I Want To Ride My Bicycle – I Want To Ride My Bike

Using low cost interfaces for Virtual reality

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The paper will give an overview of our experiments in the past years in developing different interfaces and workflows for the use of low cost Head Mounted Displays (HMD) for Virtual Reality solution. We are mainly interested in using VR tools for designers in the early phases of their design. In our opinion VR tools can help to bring back a better understanding of space and scale which have been lost a little bit in the last century with the change from analogue to digital tools. After teaching architectural and urban design for many years we can clearly say that this effect is still ongoing and it is time that we develop digital tools that try to reverses thi effect. We will then concentrate within this paper on discussing some aspects of data reduction that are important to be able to use these tools in the design process. We are also showing how we use our interfaces presenting some results of student projects for a design in Hong Kong and the strategies and methods for using VR for a ongoing work on a project about the establishment of a so called ``bicycle highway'' in the city of Graz in Austria.

Keywords: *Virtual Reality, Head Mounted Displays, Low Cost Interfaces, EeZee click*

INTRODUCTION

The new VR rage started a few years ago - approximately 25 years after the first VR rage. It is based on the development and availability of low-cost VR hardware - mainly the Head Mounted Displays HMD, in particular those that use mobile phones- started by the development of Google cardboard. The PC based systems like the Oculus Rift and the HTC Vive (and nowadays several others) played a major role in these developments. This also sparked a lot of new interest in developing software solutions and new interfaces for using these devices - most of them because the gaming industry is again interested in the field. This made it possible for institutions and universities with little financial resources to take part in this game. We were also interested to use these new - now affordable technologies based on old ideas in the field of Architectural design and Design education. In Architecture - at least on this level - there is no money available and the resources are scarce. But there is the big potential that these new technologies can give new opportunities to architects and designers to use VR as part of their design toolbox and not only as a presentation tool -which is still the main use of these devices.

In the past decades, some studies have made experiments to infer the importance and the differences of the understanding of projects through different representations techniques from hand drawing perspectives to the use of virtual reality head mounted displays. Montiel and Loyola (2016) compared the understanding of an urban design project presented with physical 3d models, plans and images generated from a digital model in one room and the presentation of the same project through an immersive walk through the digital model with a virtual reality head mounted display in another room. They concluded that traditional media and physical models help in the understanding of the general organization of the space, transmitting complete and integral information while the immersion in the virtual reality environment brought more sensorial and less cognitive answers from the users, but with deeper reflexions.

Analysing the different understanding of an urban project by the presence in the built environment and visualizations of its digital model produced by the architecture office for public presentations Wergles and Muhar (2009) concluded that the visualization of virtual landscapes has different responses to the presence in their corresponding real-world landscapes. While the presence in real environments aroused subjective perceptions of the users, virtual landscapes were more effective in transmitting some intentions of the designers. From those studies it is possible to infer that the grades of immersion in a space play an important part in the way projects are understood. Our aim is to find simple and affordable solutions to include these benefits of VR in the design process of architects.

In the past years, we experimented a lot with new interfaces for navigation using the HMD mobile phone-based displays to test their immersion capabilities. We presented the EeZee click interface for walking in the virtual world without external tracking systems and the training bike interface for experiencing urban models. These projects have been presented in several conferences in the field. For us the main advantage of these systems - besides the cost - was the fact that they are completely independent from external tracking systems that limits the space in the real and the virtual world. The mobile systems that we used for these experiments have less process capacity than PC based systems which poses a challenge for visualizing urban projects. Even high-end smart phones are getting to their limits when it comes to quicker movement in urban models. The data efficiency of these models is crucial and the question on how much detail you need to understand design implications is very important.

The comprehension of urban projects usually requires large models, not only of the project itself but also of the urban environment. Architects and students now have PCs, or even laptops, with good processing power and are able to model details and include building information - in the case of BIM software. Those models need rather expensive graphic cards to render and many of the details are not even seen in the first-person visualization for VR in HMD. For that reason, we have developed strategies for creating or adapting models for the best possible use in VR with HMD mobile phone-based displays.

METHODS

Besides the technological requirements for allowing the real-time rendering processing for VR, creating a good and healthy user experience is also very important. Highly detailed models are more expensive for the processing which lower the rendered frame rates, and this can cause motion sickness for the user. But even slightly differences in lower frame rates make the experience of the VR environment uneasy and unnatural, making the understanding of the designed space more difficult.

