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Interactive Interior Design Of Buildings Using Virtual Reality

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Abstract—This work presents the features of using virtual reality-based technology as a medium to visualize the interior of a building before it is being built. Interior design in virtual reality is considered important in making its interior look more realistic and appealing to the user. The paper explains how virtual reality along with the latest software and hardware can be used for an immersive and interactive user experience. Virtual walkthrough was developed using Unity 3D software and the head mounted display called HTC-Vive. The user can move around the space and visualize the assets in the building. In addition to creating virtual walkthrough, interaction is also enabled so that the user will be able to change colour and texture of the assets in the building. The effect of aliasing is negated through polygon reduction of the models in 3D modelling so as to provide a seamless user experience. The merit of this work is discussed in the conclusion chapter.

Keywords— Virtual walkthrough, virtual reality, assets interaction, aliasing effect.

1. INTRODUCTION

Virtual reality is a relatively new technology for the visualization of computer generated images that constitute a virtual environment. VR is an electronic simulations of environments experienced via head-mounted eye goggles and wired clothing enabling the end user to interact in realistic three dimensional situations. The three major I's of virtual reality are Imagination, Interaction and Immersion. In order to have better user experience these three components must be addressed. This will obviate motion sickness and cyber sickness. Immersion refers to the sensation of being in an environment and the degree to which the user is involved in the virtual world. The sensory feedback refers to the response by the virtual world for the user's interaction. Interaction in virtual reality refers to the user's activities on the virtual objects in the virtual world.

Virtual reality has wide applications in the architecture, engineering, medical and many other fields of science and technology. Virtual walkthrough and visualization of the entire building is useful to visualize the building even before it is built. Virtual reality is used in maintenance work and training of manpower to assemble and dismantle assemblies. This will help to reduce the lead time required in such processes. Virtual reality is used as training simulator in medical field to provide training to the medical students in carrying out surgeries ahead of the real task. It is also used as simulator to treat patients with post-traumatic stress disorder.

Implementation of virtual reality in architecture using Blender and Unreal Engine software was attempted by Anett Racz et al [1] in which a virtual walkthrough was provided. In addition to the walkthrough, interactions effect was provided to change color and texture of the objects in the virtual building. Both dynamic and baked lighting options were provided to

enhance the interior aesthetics. Navigation is achieved through teleportation in which the user has to select the region where he has to reach.
The impact of Virtual reality in the field of architecture and environmental planning was reviewed by Portman et al. [2]. The collaborative approach in the design process was evaluated in which the designers from remote areas can collaboratively interact with the 3D model for brainstorming.
Virtual reality as an empirical research tool to access the user experience in the real building model and the virtual model was analyzed by Kuliga et al. [3]. Experiments were conducted with 23 persons indicated that the users find difficulty in depth perception of the virtual environment. The tests consist of virtual walkthrough through different environment for different person. It also included a group walkthrough in virtual environment that provided them less immersion with respect to viewing the real building.
The application of virtual reality in forensics were experimented by Til Sieberth et al. for the witness to interact with the recreated incidents and record their behaviors that can be recorded as an evidence for the trial. The actions performed are recorded as Comma Separated Values (CSV) file. Virtual reality in a collaborative environment were implemented by Jing Du et al. [4] in which a collaborative walkthrough was provided among the designers to understand the user requirement with no communication barriers. Building Information Modelling (BIM) imported to the Unity software was used for the collaborative task. Anyone user inside the virtual environment can leave the virtual world at any time without disturbing the other users in the same virtual model. Oculus rift was used for the visualization of virtual world in which multiple players can interact with the same model.
Virtual Reality for the visualization of CAD model was discussed by Rodrigo Perez Fernandez et al. [5] to study the deviation in accuracy of 3D model from design to manufacturing stage. Virtual reality provides illusion depth during the design review process. Head mounted display was used to view the designed environment in virtual reality that provided a lot of flexibility in the camera angle and head movement tracking. FVIEWER is a tool to visualize the design and provide a real time walkthrough over the design. User can view the objects with enhanced lighting and shading of the model. Camera path and object path can be defined in the FVIIEWER where camera path defines the navigation path around the vessel and the object path defines the simulation of the object part in the mounting and dismounting process.

A virtual architecture environment was created with high degree of realism and immersion by Drettakis et al. [6]. The realism included the projection of the shadows, crowd simulation along with virtual objects possessing high level of detail of around 80,000 polygons. The behaviour of the user between an immersive virtual environment and a real building environment was evaluated for the user perception by Heydarian et al. [7]. The purpose of the study was to evaluate the virtual environments for adequate representation of the physical environment so that the difference in perception of the users between the two environments can be studied. The study emphasized the difference in the perception of users particularly in virtual environments where the immersion and presence were lower compared to the real building environments. The application of virtual reality technology in the field of architecture design, construction safety training, equipment and operational task training were studied using VR technologies like desktop-based VR, Immersive VR, 3D Game based VR, BIM based VR and augmented reality. A game-based VR was developed for training workers on maintenance and safety operations in construction industries. BIM based VR was also developed in which the material and cost information were analyzed in virtual reality. The

advantage of using BIM in virtual reality is that the models are capable of reflecting the real time changes in BIM. The Augmented reality-based VR provides a new dimension of interaction with virtual objects in real time placed over a real environment as experienced by Wang et al. [8]. Whyte et al.[9] described that the data exchange between Computer Aided Design (CAD) packages and virtual reality game engine is essential for seamless visualization of the models in virtual reality. The models imported through the neutral file format method are subjected to optimization that involves reduction in the number of polygons of the model. Optimization of data to reduce the weight of the model thereby reducing the latency in the user interaction in virtual reality. [9].

