DESIGNING ‘ACTION TRIGGER’ FOR ARCHITECTURE MODELLING DESIGN WITHIN IMMERSIVE VIRTUAL REALITY

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Abstract. Architectural modelling is radically evolving with time. The introduction of VR into gaming and education has also encouraged architecture to integrate VR into its course of the design process. However, the current integration of Augmented Reality (AR) and Virtual Reality (VR) components is mostly limited to enhancing visualisation, especially towards the corresponding design tasks. This opportunity lead to an increase in attempts to bring the modelling process into the immersive environment. This paper aims to challenge the current design capabilities within the immersive environment and introduce a new interaction method between the human and the virtual reality. The research in human-computer interaction (HCI) has been ongoing for years till present day to observe how humans interact with computers and design technologies. The appearance of the smartphone has extended this HCI research towards hand-carried devices. With VR, although the hardware is still considered ‘computer’, the interaction is very much different. Since the human is immersed in the virtual environment, the interaction is already beyond the traditional keyboard and mouse. This paper responds to the conference theme by capitalising the power of VR technology to bring new methods of HVRI to the architecture design process.

Keywords. VR; HVRI; Interaction; Action Trigger; Immersive.

1. Introduction

As virtual reality (VR) technology become more commercially available and accessible, gaming and education are incorporating VR into their industry. This approach offers players and users a more immersive experience in the virtual environment. For gaming, players can enjoy exploring the fantasy world in the comfort of their home. For teaching, educators can present stories, settings and even object clearly to the students. These can range from historical artefacts, to bring extinct animals to life. In the medical field, doctors are using VR to demonstrate the details of human anatomy which could show sections of parts and even microscopic details. All these benefits of VR can also be utilised to enhance the engagement and interaction of architecture design. VR can enable various stakeholders to work on the same virtual model using VR and discuss
design at the comfort of their office, especially when many projects are done with companies around the globe. Architecture details such as mechanical utilities and structures can also be shown in real-time within the VR to see where the problems are and how they can be resolved. However, all these interactions and communications can only be done well if the experience is intuitive and pleasant. In architecture, the requirement for the Human-VR Interaction (HVRI) is much more stringent because there is a need for the experience to be efficient, transparent and easy hands-on. This paper aims to understand the current HVRI and observe its benefits and limitation. A work-in-progress prototype system is also introduced to demonstrate how HVRI can be designed to further enhance the experience in engaging the architecture design.

2. Immersive Architecture

Before diving into HVRI, it is necessary to understand the development of VR and the characteristics of its interaction. The understanding of VR is continuously changing with the advancement of technology. Maver and Alvarado (1999) defined VR as emergent computer technology for full 3D-simulation. At that time, the most advanced VR equipment was a massive installation such as CAVEs and panoramic displays to give users a sense of immersive-ness. The equipment usually was not very convenient that involved much hardware and required building spaces. Moreover, the interaction with the environment was very restrictive and not much of difference compared to working on a monitor using a keyboard and mouse. However, such experience was later used by Schnabel and Kvan (2001) only described as Virtual Environment (VE) and VR are defined as a visualisation technology to create total VE. For the first time, immersive VEs were successfully employed to create and communicate architectural design in a larger context (Schnabel et al., 2007). At present, VR is no longer only employed for basic operations; it can be used for applications such as construction of 3D models, dynamic renderings, closed-loop interaction, inside-out perspective and enhance sensory feedback (Sorguç et al., 2017). VR includes equipment that is a headset and hand-held pointers for interaction although there is an option that requires a certain amount of building space to have manoeuvre capabilities within the environment.