For architecture and urban design these scale of spaces can be translated as interior spaces, building scale spaces and urban spaces. Which lead to different modeling strategies for VR according to the subject of the project. In our case, to reproduce the movement of riding a bike we need to elaborate

Table 1
Approximate order of importance (with 1 being most important) of visual cues for perceiving egocentric distance in personal space, action space, and vista space. Reference: Jerald, 2018: 115.

	Space		
Source of Information	Personal space	Action space	Vista space
Occlusion	1	1	1
Binocular	2	8	9
Motion	3	7	6
Relative/familiar size	4	2	2
Shadows/shading	5	5	7
Texture gradient	6	6	5
Linear perspective	7	4	4
Oculomotor	8	10	10
Height relative to horizon	9	3	3
Aerial perspective	10	9	8

models for vista space. Which means having as top priorities occlusion, relative/familiar size and height relative to the horizon.Occlusion can be ensure by simplifying materials, using less transparent materials as possible, to simplify the the rendering process. In Unity 3d and other game engines materials with different characteristics have different shader files, the more complex the rendering pipeline, the bigger the chances for errors, making objects that should occlude other become semi or completely transparent.

We found out that our EeZee click system already reduced motion sickness significantly compared to using the inbuild switch in google cardboard to walk.

Thompson et al. (2004) concluded after exposing users of HMD the same environment rendered with different degrees of detailing and textures that photorealism is not important for distance judgments. With our previous experiments we empirically concluded that for creating comfortable experiences in VR for urban scale projects one to keep in mind is that photorealism is not important for the comprehension of the spatial distribution of architectural elements and the comprehension of scale.

The best strategy should be to model only essential parts for spatial understanding and not aim for a photorealistic rendering, but use colour, light and environment setting that it is aesthetic pleasing but does not disturb the spatial perception. Those non-photorealistic styles have already been developed through the years for image renderings.

Ghinea et al. (2018) compared the perception of absolute distances with HMD and CAVE-systems. They concluded that HMD provides the best results for distances above 8 meters while the CAVE provides the best results for close distances. Which corroborates with our idea that HMD are a good medium to visualize urban projects in VR. Jason Jerald (2018) classifies judgments for space perception between exocentric - object-relative, sense of where objects are relative to other objects, and egocentric judgements - subjective-relative, related to the body of the user (p.112). In our research, we explore egocentric judgments with the EeZee Click and the training bike project. Now we are focusing in essential exocentric judgments for creating proper VR environments, especially in the quality of the 3D models. For Jerald depth cues are more important than photorealism in VR experiences and different depth cues have different grades of importance for experience depending on the scale of the model visualized. He considers three different scales: personal space, action space and vista space (1995) - for VR experiences and graded the importance of different depth cues for each of them (see table 01).

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Figure 1
On left - high detailed model with transparent materials for high quality rendering, on right - reduced polygons model, with textures replacing geometry for details and no transparence. Font: Author's archive.

Relative/familiar size is improved with the inclusion of humans, 3d figures and urban furniture in the model, giving references for the user to compare building models and distances with the human body. The existence of a dummy that simulates the body of the user in VR also improves the experience, but making this dummy react to the movements of the user is not so simple for beginners in game engines programs.

Height relative to the horizon can be done by adding a sky box in the model that gives the user the reference for the horizon line.

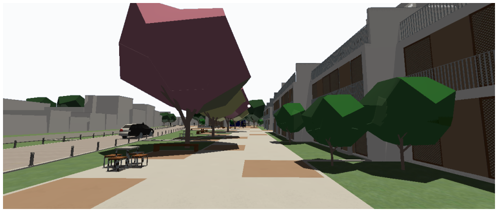

Figure 2
Model in Unity3D without use of a skybox for simulating the horizon

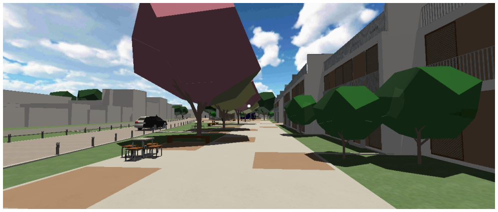

Figure 3
Model in Unity3D with a skybox

In case of areas with rugged topography this should be considered for modelling the terrain. In many cases that we have observed, the terrain and the texture of the floor make significant improvements in the quality of the VR experience of urban projects than detailing in building facades.

