Novel approach of Virtual reality to Simulate residential buildings and it's interior

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Abstract — Nowadays many inventions are going on to make our world digital and graphical. Virtual Reality is one such technology. This research work reviews the application of the virtual reality in the field of Architecture. Earlier, the cave man used to make plans of structures on stone, then use of wooden art was done and then came paper layout design. And with the time the technology is becoming more powerful which has led to the invention of 2D and 3D model planning of buildings and thus it has come into existence. Now, as the world is becoming digital so is the advancement required in this field too. In this article, use of virtual reality and its components (headset and remote) is employed for real time experience of user in designing the layout of architecture.

Keywords- 3D models, Virtual Reality, Architecture, VR Headset, Real Estate

I. INTRODUCTION

As the world advances in the field of architecture and building mega structures. So, new tools are needed in this field to be more accurate and efficient in designing the structures as before building of the structures the architect needs to design them and view how it would look is necessary. Till now the designs were in the in 2D and 3D format and from it architect and builders use to imagine that structure of it would look in some manner. Even contractors got confused while investing in big project just by looking at planning; like if the outcome of construction does not go as good as design the contractor would be at loss. People even got confused while selecting the texture and colour of the house they want to build. But research is going on of changing this designing format by just imagination replacing it with use of virtual reality architecture as the judgments that must be taken during the design phase of large scale architectural projects are often the most important delicate ones, because of their large effect on the projects, timings, and costs. Designs usually called the Mock-ups are usually used for such decision-making process. Virtual prototyping allows designers to test and improve their design as when using physical mock-ups, but better, earlier and with more opportunities for multi-site collaborations [7]. Architectural building walkthrough have been one of the most successful applications of virtual reality. These systems, the simplest examples of virtual prototypes, permit the architect to prototype a building and to iterate with his client on the detailed desiderata for it [2, 15]. So, to overcome the limitations of the applications of the designing tools like the CAD the use of the VR is found to be increasing.

Virtual Reality is a powerful new technology with great opportunity to help contractors and architect for making their presentation of plan layout better. This paper focuses on real-time experience of virtual reality. User can view model of their architecture in virtual reality. Here they get a walk-through environment of the property they are planning to build. Even as it is a new technology architect and contractor can satisfy and convince their customers more easily. Even interior and texture of the house can be designed, using this user gets a real-time experience and walk through environment of the architecture. Benefits of virtual reality architecture are.

a) Converting 3D models into virtual reality.
b) Viewing designed architecture into virtual reality.
c) Real time and walk through environment of architecture.
d) Texture and colour selection of architecture can be made easy.

II. PREVIOUS WORK

Virtual reality (VR) is an old concept. The origins of VR can be traced as far back at least as "The Ultimate Display", a seminal paper by Ivan Sutherland [1]. He talked about the sensory inputs and the outputs of the immersion technology which are the major field of the research projects today. In the mid of the 1980s various technologies combined and gave rise to first ever properly developed virtual reality system which was headset. At MIT, at the beginning of the 1980's, a limited three-dimensional virtual workspace in which the user interactively manipulates 3D graphical objects spatially corresponding to hand position was developed [15]. Since then there has only been the increased research work going on in the developing field about the applications of the VR in every field. The applications of the VR are vast ranging from the medical field, to training of the pilots, engineering,0 archaeology, media, architecture

and many more. At the end of the 1970s the first CAD program was made, with version 1.0 of AutoCAD .One of the first recorded uses of virtual reality in architecture was in the late 1980s when the University of North Carolina modelled its Sitterman Hall, home of its computer science department, in a virtual environment.[13] Several companies, like the IrisVR and Floored, Inc., they provided the software that enabled the architectural design firms and various clients of the real estate industry to have look at the virtual model of the proposed designs. Iris VR have created a software that can convert the files that are designed CAD to the programs like Sketch Up and Revit into files viewable with an Oculus Rift, HTC Vive, or a smartphone with a single click and not needing the complex knowledge Unity3D.Floored, meanwhile, manually constructs and refines Rift-viewable 3D models in-house from either CAD files for un-built designs or scans of already built buildings and provides clients with a view to its own viewing software, which can be used with either an Oculus Rift or a standard 2D web browser, afterward[18]. This has helped not only the architectures but the engineers of the designing team to know the limitations of their model and even the strength. So, if we have an interactive vr model that we do not need to make the physical miniatures as how the design would look. VR even helps the potential buyers of the estate to make a tour even though they are not physically present there. It can increase the long-distance customer interactions possible.as long as the potential customers are having the access to the vr headset. In the year 2007, the virtual reality software which utilized the design coordinate geometry used by the civil engineers and the spatial information combined was developed. In 2010, 3D virtual reality was beginning to be used for urban regeneration, planning and transportation project [14].

