VIRTUAL AIDED DESIGN (VAD): DEVELOPING A FEASIBLE VIRTUAL REALITY SYSTEM FOR ARCHITECTURAL DESIGN AND EDUCATION

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Abstract- Virtual reality is an emerging technology of recent years. It has the potential to enhance an architect's imagination, space perception and decision making skills. These potentials could contribute significantly in improving the architectural design process. The objective of this paper is to highlight virtual reality as a useful tool for architectural education and to make it more accessible. Through interviews, surveys and analysis of common virtual reality components, an integrated Virtual Architecture Design system called VAD has been created. The system supports design and interaction of an architectural space within a virtual environment. This integrated system is composed by a number of equipment and software that is easily available in the current market. A brief discussion on its advantages and limitations is presented as well. Public awareness is also an intention of this paper in hope that users of VAD could further develop and in novate the system.

Keywords- architecture; education; virtual reality; design process; virtual architecture design

I. INTRODUCTION

Before computers architects used pen and paper to design and to produce drawings. As technology evolved and became commercially available, architects started to use Computer-Aided Design (CAD) systems in the mid-1990s.[1] Since then new technologies have frequently emerged in the market, and one of the latest is virtual reality (VR).

VR is a computer simulated environment in place of reality viewed through a wearable headset or glasses.[2] The simulated reality could either be a replication of the real world or an imagined one, allowing users to interact with the environment through the five human senses. The artificial sensation created by the virtual environment is important in understanding spatial design. Architectural design field could take advantage of the potentials of VR by integrating it as one of the daily design tools.

Currently, VR technologies are gradually being utilized by renowned architectural companies to assist in their communication and design language.[3] This sparks an interest for adopting the tool in architecture education to prepare students with necessary exposure towards VR early on. This paper will discuss how VR could be made more accessible to the architectural design field, especially for the students.

II. BACKGROUND RESEARCH ON VR

2.1. Current VR technologies

VR has been in development since the early 90's, when the first commercially available VR headset, the Forte VFX1 was announced. However, this early technology was unsuccessful in the marketplace due to its primitiveness.[4] It was not until 2012, when a new era of VR headsets emerges with the announcement of Oculus Rift development. Since then, multiple competitors have appeared alongside Oculus. Examples of VR headsets currently in the limelight are the HTC Vive, Samsung Gear VR, PlayStation VR and Google Cardboard. These headsets are currently either commercially available or under development to refine the VR experience.

2.2. Literature review and findings

Literature review of this research was initiated from the following hypothesis; "in the near future, architects will design in virtual reality." Findings from a journal written by Terri Meyer Boake titled "Defying Gravity: Space Architecture in Film Environments, An Opportunity Lost" shows that architects do not only design for real spaces, but also for imagined ones like film environments.[5] The definition of imagined spaces bore great similarity to that of virtual realities.[2]

Andrew Selby highlights in his book "Animation in Process" the various animation techniques used by designers to communicate their thoughts and ideas.[6] Some of these works and designers are related to architecture. For example, video animations of the unbuilt spaces in form of a short movie or film are currently among the most popular and effective techniques to convey design ideas. In this respect, VR could easily emerge as another highly sophisticated tool for accurately conveying ideas of the unbuilt spaces to the client.

Through these literature reviews, an inference is derived. Virtual spaces allow room for design exploration that has never been done before. Benefits of VR towards architectural design are the ability to truly experience imagined spaces, the capacity to explore limitless design expression and the efficiency of the design process.

2.3. Data collection on the relevance of VR for architectural design

Between January and March 2015, surveys have been done to establish the scope of this research. The

purpose of the surveys is to find out public opinions on the relevance of VR as one of the architectural design tools in the near future. The surveys were done in two different methods; questionnaires and semi-structured interviews. Interviews were conducted with professional architects and academics of architectural design, while questionnaires were distributed among students of the same field. The two had similar questions and objectives.

Both survey methods begin by analysing the general knowledge of respondents on techniques peculiar in architecture, such as animation, film and graphic design. It then follows up to seek their views on the relevance of these techniques as architectural design approaches. The survey concludes by summarizing the respondents' opinions on whether more emphasis should be put on integrating such techniques in architecture education.

Questionnaires were conducted through online distribution and hardcopies towards a total of 54 students of architecture and design from three universities*. Results of the two main questions in the questionnaire are shown in the charts below.