Latest VR equipment allows users to immerse themselves in a virtual social environment with multi-dimensional elements to enrich the design engagement. At the same time, the standard architectural software can easily be visualised in real-time, interactive and social design experiences in a VR realm by innovative game based platforms. Building information and other data are linked in real-time that it enriches and offers additionality within an immersed virtual environment (IVE). In the US, and increasingly in other countries, architecture firms are beginning to incorporate VR into their practices. By putting on the headset and getting immersed in the virtual environment, the users can experience the design project as if it is built and get a sense of the spatial relationships and massing. They can critique if the design is of the right proportion or if the material choices suit them. The most convenient part of VR is that the users can instantly make changes to the virtual environment and observe the differences in real time. In
addition, architects such as Brian Hopkins are looking into using VR to visualise the intangible data such as daylight quality in the built environment. This brings visualisation into a new paradigm. Not only does VR allow architects to see the complex data, but it also allows them to ‘feel’ the spatial qualities by understanding how the environment might react to the natural climate. With all the capabilities within the VR to visualise and experience the architectural design, the question is how user experiences for the various stakeholders can be enhanced to better interact with the model such that they can interact even with architectural details to simulate they are within the environment at different times of the day.

3. Human-VR Interaction

The research in human-computer interaction (HCI) has been ongoing for years till present day to observe the ways in which humans interact with computers and design technologies. The appearance of the smartphone has extended this HCI research towards hand-carried devices. With VR, although the hardware is still considered ‘computer’, the interaction is very much different. Since the human is totally immersed in the virtual environment, the interaction is already beyond the traditional keyboard and mouse. Such interaction is approaching close to the real-world interaction where the human will use his/her full body gestures to interact with the components in the virtual environment. There are already studies to understand such human-VR interaction (HVRI) but not yet reach the domain of architecture. Since VR is getting more attention, there is also research into using VR to examine human behaviour in architectural space (Chowdhury et al., 2017; Lo et al., 2018) Yet, there is little research into how human interacts with the virtual architecture model. This paper, therefore, studies the HVRI and introduce ‘action trigger’ which could enhance the design modelling process within the virtual environment.

This paper intends to use a third-party software, Fuzor, in this study. Fuzor is an upcoming BIM software that is targeting to connect the whole Architecture, Engineering and Construction (AEC) industry. At present, Fuzor is very matured in the field of construction (C) providing a wide range of capabilities for companies to visualize, collaborate and facilitate the construction process. They even have a VR environment for companies to provide training simulation for construction workers. Fuzor has also developed clash detection and looking into bringing building performances into the system to enhance its ‘E’ component. In the area of architecture (A), Fuzor is still in the developing stage. Their plan is to break out of the traditional design method with keyboard and mouse. The aim is to bring the ‘A’ component, the design modelling process, into a fully immersive interactive environment. This research coincides with the aim of Fuzor developers and the author works closely with the team to develop a set of HVRI methods. Action trigger was initially developed for architects to set up simple actions within the VR for the users to trigger and visualise the design changes prepared by the architects using the needed ‘actions’ made within the virtual model (Figure 1). The architects will prepare different sets of design with the description of the design and most importantly the cost in order for the users to make the right design decision based on their needs (Figure 2). This research hopes to extend such capabilities with a
prototype VR hardware to enrich the HVRI methods which could further enhance the design modelling experience within the immersive virtual environment.

Figure 1. Design options in Fuzor for users to select and view in real-time at different angles (kalloctech, 2018).

Figure 2. Cost information in the VR system to aid users’ design decision making (kalloctech, 2018).

4. Designing Action Trigger

The idea of action trigger is for the designers of the architecture models to prepare a set of ‘events’ that they hope to achieve when the users interact with their model. This can simply be switching on the interior lights, playing the tv or radio, opening the doors and windows, or changing the environment from daylight to nighttime. Then, the designers decide what ‘action’ types they would like the users to make to ‘set off’ the events. The action can be either active or passive depending on what
effects the designers want the users to experience. For example, the designers could design a light switch and set the event to it such that users need to "trigger" the light switch to switch on the light, or the designers could set a passive boundary such that when the users are within one meter away from the switch, the light will automatically be triggered on. The set up of the whole action trigger event is very intuitive; Figure 3 shows the step by step interface in Fuzor where designers just need to select an architectural component and attach an action to it. At present, the action types are limited but it is possible to expand using the API of Fuzor.