Latest developments in virtual interior design is to use Artificial intelligence to select furniture and its positioning in an environment. This could be implemented in two stages: a data driven probabilistic model and a stochastic model. The stochastic model analysis include the analysis of ergonomics, psychological factors and safety regulations.

In this work, virtual reality is used as a medium for the visualization and interaction of the interior design of the buildings. Visualization was accomplished using the head mounted displays like Oculus rift, and HTC Vive. These hardware enable to track the position of the user in the virtual world. The interactions enabled along with walkthrough are change of texture, colour of the selected objects, and positioning of the objects anywhere in the virtual room. It also provides an option to replace a particular furniture with the other of similar kind of designs.

2. VIRTUAL REALITY FOR INTERIOR DESIGN

Virtual reality for interior design involves the pipeline of modeling and texturing of interior assets which are then assembled in an organized way for the interaction by the user. The sequence of work carried out is discussed in the subsequent sections. The software used is Unity 3D game engine and the hardware used is HTC-Vive.

3. METHODOLOGY

The proposed work was created in two modules. The first module was the development of 3D models and assets that were then imported along with the meshes to the Unity 3D software. The second module was to enable interaction to the developed scene. The first stage of interactions has visualization and navigation inside the interior and the second stage has the provision to choose a particular object from the available varieties of model. The final stage of interactions includes color and texture change, toggling the lightings and water flow simulation. The flowchart of activities is shown in Figure 1.

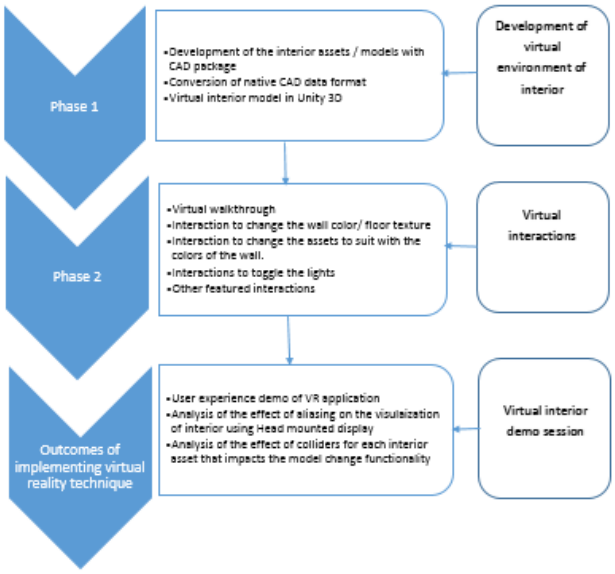

Figure 1. Flowchart of activities

4. DESIGN AND IMPLEMENTATION

A. Development of the Virtual Environment

The assets for the interior that include sofa, bed, and chair were organized and placed inside the 3D model of building in a single scene using Unity 3D as shown in Figure 2. The models were imported from the 3D modeling software after polygon optimization to reduce the polygons in the model. The interactions provided in the interior are discussed in the subsequent sections.

Figure 2. Interior of a room with 3D models of furniture in Unity software environment

B. Navigation

This module allows the user to walkthrough the interior of the building to visualize and understand how the room will appear in reality. Navigation inside the virtual interior was realized through the concept of teleportation. It is the process by which which the user navigates in the virtual environment by pointing to the desired location with the help of the HTC-Vive and its accessories as shown in Figure 3.

Figure 3. User interacting with the help of HTC-Vive and accessories for teleportation

The user can directly switch to the next room for navigation just by pressing the appropriate button in the accessories of HTC-Vive.

Figure 4 User switch to the next room by teleportation

Ray casting concept is used to realize teleportation. The ray hits the objects as soon as it is cast and the event is recorded by the system to identify the object along with its depth information in the scene. As signal is triggered from the HMD controller, a ray is cast from the camera. The ray navigates through the scene and hits the object with lowest depth value, that is, the object which is nearer to the camera. Then the object is identified and checked whether it is a suitable platform to teleport. Teleportation is accomplished if the conditions hold.

C. Interactions

The interior model used in Unity software environment enables the user to change the color and texture of the selected in the interior as shown in Figure 5 and 6.

Figure 5. User selecting the region to change the colour of the wall

Figure 6. Wall colour changed by interaction

D. Selection from Model Varieties

The other important module of the interior design is to provide the user with a flexibility to choose a particular model of a furniture that will suit the interior. For example, when the user interacts with a sofa by touching it in the virtual environment, the user will be given option to change the default model by other models available in the library. The options available in the virtual environment are shown in Figure 7. Different varieties of such model assets were stored in a separate model library for swapping of models.