The beginning of the 21st-century, the application of the architectural programs, became an essential tool whenever any architectural design was done .But with the increase in the complexity and the solutions became hard so the introduction of the BIM software was done in the field of the VR .BIM applications are not in themselves a means to represent architecture projected in a traditional manner, but rather are tools to project architecture directly: from where the model can be treated as an architectural item with particular characteristics[9]. In this application counterpart to the earlier applications where circles and lines were introduced to make the architectural designs. Here the designs can be being made by introduction of the architectural items like walls, columns, beams, stairs, roof, doors, etc. thus it now got possible to insert a 3D object in the design and model an area of land. The BIM Archicad program to design an individual family dwelling between separation walls and then export the light wooden framework structure to a sizing program [18]. This can be seen in the example below where even the plumbing, the Water system, electrical connections and even the heat insulating capacity of the design can be measured even the bioclimatic features of the design can be measured in accordance to the location of the project.

A new project is going on to incorporate XML algorithm into the field of the architecture. The researcher has developed algorithms in XML in a new function that can be used in the micro simulation player of the VR environment, VR Studio program. The goal is to realize how the construction takes place in certain order. Now, even the 4d models have been introduced in this field of architecture. This model combines the 3D model along with the line of the project. Which means this model combines the geometric data along with the description schedule data of the design. VR technology has been used to render 4D models more realistic allowing interaction with the environment representing the construction site. Thus, the use of this 4D technology in VR is another more economic and administrative beneficial project work. 4D models are being used to improve the production, analysis, design management and construction information in many phases and areas of construction projects [8]. VTT Building Technology has been developing and implementing applications based on this technique providing better communication between the partners in a construction project [10]. The didactic models like this provides the step by step evaluation of the design and thus useful in field of the civil engineering as well as for the architects.

III.   PROPOSED WORK

Inspiration of writing this paper came from a game developed in 2000 named 'Second Life', which contained avtar based VR of a town building. It had just a map of town in which player can move freely. After a research, we came to know that the same can be applied to planning of construction site. And with which one can move into the plan layout virtually. A combination of website and mobile application is developed so that both Simulation and Desktop based VR can be experienced. User can upload their own plan of buildings and view them in VR. We came to conclusion of some features that can be a next step in field of Virtual Reality Architecture.

1) User can select the texture of architecture and interior.
2) Can decide the colour of house virtually.
3) User can see the change in colour and design of house during day and night time using the day/night mode.
4) Easy access from one place to another place in virtual world sitting at a single place.
5) Option of Simulation-Based as well as Desktop-Based VR is available using the same model for both.

