disadvantages of representing a building with the VR functions in the QUAKE III game engine and EON Reality Inc.'s Web 3D software EON Studio. Two technologies will be compared in terms of interaction features for analytical representation. Mies Van Der Rohe's Farnsworth House is selected as a case study model. The simplicity of the building and clarity of details makes this building a good example for this study.

2. Representation with Interactive Media

As architectural design becomes more complex and dynamic, a new form of representation is required to promote better understanding of the structure and better communication between clients and designers. Traditional forms of representation techniques such as photos, drawings, and animations are limited in conveying knowledge about how architectural structures are made, how they work, and how they influence people's perception of space. Game engines and real-time visualization enable web 3D environments can enhance the design in various stages as well as better present concepts. VR reduces the mental effort required to comprehend a complex 3D structure by assigning relevant content at specific design stages, making VR an effective representation tool.

2.1. REQUIREMENTS FOR INTERACTIVE REPRESENTATION

2.1.1. Real-time Walkthrough

Walkthrough animations are rendered along a pre-defined path through a model. They can provide a highly sophisticated model and quality rendering but the user experiences a low sense of immersion because of its one-directional presentation and an inability to provide possibilities for user directed exploration. Besides, the time and energy spent on modeling and rendering for just a few seconds long animation may keep the designer from

opportunities to develop alternative ideas (Uddin & Yoon, 2003). A Real-time walkthrough with a self-guided tour create the effects of immersion that is the sense of being physically and psychologically involved in the simulated environment.

2.1.2. Interaction with objects & materials

For effective architectural representation, interaction with the design elements in real-time is also important. Interaction with the objects in the environment produces a high-level of immersion in the architectural representation. Researchers have assumed a strong relation between the sense of immersion and the level of interactivity. The ability to change an object's features such as position, rotation material, visibility, etc. in real-time leads the designer to effective communication with clients. It enhances understanding the relation between the structure and its environment. Difference design ideas and suggestions can be displayed without leaving the scene; constructional details can be exposed in real-time.

2.1.2 Environmental Effects

VR environments should provide lifelike effects such as sky, water, wind, sunlight, and fire, making the simulated environment more believable.

2.1.3 3D Sound

Using sounds in a scene change the whole impression of the environment. Effective sounds can create more lifelike surroundings. By adding sound effects, the designer can indirectly guide the users walk-though tour. 3D sound systems in VR environments can give a sense of location about the sound source. This type of interactivity also contributes to adding another dimension to architectural representations.

2.1.4 Multi-user interaction / Avatars

Multiple user accessibility is another issue in high-end interactivity. By having avatars who are the self representatives of users in a virtual environment, the sense of immersion becomes stronger. Interaction with other social entities (e.g. other users) inside virtual world and even mere existence of them contribute to the feeling of immersion (Biocca et al. 2001).

For more practical purpose, architectural companies have spent substantial amount of money to establish multi-user environments for compelling client presentations or web-based collaborations among designers.

2.1.5 Availability of VR environments for Architecture

Although no specific VR authoring application for Architecture has been developed in the market, a few pioneer architectural companies and academic groups started using 3D game engines or non-game web 3D environments for architectural representation purposes. However, simple real-time walkthrough and change of view is the most common usage among these pioneers. Understanding additional interactive features also available in these two types of VR environments will stimulate more effective usage of these tools for architectural representation. The following chapter describes and compares interactive features offered by each environment.

3. Interaction in the QUAKE III game engine

Figure 1. Interaction in a game engine (QUAKE III)

Game engines are very popular in the market because of their life-like effects; high quality textures, seamless real-time rendering, and smooth navigation allow impressive architectural presentations. Also hardware requirements are more affordable than most of the other high-end modeling/rendering systems. Game engines runs with high quality real-time rendering on home PCs. And level editors, the development software, are not complicated because their original target users are general game players. Therefore, the learning curve is much shorter than professional 3D software. We chose to examine the QUAKE III engine as a representative for 3D computer games, but the other game engines such as Unreal Tournament, Max Payne, etc. share many common aspects with QUAKE III. Also since it is one the oldest games in the market, there are plenty of on-line resources for technical questions.

If there are a lot more interactive features beyond real-time walkthrough with changeable viewpoint in game engines, it is the area that needs to be further explored by architects and designers. QUAKE III level editors provide a number of built-in scripts to animate objects such as real-time rotation or transportation, e.g. sliding doors, elevators, conveyers, or vehicles. Those functions can be programmed in three different ways: direct touch,

buttons, and proximity sensors. One object can work as a button to trigger an action for another object. Coming closer to an object also can trigger actions and the degree of action can vary as a user approaches, i.e. proximity sensor.