Figure 7 Options to replace furniture in virtual interior

E. Featured Interactions

1. Toggling the lights:

Lights in the interior were toggled on and off through interaction using the switches placed in the virtual interior as shown in Figure 8 and 9.

Figure 8 Lights in the OFF state

Figure 9. Lights in the ON state

2. *Visual and audio enrichment:*

Television model placed in the interior was provided with an option to play a video using the switches placed in the virtual television.

3. Water flow simulation:

Water flow effects were provided on the models such as taps and wash sinks for immersive experience in the virtual reality.

F. Anti-Aliasing

The models in the interior are of high polygon count which when viewed by the HTC-Vive produce an aliasing effect reducing the user immersion in the virtual environment. The difference between the anti-aliased polygons and the aliased polygons are shown in Figures 10 and 11.

Figure 10. Anti-aliased polygons

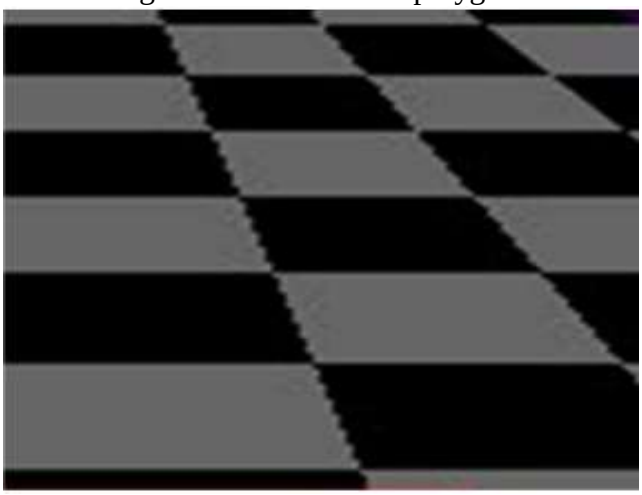

Figure 11. Aliased polygons (jagged edges)

In order to overcome the aliasing effect, a velocity buffer was provided to the camera placed in the scene thereby reducing it. The manual mode of reducing the aliasing is also done to reduce the number of polygons. The aliasing effect gets reduced because of the light weight of the models created.

5. CONCLUSION

Thus, a Virtual Reality application was developed for the virtual walkthrough and interaction to improve the visualization of interior of a building.

The interactions effect enabled in these models further enhance the immersion. It is a provision for the user to change the color and texture of the walls of the interiors and furniture.

Interaction effect help to choose the required furniture from the model asset library and place it in the virtual room. This helps the users to find the suitability of that furniture in a particular space.

The additional features include video and audio enrichment for better immersion in the virtual world.

This work obviates the need to build model apartment to explain the features of the building design. Changes requested by the customers can be made in the virtual model and their approval can be obtained after verifying the same.

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6. REFERENCES

[1] Anett Racz, Gergo Zilizi, "VR aided architecture and interior design", International Conference onAdvances in Computing and Communication Engineering, pp 11-16, 2018.
[2] M.E.Portman, A.Natapov, D.Fisher-Gewirtzman, "To go where no man has gone before: Virtual reality in architecture, landscape architecture and environmental planning", Journal of Computers, Environment and Urban Systems, pp 376-384, 2015.
[3] S.F.Culiga, T.Thrash, R.C.Dalton, C.Holsher, "Virtual Reality as an empirical research tool – Exploring user experience in a real building and a corresponding virtual model", Journal of Computers, Environment and Urban systems, pp 363-375, 2015
[4] Jing Du, Yangming Shi, Chao Mei, John Quarles, Wei Yan, "Communication by interaction: A multiplayer VR environment for building Walkthrough", Construction Research Congress, 2016.
[5] Rodrigo Perez Fernandez, Veronica Alonso, "Virtual Reality in a shipbuilding environment", Advances in Engineering Software, pp 30-40, 2015.
[6] Drettakis, G., Roussou, M., Reche, A., Tsingos, N. (2007). Design and evaluation of a real-world virtual environment for architecture and urban planning. Journal of Presence: Teleoperators and Virtual Environments, 16(3), 318-332.
[7] Heydarian, A., Carneiro, J. P., Gerber, D., Becerik-Gerber, B., Hayes, T., & Wood, W. (2015). Immersive virtual environments versus physical built environments: A benchmarking study for building design and user-built environment explorations. Automation in Construction, 54, 116-126
[8] Wang, P., Wu, P., Wang, J., Chi, H. L., & Wang, X. (2018). A critical review of the use of virtual reality in construction engineering education and training. International journal of environmental research and public health, 15(6), 1204.
[9] Whyte, J., Bouchlaghem, N., Thorpe, A., & McCaffer, R. (2000). From CAD to virtual reality: modelling approaches, data exchange and interactive 3D building design tools. Automation in construction, 10(1), 43-55.