So this 3D models of architecture can be converted to virtual reality using Unity3D tool. In which the 3D models are in point format, so this collection of points unitedly make a model and which is in .obj format. Now when this .obj is imported in Unity3d tool for converting to VR, the point structure of model is converted to triangle structure and unitedly it creates a VR model following x, y, and z axis. This model has no void space.
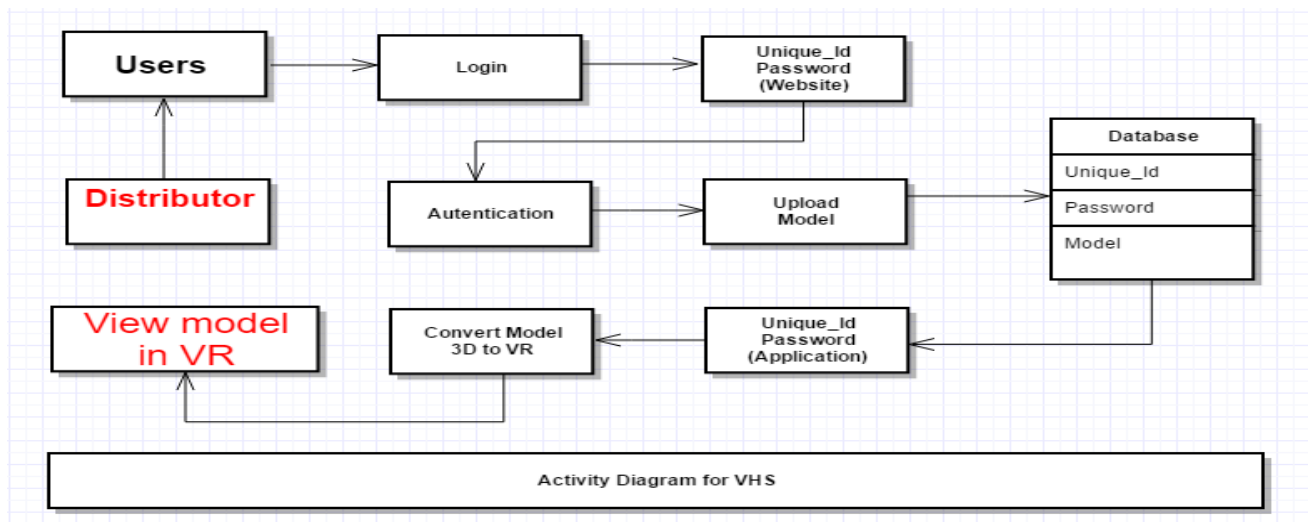
Figure 1: Work flow of proposed model

IV. METHODS AND ALGORITHM

4.1. Virtual Reality Architecture works on four bases i.e.

1) Simulation-based VR
2) Avtar image-based VR
3) Projector-based VR
4) Desktop-based VR

This paper focuses on Simulation based and Desktop-based VR. Main tool used for VR is Unity3D and its plugins along with components of VR such as: Oculus rift and Remote controller. First, 3D models designed in any software such as Sketcfab, AutoCad, Maya are to be uploaded to the tool. Then the user would be asked to login to the application. And there he can view bundle of models in 3D and then he could view the same model in VR stimulators. The simulators contain of several systems such as: a real time walk through experience; motion, visuals, and audio in total giving environment of building structures. A control of 3D to VR system acting as interface between user and simulators; an operator console for monitoring system operation; and system integration managing information and data transfer among subsystem and synchronization this is how the Simulation based VR works.

4.2. Virtual Reality Architecture concept works on following basis:

The VR headset is one of the most important component which takes us into the world of the Virtual reality and they are known as HMDS which is abbreviated as Head Mounted Displays examples of HDMS is the headsets like the Oculus rift and even the Google cardboard which works without the Audio and hand tracking just by placing the smartphone in front of your face. The hardware in the VR does is that it creates a 3D environment which is without any boundaries which are seen in our televisions or laptops. Virtual reality is completely opposite to that of the augmented reality so screen follows you wherever your face goes thus it creates a whole new 3D world.

A. *Working of Headset*

- The creation of the 3D environment in a 2D monitor is itself a very huge task and require a lot coding and programming. The basis of the creation of this environment is splitting two of the square video feeds on the same screen. This fools our brain into thinking that it is 3D but it is 2D images, then video is sent to the headset using the HDMI cable and this also had the USB cable which transfers the data as well as the power to the device.

- The headset also enables us to adjust the distance between the two lenses on the goggles so that it can fit any head shape and even with the spectacles on. The main component of the headset which enables it to track very small head movements is called the adjacent reality tracker. Most of the VR have a 100-110 degree view maybe 360 degree can be done but it is too costly and right now not necessary.

B. *Head Tracking:*

- Whenever you wear a headset the picture that you are seeing shifts wherever you see this is done in the manner that the system measures the movement of your head in three axis i.e. x, y and z axis. This allows to see 360-degree view of the architecture.

- The technology the head tracking uses system such as magnetometer, gyroscope or even the accelerometer. The head tracking is very important as it can increase the sense of the immersion and decrease the motion sickness and another advantage of it is that it can help the wearer to have a sense of the distance.

C. *Motion Tracking:*

- The tracking of our hand or other body movements is done in motion tracking. This is aided with the help of the infrared sensors like in the oculus rift and experiments are going on to use kinetic cameras to measure our movement.

- This motion tracking make your presence in walk through environment of Virtual Reality.

D. *Touch:*

- The wireless controllers are present that can help to mimic the movements done in the virtual reality making the users feel as if the users are using their own hand. This is done using the controllers having buttons and triggers.