Texture animation is another useful function. Level editors provide built-in interactive textures for water, sky, fire, fog, and rain. Users can customize textures by simple modification of these resources. 3D sound effects can make the environment more entertaining and more immersive. Sound effects can be assigned to a specific object and background sound can be controlled with buttons or proximity sensors.

Interacting with other users in the same environment is valuable feature of game engines for design project in collaboration with the other designers or clients. Low polygon characters called avatars represent users. Although their looks are not always going along with the environment unless customized, avatars still can play a role as a scale indicator. While text box appearing at the top of the screen is the only communication method within the game environment, more commonly game players use teleconference software, e.g. TeamSpeak, or telephones with headsets.

4. Interaction in the EON Studio web 3D environment

Figure 2. Interaction in a non-game web 3D environment (EON Studio)

Since VRML, Web 3D environments have gained recognition for architectural representation. VRML initially appeared promising in theory but has been compromised by serious drawbacks with its low quality graphics and slow frame rates (Uddin & Yoon, 2003). Many Private companies including EON Reality, Viewpoint, Parallel graphics, and Cycore have introduced various non-game web 3D environments with advanced technologies. EON Studio has been studied as one of non-game web 3D environments in this paper. However, the focus of this paper is general interaction features that may apply to other web 3D environments.

While interactive presentations of consumer products for marketing purposes have been gaining more attention from those web 3D technology developers, architects can benefit from the level of interaction and graphic quality these technologies can offer for interactive architectural representation. The EON Studio provides more options than the QUAKE III in terms of interactions with objects and materials such as real-time transformation, opacity control, hiding objects, and replacing textures.

Unlike gaming environments, an EON Studio environment can be embedded in a webpage and interactions can be incorporated with the webpage elements beyond its web 3D environment. To view the EON Studio environment, audiences do not need to install additional software to install after the first time they access the environment. Web 3D companies distribute free plug-ins to display web 3D contents using their technologies; an EON Studio environment requires an EON plug-in to view it.

5. Case Study: Farnsworth House by Mies van der Rohe (1950)

Since investigating interactivity within given environments are our purpose for this study, the Farnsworth house designed by Mies van der Rohe was selected. This modernist building allows us to focus only on the interactivity in representation rather than modeling or texturing because of its simplicity.

Figure 3. Farnsworth House Plano, Illinois (1946-1950)

The building consists of a beam-column steel structural system and glass walls enclosing the space.

Because its glass-and-steel structure is unique for a residential house, the Farnsworth house became very controversial when it was built in 1951. The house is rectangular with eight steel columns set in two parallel rows. Suspended between columns are two steel-framed slabs (the ceiling and the roof) and a simple, glass-enclosed living space and porch. All the exterior walls are glass, and the interior is entirely open except for a wood paneled area containing two bathrooms, a kitchen and service facilities.

In this case study, interaction attributes in both QUAKE III and EON were examined through revealing the building details, structure and the relationship between the vertical/horizontal components of the building, in addition to the modeling and texturing process. The graphic quality and the users' walk-through experience of the final products were also compared.

5.1. INTERACTIVITY ISSUES IN THE MODELING PROCESS

Generally, creating an accurate building model in standard 3D software, e.g. 3D MAX, is the first step. Once the model is built, it needs to be converted to each development software format for interactive elements. Good compatibility expedites the rest of the process without remodeling and reduces time it takes beginners to learn how to model with new software for beginners. EON is superior to QUAKE III in compatibility. Models created in 3DS MAX or Form-Z can easily be converted to EON Studio format using plug-ins available for most of the 3D software that architects and designers are familiar with. In addition, EON Studio receives texture/material and lighting information from 3D software without distortion. No matter how complex the structure is, EON can bring in without difficulties.

On the other hand, modeling complex geometries is a challenge in QUAKE III because of the compatibility problem. The level editor alone is not enough for sophisticated modeling and the number of polygons for a model is limited to 1000 polygons. Recently, Discreet Inc. presented a free 3D modeling tool based on 3DS MAX called GMAX. QUAKE III is one of the games GMAX supports. Even with the GMAX, compatibility remains a major problem for QUAKE III. The model conversion using GMAX is still imperfect: often models either disappear or are distorted during conversion. Considering that GMAX is in its infancy, it is likely to be improved in the future. In our case study, the modeling for the QUAKE III environment had to be recreated in GtkRadiant, the QUAKE III level editor. Because GtkRadiant was originally designed for QUAKE game players, it is very easy to learn. However, its interface follows a different logic from standard 3D modeling software (Figure 4). After modeling is done, all the components used for the scene, e.g. maps, models, sounds, and textures, were compiled to run in QUAKE (Table 1).