![Figure 3. Fuzor interface showing the steps for setting up an action trigger.](image)

The action trigger is not limited to just allowing users to trigger various architectural components. It is true that by adding such actionable events, the VR experience is enhanced., but only to a certain extent. The benefit to this
function is that designers can use it to obtain feedback from the users (Figure 4). Designers can set various points of interaction for users to input their observation and comments about the space. Once the input is made, the data will instantly be sent to the designers’ designated email. The more detailed the action triggers are set up around the architecture model, the more data the designers can receive. Even if the users do not interact with any points, that itself is a data showing that users are not interested in that spot. In addition, there is a function in Fuzor call ‘presence-mapper’ which allows the designers to record all the activities done by the users in VR. It can map out all the locations the users have been and the direction of the views which the users take. This enables the designers to understand which part of the design attracts the users most and which part is too insignificant to capture the users’ attention.

Although action trigger in Fuzor increased the types of interactions designers can prepare for the users to engage, the interaction within the VR is still using the headset and hand-held pointers (Figure 5). There are few buttons on the VR hand-held pointers, the users will have to click on one of the buttons to show the menu to make any necessary adjustments within the VR. With the action trigger, the users will just have to point the device to the architecture components to trigger the events. This paper has demonstrated the capabilities of how having the action trigger could bring about more interaction possibilities within the VR environment. However, this paper also thinks that it is not enough to break out from the hand-held pointers point-and-click kind of HVRI interaction. The next part will demonstrate a prototype which this research is working on to enrich HVRI.

5. The Prototype “TMR”

At present, the common VR hardware used to experience the design process is the HTC Vive or Oculus Rift which is quite a heavy set of equipment. There are still a handful amount of participants who feel uncomfortable wearing the heavy
headsets. Also, not everyone can handle the total immersive-ness of the virtual environment. Due to the lag in the motion within the VR environment, some users got uneasy after being in the VR for a short amount of time.

This paper, therefore, looks into an alternative VR technology to engage the users called The Multi-immersive Remote projector (TMR)(Figure 6). This is currently still in development but will be presented at the conference as a workshop. The technology is showing great promises to bring about new methods of engaging the architecture model. Instead of having the users wearing heavy headsets, they will have to wear special glasses, like those used in cinemas. However, the main difference is that the glasses are not just showing 3-dimensional images like in the movies. There are motion trackers in the glass to re-position the perspective of the model for the users. The models will also be interactive to allow all the functions described in Fuzor to be in the new system.

![Figure 6. Proposed VR prototype “TMR”.](image)

Most importantly, the immersive environment can be projected in any space available, from a simple table to a whole room. Using HTC Vive, the users will only be able to manage the architecture components through a hand-held pointer that comes with the headset. The interaction is therefore not as intuitive. By using TMR, the users will not need any handheld device, with just a simple pair of glasses, there will be a tracker device (Leapmotion) to track the hands of the users. The users will have to use their hands to interact directly with the models. The hand gesture will be the action to determine which event to trigger. Also, TMR allows multi-users to work on the same model on-site or remotely. At present, VR equipment such as HTC Vive only allows individuals to experience the virtual space; bystanders will only be able to experience the same environment through the monitor. They will only be able to be in the same virtual environment if there is another set of HTC Vive. This is very inconvenient and costly for multi-users participation. TMR is aiming to allow multi-users by increasing the number of wearable glasses and allow them to view the same model at the same time. The
difficulty at this stage is for the sensor to differentiate each glasses from multi-users and have its specific point of view. By introducing a new form of VR experience, this research hopes to enhance the design participation of the people to bring about a more coherent collective design experience, which would then bring about a more vibrant open design outcome.

6. Conclusion

This paper responds to the conference theme by capitalising the power of VR technology to bring new methods of HVRI to the architecture design process. By integrating available software such as Fuzor that has the action-trigger function, it enables the prototype TMR to bring about new HVRI methods to engage the users in the architecture model. With the introduction of the new coming VR technology, there are even more opportunities to enable people to engage efficiently and immersively in the design process with the architects. This enhances human creativity to bring about intelligent design output which in turn enable users to be more informed.

References