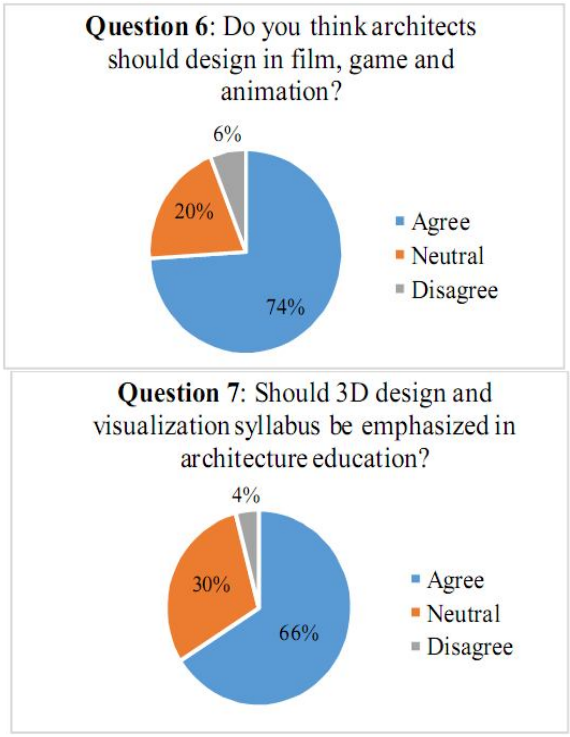


Figure 1: Result of the main questions (question 6 and 7) of the questionnaire based on 54 respondents.

Results show that majority of respondents believe that aforementioned techniques are going to be important in the architectural design field in the near future.

Interviews in turn were conducted with 16 respondents across professional architects and university academics from architecture and design. Similar to the questionnaire, the main importance of the interviews was to extract the relevant views of professionals on the same particular techniques.

It is important to realize that the surveys only mention particular techniques on architectural communication and design. This is because these techniques are the cornerstones of VR. VR itself was not mentioned specifically to avoid prejudice, both good and bad, which is so common to new technologies.

10 respondents gave positive opinions on techniques relevant to VR as potential architectural design tools. 5 respondents reacted neutrally while 1 respondent did not see the relevance.

Positive remarks included the fact that these techniques add a realistic effect of scale and proportions, that they are a problem solver in communicating complex ideas, and that some companies are already using them as tools for visualization.

III. FINDINGS ON VAD SYSTEM

2.4. Developing the VAD system

The design of VAD system is derived from two distinctive issues found during the research, which are mainly about the accessibility of VR towards the architectural design field in general.

The first issue is that current VR technology is either under development, not commercially available or not affordable for architecture education and students.

The second issue is based on a survey conducted by Kym Porter[7], which stated that there are currently no commercially available VR platforms that allow full interaction with the 3D model. This means that the design needs to be created in a normal 2D medium using 3D model software, such as SketchUp or Rhino. Then, the 3D model will be exported into the VR environment to experience the space. Changes to the model while still remaining in VR are currently not possible. The only way is to revert back to the 3D software for further editing.

From these issues, two main objectives of this research are explored.

- To make VR more accessible and affordable in architecture education and for students.
- To create a suitable platform that supports design and interaction within the VR environment in real-time.

From these research objectives, investigation on different types of VR headsets were piloted, with focus on their affordability, availability and public reception. In the end, this resulted in a smartphone-based approach for the headset, as it was easily the most feasible one.

Research on a suitable CAD software that has the ability to support VR was experimented based on common CAD platforms used by architects today. AutoCAD 2014 and SketchUp 2014 were tested for their ability to support VR by adding a plugin or patch. This approach arrived at a dead end as the support for VR of these CAD platforms was under rather limited development, and inaccessible to open

market at the time of writing this paper.[8] Though due to the modular nature of VAD system, later integration might be possible.

The research was thus broadened to find and identify any current software, platform or even a game that could support VR. The main criterion for the one to be used in VAD system would be the ability to create and interact with the 3D model while still remaining in the VR environment.

2.5. Anatomy of VAD system

The VAD system is an integrated modular system composed from a number of equipment working together as a whole. The components of VAD system are divided into four categories, which are primary tools, secondary tools, software and apps.

The primary tools of VAD system are a mid-range PC, mid-range smartphone and a headset to hold it in. The most important specification of a mid-range PC is that it should have a decent graphic processing unit (GPU). A crystal clear HD display is ideal for the smartphone because the headset places the screen very close to the eye. Some models of headsets can be purchased as low as $5, and design templates for producing it from recycled materials are also widely available online.