Compared to EON Studio, QUAKE III's interactive features are very limited to a few built-in functions like rotating and moving objects. Changing texture attributes possible without advanced programming knowledge. On the other hand, EON Studio has a variety of interactive options to dynamically demonstrate the structure for analysis: changing transparency, changing colors/textures, making objects hide/unhide, changing visibility and even transforming objects in real time. Multiple

camera views are also available in EON Studio. With this feature, an object or entire environment can be seen from different angles at the same time. When a structure is complicated, more than one view helps to greatly understand the 3D space or constructional compositions.

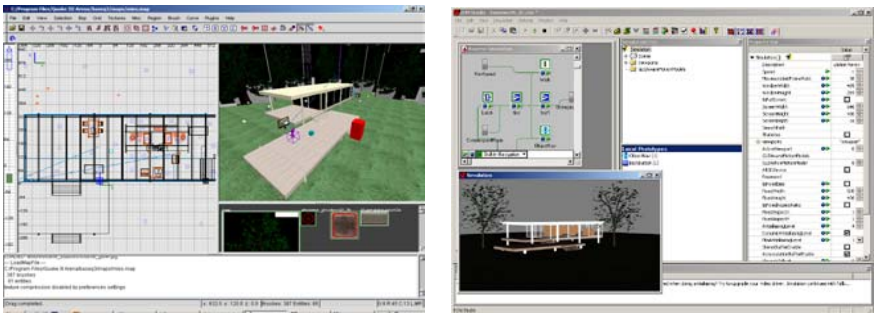

Figure 4. QUAKE III GtkRadiant(left) and EON Studio(right)

Table 1. Development Process

QUAKE III	EON
Modeling in 3D MAX	Modeling in 3D MAX
Converting to editabl format via GMAX plug in	Exporting to EON Stuc o using EON plug-in within 3D S MAX
Assigning Textures and Interactivities in GtkRadiant; the l vel editor	Assigning Interactivi ies in EON Studio
Compiling the envir nment and playing in QUA KE III	Publishing the environ ent for a web enabled format .eoz)

If the model is already created in a 3D modeling software, EON Studio imports virtually any format. Regardless of the complexity of polygons or texture size, what you see in 3D modeling software is reasonably close to what you get in EON Studio when converted. Once the model is imported, EON Studio gives you options to optimize the number of polygons as well texture quality. EON Raptor, the 3DS MAX plug-in, even allows adding interactions and animations to objects without leaving 3DS MAX. However, learning EON Studio is necessary for advanced interactions and

camera movements. Overall development process of creating an interactive building presentation using QUAKE and EON Studio is shown in table 1.

5.2. REAL-TIME RENDERING

Texturing and rendering options in most game engines are not very sophisticated. Yet their quality is amazing for real-time rendering considering the fact that rendering a frame (24~30 frames for one second movie) might take a few hours in standard 3D software depending on the complexity of the design.

For rendering quality, lighting and textures are major determinants. Shadows, shades, and reflections on surfaces also make big differences in perceived realism in graphic presentations. Among different game engines, some seem to be better than the others at rendering quality. For example, QUAKE III does not provide surface reflections whereas some game engines do, e.g. Unreal Tournament. The file size of textures should also be kept as small as possible for real-time rendering. Therefore, finding a balance between the file size and the quality is the key to success in rendering quality. This applies to any real-time rendering technologies including non-game web 3D.

EON Studio strength is in its superb visual quality, which is in the developers' best interest, i.e. realistic visualization of consumer products. EON Studio has the capacity for excellent lighting and texturing including reflection effects, shadows, and multi-layer textures. In order to create photorealistic visual quality in EON, a 'render-to-texture' option added to 3DS MAX's new version allows replicating real-time lighting effects on textures instead of rendering the whole scene for every frame. The manipulated textures with lighting and shadows projected on them then will be applied to respective objects. Since calculating lighting and cast shadows takes up a lot of processing time and memory, realistic graphic quality in a real-time rendering setting would have been problematic without faked lighting effects.

Table 2. Comparison Table : QUAKE III vs. EON Studio

	QUAKE III	EON Studio
Starting from scratch	Level editors - GtkRadiant or Discreet GMAX - available	No modeling module, plug-ins available for 3DS MAX/Maya
Learning Curve	Short. Designed for general game players	3DS MAX knowledge is enough for basic interaction and photo-realistic walkthrough
Importing file	GMAX or special coding needed for converting objects from 3DS MAX. Yet imperfect. Each object cannot exceed 1000 polygons, which is very limited	Simple. Plug-ins for major 3D software convert objects and textures
Textures / Materials	Assigned in its own editor GtkRadiant or GMAX	Shares textures with 3DS MAX/Maya and can be edited in EON Studio and 3D software
Presentation	Only plays in the QUAKE III Arena III	PowerPoint, Internet, & Stand alone CD
Cost	Level Editor - Free QUAKE III Game -$50	Viewer - Free 3DS MAX Plug-in - $495 EON Studio 4.0 - $3950 (Academic use – 70% off)

Although EON's visual quality is definitely superior to QUAKE III's, real-time walkthroughs feel more realistic in QUAKE III. There is an obvious trade-off: EON's high visual quality or QUAKE III's immediacy of the interaction during walkthrough. Table 2 below summaries QUAKE III and EON Studio's differences discovered through our case study.