Contemporary design processes are a flow between different analogue and digital design techniques, from hand drawn sketches to 3D digital models. passing through CAD or BIM programs, the easier this transitions between media is, the better for the flow of the process. To include VR visualizations in this process, knowing all the limitations that this technology still has it is necessary to have optimized models, for that we found three options in our tests so far:

- Make a new model
- Make bounding boxes, texture and normal maps
- Make a model thinking that it will be exported to VR

The first option is the less optimal for the design process, to make a new simpler model takes time and the model has to be redone every time the design changes, but it can be an option for projects that are in an advanced stage of elaboration.

This was the case with the project of students in Hong Kong with the project site being on an unaccecible slope. The VR model was very useful to understand the context of the site

The second option is the creation of a very simplified volumetry that will have details added as texture and normal maps. This usually has significant improvements in the rendering performance. This can be done in softwares like Blender, but require additional software skills that are not too common for architects so they consume additional time during the design process - at least in the beginning during the first attempts.

The third option maybe be the best case for the integration of VR in the designing process. This can be done by organizing the layers of information from the beginning of the modelling processes thinking in what will be visualized in VR and what is irrelevant.

For example just external faces of the model can be exported for VR visualization if they are labelled for that or added in a different layer in the modelling software. Other option is to add blocks or components with a simpler geometry attached to it, and export just this geometry for VR. For example, 3D models of trees can have a lot of triangles, for detailing leaves and other parts, but a simpler geometry can be used just to represent the external volume of it. In any case the option for any of these strategies is related to the designing process of each architect and the team.

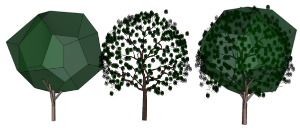

Figure 4
Example of tree component with two different geometries, one for high quality rendering and other for VR

Figure 5
High quality model rendered for printing material

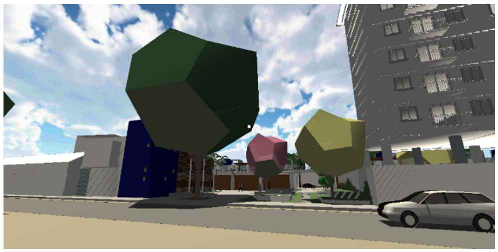

Figure 6
Model with reduced number of polygons, without flat components that always face the camera for VR experience in Google cardboard

Different projects can also require different strategies for VR visualization. Unregarding with the mod-

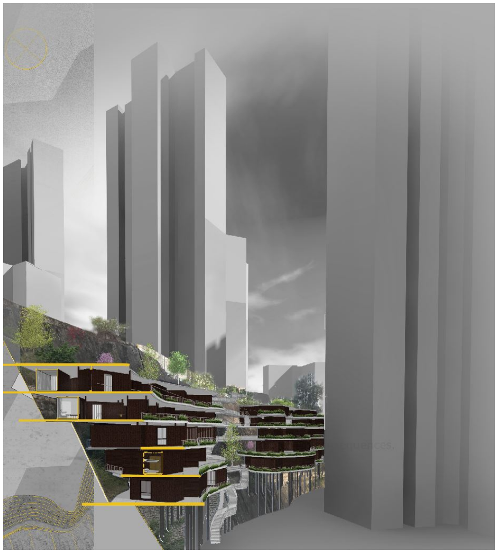

Figure 7
Rendering of the context of the Hong Kong project with more detail (Eszter Katona and Peter Vörös)

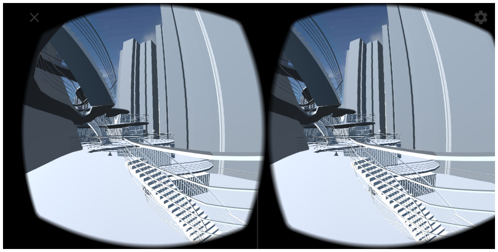

Figure 8
View from the Hong Kong VR model (Eszter Katona and Peter Vörös)

Figure 9
Final Rendering of the Hong Kong project from inside (Eszter Katona and Peter Vörös)

els will be specifically made for the VR experience or adapted from the design software, in our experiences, we have concluded that it is better to export the FBX and OBJ models from CAD and BIM programs without the materials and textures, and apply those directly in Unity3D.