- Other are the use of the photocell sensor to show the movement of hands and even head done by the valve's light up positional tracking system controlled for the vive headset, connecting the controller to the pc or even the treadmills which helps us to stimulate walking in VR environment.

- This thing would help to move through the VR environment. Collider scripts can be used to move inside the bounded areas.

E. *Eye Tracking:*

- It is only right now available in the Fove's headset. In this the infrared sensors keeps track of our eyes inside the headset and so in short, the headset knows where your eyes are looking in VR environment.

- One of the best advantage of this is in the viewing of interior where it can make users feel the depth and it seems more realistic. The way our eyes work is, the far objects which are not of our interest gets blurred and we focus on the stuff that is important so the standard VR headsets are not able to do it but the fove's headset can do it.

- One major throwback is that the headsets are not as hi resolution as they should be so the images appears as to be grid effect. So, eye tracking is important to focus and blur stuff to make it look as real as possible. This can help to reduce the motion sickness and remove the feeling from your brain that something is absurd.

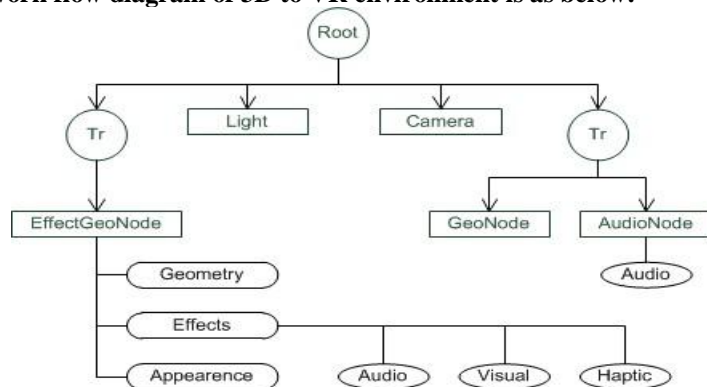**4.3. A work flow diagram of 3D to VR environment is as below:**

Figure 2: 3D to VR conversion

V.   RESULTS

1)   View of mobile application

Figure 2: Mobile application view

2)   (a) 3d model of villa

Figure 3: Before converting to VR 3D model of villa
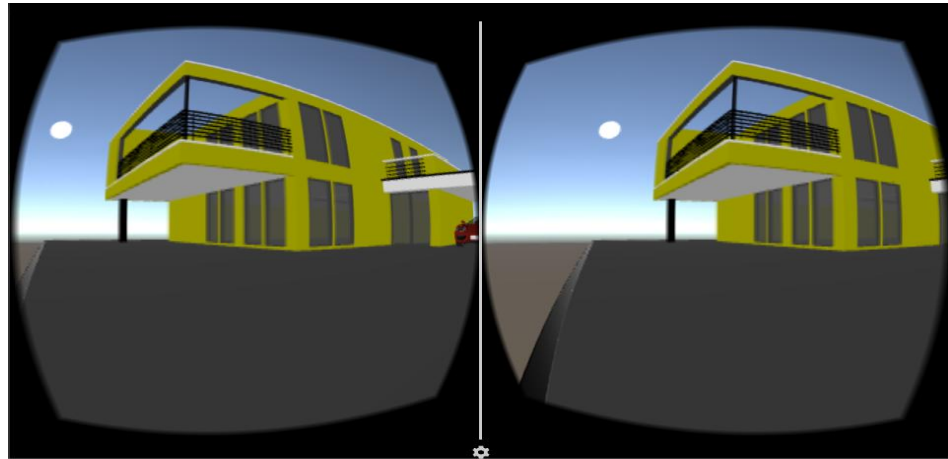
(b) View of villa in VR