6. Conclusion

The interactivity increases the sense of immersion in represented environments using game engines and non-game web 3D technologies. It makes user learning about the presented architecture more entertaining with advanced level of interactions such as real-time control, changeable viewpoint, animated water/sky/fire, and sound effects. We believe that what these technologies can offer deserves substantial attention in the architecture community as representation tools. Although both game engines and non-game web 3D technologies have great advantages over time-based media, differences among real-time representation tools make matters complicated.

When one considers using 3D game engines or non-game web 3D technologies for architectural representation tools, understanding their characteristics is important in order to end up with an appropriate tool with more effective interactions for the user's purpose. Before selecting a tool, designers should think about what they want to do to make their representations more effective.

The QUAKE III has more transparent interface than EON. The QUAKE III also gives a more life-like experience in environments with realistic movement and changeable view. Its easy-to-use level editor does not require users' knowledge of 3D modeling/rendering applications or any other programming. Unfortunately the default eye level in QUAKE III is not exactly human scale because QUAKE III was originally designed for gigantic figures in virtual battlefields. Yet, QUAKE III's realistic movement and environment effects along with high-quality graphics makes an impressive representation for rapid prototyping for study models. If realistic spatial experience is a major concern, we believe gaming engines are one of the best among architectural representation tools.

On the other hand, EON Studio allows more diverse interactive features compared to QUAKE III. EON efficiently provides design alternatives with a plenty of high-level interactive options. However, in order to fully take advantage of EON Studio type non-game web 3D environments, web programming such as Java script, HTML and 3D application knowledge are strongly encouraged. Another advantage of EON Studio is that the users can easily convert the data to advanced level VR environment format such as CAVE with HMD (head mounted display) technologies or stereoscopic displays. Multi-user can access to EON just the way they access to a website. Even though low polygon human figures from game engines are not available in EON, higher quality graphics and wider range interaction options of the EON environment are often the most important factor for many designers.

Finally, if some talented software engineer could develop an ideal representation tool for architects and designers based on existing technologies of game engines or non-game web 3D environments, our wish list would contain the following: a wide range of interactive options from EON, realistic walkthrough movement with freely changeable viewpoint from QUAKE III, environmental graphic/sound effects from QUAKE III, good compatibility with standard 3D modeling applications, e.g. 3DS MAX, Form-Z, or Maya, from EON, and unarmed avatars at human scale.

This study demonstrates the useful features of in a game engine and a non-game web 3D environment used as architectural representation tools. Their potential seems to be an invitation to another genre in the field that animation-enabled CAD systems have not yet achieved. Our research group

plans to continue endeavoring to explore different gaming engines and web 3D environments to support architects and designers who may consider these technologies in the future. It is also hoped that our study contributes to software development where users' needs are essential, whether it is a new application or additional features in existing applications.

Acknowledgements

This paper is the result of a research project in Design with Digital Media program at Department of Environmental Design in University of Missouri-Columbia. The authors would like to give special thanks to Bilge Senbabaoglu who helped us in developing architecture models for the case study.

References

Ahmad Rahi, M.E. and Karboulonis, P.: 2000, *The Importance of Virtual Environments in the Design of Electronic Games and Their Relevance to Architecture*, 18th eCAADe Conference Proceedings, Weimar, pp. 181-185*e*

Vandenberg, M.: 2003, *Farnsworth House Ludwig Mies Van der Rohe Architectural in detail,* Phaidon Press Inc.

Uddin, M.S. and Yoon, S.: 2003, House X, Scheme G: From 3D Game Engine to Virtual Representation of Architecture, *Journal of the Design Communication Association Conference,* 6(14), pp64-69

Webster, A. and Morton, F., The Farnsworth House by Mies Van der Rohe. Available from <http://www.columbia.edu/cu/gsapp/BT/GATEWAY/FARNSWTH/farnswth.html>

Sagun, A.: 1997, *Virtual Environment Systems in Interior Architectural Design*, Commentary Bibliography Series, Bilkent University, Turkey

Biocca, F, Burgoon, J., Harms, C., & Stoner, M.: 2001, *Criteria and scope conditions for a theory and measure of social presence*, Presence 2001 Conference, Philadelphia, PA