In the Unity3D environment it's important to transform the models in "prefabs", this works as "components" in SketchUp or "blocks" in AutoCAD, copying changes done in one prefab to it's clones in the scene. Unity3D handle physics interactions separately from geometry, so a "collider" must be added to the model to allow users to walk on the floor without "falling" through the face or to walk through walls and other vertical elements. For better performance this collider can have a very simple geometry, taking just the most basic geometric form that contains the object geometry. For example the collider of a table can be just a cube, if the user is not supposed to walk under it.In Unity3D, working environment is also important to organise all the scene elements in the "resources" folder, prefabs should be in a subfolder called "prefabs", materials in a subfolder named "materials" and so on. This is important because Unity3D has a function "Resources" that loads files directly from this folder.

RESULTS

The Hong Kong projects clearly showed the additional value of the VR systems because the project was designed within an existing estate on a steep and not accessible slope. By using our devices and workflows the students could walk within their own design on this slope and could get a very good feeling for their design in the context of the existing estate. In fact, they found out a lot about some qualities of their own design, which they did not, had expected during the initial design phase.

The second project is the ongoing work on a proposed project about the establishment of a so called "bicycle highway" in the city of Graz, Austria. The idea was based on examples from the Netherlands were they create bike highways as a fast and safe connection between neighbouring cities. In Graz this "highway" is proposed to connect different university campus sites. Due to the fact that this development is proposed within the existing city fabric it turned out to be a politically very sensitive project. The fact that space is limited and for a project like that parking spaces for cars would have to be reduced caused the politicians not support the project anymore.

Originally we wanted to visualize the movement on this new bike Highway with our training bike using EeZee click at a big event about cycling in the city but these political problems made this not advisable and slowed the project down substantially so it is still in its initial phase. Because of this lack of support we had problems in getting enough data for the model and had to rebuild a lot.

At the moment we are still trying to develop a new biking interface to explore this project further and we hope that we will be able to report about the latest results on that at the conference.

DISCUSSION

The Field of using Ultra Low Cost HMD VR Displays in Architecture - especially in the design phase is still young and developing. In our opinion VR tools can help to bring back a better understanding of space and scale which have been lost a little bit in the last century with the change from analogue to digital tools.

To make low cost VR tools available for designers in the early phases of their design is still our main goal. The most important aspect is to establish a workflow that can be used in the design process without too much knowledge in programming and scripting - many architects are not very proficient in this field or just are not willing to invest much time. Also necessary are easy to handle interfaces that allow a "natural" interaction with the model.

Because of the dynamic development of these kind of tools for the gaming industry there is on the one hand the chance that better tools will be available soon but on the other hand there is also the problem that the industry is losing interest and does not support "last years devices" anymore. In our case - because of the low cost focus - that thankfully does not mean that we invest a lot of stranded money but it means that we always have to start again to adapt our systems.

We advocate that it's already possible to use VR in the design process of architectural and urban projects, especially for architecture student's education. But to make this possible in a satisfying way some principles and strategies have to be taken in preparation of the models for VR. Some instructions on the use of game engines is beneficial like Prof. Tomohiro Fukudas online Tutorials.

Studies have proved the advantages of using virtual reality in the design process for better comprehension of the architectural and urban space. The industry is working in solutions for the integration of VR visualization in CAD and BIM software, but this is still at the beginning and rather expensive in terms of time and money.

For our next experiments we also think of alternatively trying to use web-based VR solutions like WebVR, that works in a web browser. This solution requires more scripting abilities, but avoids the need for building and downloading an App for a smartphone with all the problems of operating systems versions and updates.

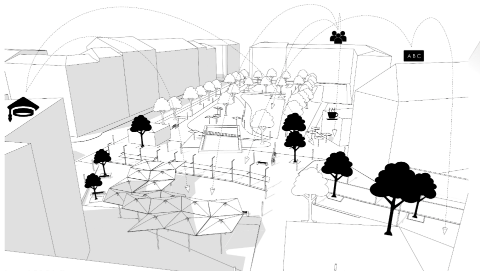

Figure 10
Detail from the bike Highway project (M.Monsberger,A Salazar Luciani, B.Thommesen, A. Zambo)

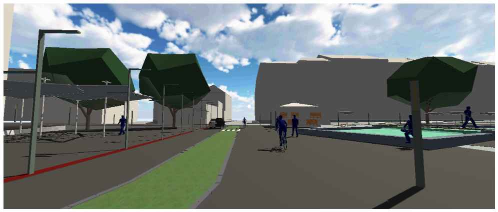

Figure 11
VR model done from the bike Highway project (M.Monsberger,A Salazar Luciani, B.Thommesen, A. Zambo)

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