Figure 4: After converting to VR model of villa

3)   *(a) 3d model of room and interior*

Figure 5: Before converting to VR 3D model of villa

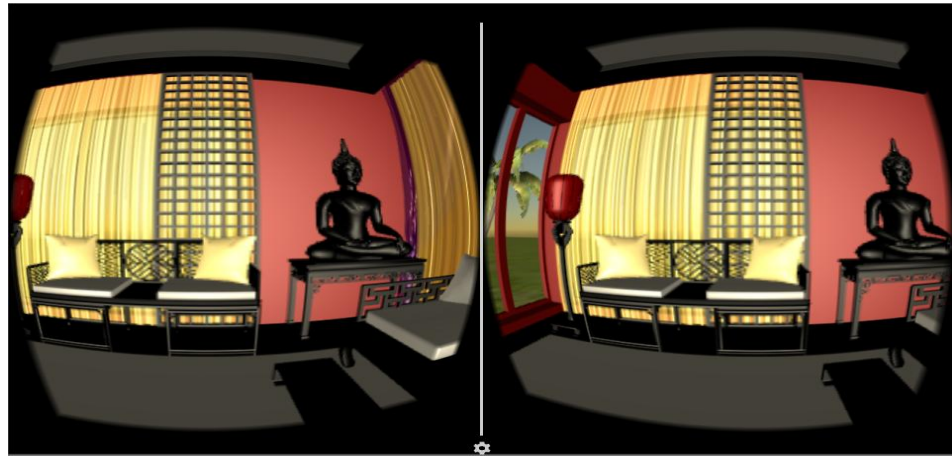*(b) View of room and interior in VR*

5

Figure 6: After converting to VR model of room

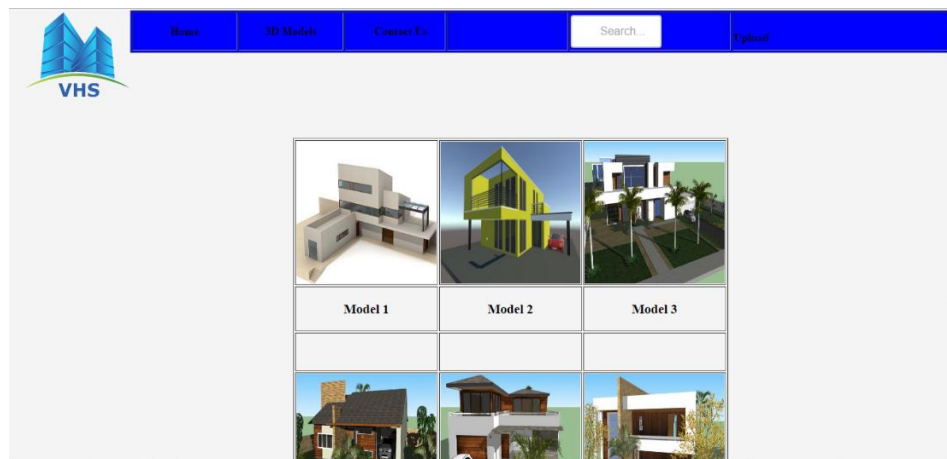*4)   View of website*

Figure 7: View of multiple selection of 3D models on website

5)   3d models of houses on website

Figure 8: 3d model viewing on website

VI.   ANALYSIS

1) Existing system related to VR in context of architecture has problem of motion sickness and poor rendering of VR environment. And that can be overcome by using collider scripts, updated plugins and good VR Headset.
2) US, Germany, Japan, UK are going to invest $107bn in projects of Virtual Reality in context of Real Estate. Home user would want their own set of VR to view the property without hiring agent.
3) Along with the technical things and the predictions of it in the future the VR applications in the real estate has given rise to many discussions and data analysis. Many big company have started the research and development of application of VR in the field of architecture and real estate.

4) The Toronto based company Intent Dev this company specializes in the front of 3D designing and the CEO of this company said that it is more convenient, gives good sense of the layout, the business can be done all over the globe and in the long run it is going to be easy.

5) Another company called terra holdings use the same VR technology and are successful in selling estate. Mathew J Leone the Vice President of this company says that "It is an incredible technology and for a salesman, it's a dream come true".[11]

VII.   CONCLUSION

As a conclusion, we can say that though virtual reality architecture is bit complex and the cost of the VR is also high but given time and proper development of VR it can have many applications. It is common to have dual thoughts on what the VR can and cannot do, and to have negative reactions barring that VR is not actually real. But we can integrate VR with the right tools and techniques in various field one of the field being the virtual house stimulation where the user can see how their house would look in real time at day and night using the VR. This also provides the user also use the stimulator to design their own house and look at house the outcome would be like the texture color and other features, the house stimulator also reduced the motion sickness which was one of the drawback of the VR. Thus, the virtual house stimulator can be still be developed and might be the future of the real estate and even architectural design.

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