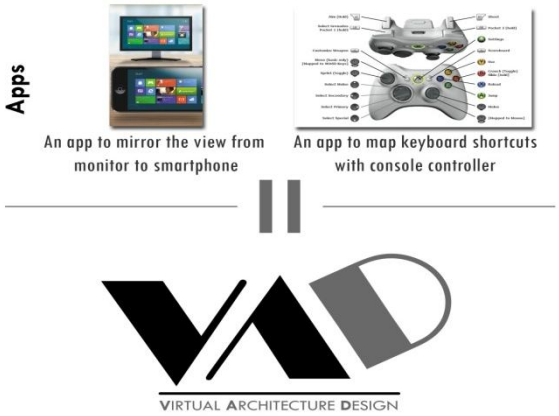


Figure 2: The anatomy of Virtual Architecture Design (VAD) system, see notes †.

VAD system secondary tools are a generic console controller and a sound system. The controller is a necessary instrument for VAD system because while emerged in the virtual environment, one cannot see the keyboard that is outside the VR. Another criterion for the controller is to be preferably wireless to allow for 360° freedom of body movement, although this is not vital. A headphone, earphone or speaker is also recommended when using VAD system, as it will help in creating a fully immersive VR experience.

However, the key to a successful VAD system is the software, as mentioned above. The software for VAD requires the ability to create and manipulate 3D architectural models, with a support for side-by-side stereoscopic view that creates the VR experience. The software could either be a game, platform or app that fulfils the criteria mentioned.

The fourth and final component of VAD system are the supporting apps: An app that is able to duplicate the screen between PC and smartphone, and an app to map the button configuration of the console controller with mouse and keyboard functions to allow control while immersed in the virtual environment.

A good Wi-Fi connection is also required to link the whole VAD system together within the same network.

III. DISCUSSIONS ON VAD SYSTEM

2.6. Benefits of VR and VAD

Experience, expression and efficiency are the main benefits of VR. As novel opportunities to accurately experience imagined spaces in virtual environments are introduced, users receive a clearer understanding of the overall look and feel of the design. Using the VAD system, users can hence effortlessly interact and change various aspects of the design accordingly. Even design in impossible dimensions is possible, as the VR is not bound by the laws of physics. Imagination is the only limitation.

Using the VAD system, expressing the 3D space will become much easier as well. Misunderstandings are common within the architecture community, as design is a subjective matter, and peculiar spaces are indeed hard to grasp through 2D mediums, including screens and monitors. Wrong impressions are all too

easy to get caught up in. Thus VR is not primarily a tool to make the design process faster, but one that will make the design process more likely to succeed in conveying the design ideas forward. VAD system can be used by architects to immerse and accurately express their design ideas to their clients. VAD system also increases the efficiency of an architectural design process and workflow. VAD system lets all of the users interact and modify the 3D model directly in VR, and as a result decision making becomes more and more efficient. By establishing a good internet connection, VAD system could also reduce the time and travelling costs of a project. This is because meetings and discussions among architects, clients and consultants could be done entirely within the virtual space via the internet, regardless of the distance in between. To summarize, the conventional 2D design method using screens and monitors has no doubt eased the architectural design workflow. Just like pen and paper, their role will not diminish as part of daily architectural design tools. However, these mediums are inadequate in conveying ideas of complex spaces, and one must not forget that beauty is in the eye of the beholder. Using VR through VAD system, architects could improve the subjective matter of design by making the intangible tangible.

2.7. Current limitations of VR and VAD

After establishing the basic VAD system, simulation exercises were held with a total of 15 participants in three universities[‡]. Feedback was gathered from these, and three main issues were found out:

- User's wearing glasses
- Connection issues (inadequate Wi-Fi)
- Sense of vertigo

These are all rather easily resolvable problems. Users with glasses are simply not taken properly into account in the headsets currently available, and Wi-Fi could perhaps be addressed by other means, such as Bluetooth for a much smoother display frame rate. The most problematic is the sense of vertigo, but it was only rarely experienced after extended time of use. Clearer and sharper displays may remove the issue in the future, or it might be possible to simply get used to it. Although the problems are real, they are not in any way preventing the use of the VAD system, and might be eliminated altogether with further development.

CONCLUSION

In the future, VAD system will provide a powerful tool for designers to experience, test and express their ideas in VR. It will also allow for exceptionally creative designers to come up with new design inventions and innovations without real world technical limitations. VR in general is not without its issues, as it is currently an emerging technology, but nevertheless these are mostly mere technological gimmicks, and likely to be soon resolved through further research and technological progress.

VAD system is a tool suitable for architecture education and students. By assembling the right equipment readily available in the market, VAD system can be an inexpensive tool to assist in architectural design and expression. VAD system is easy-to-use as it requires zero programming knowledge or skills to construct it. Due to the modular nature of the system, users are able to interchange components according to their needs and liking.

Just like computers, with enough awareness, users and demand, VAD system could become a useful tool for architectural education and students. There is no good reason to delay the introduction of VAD system and VR in general into architectural design any longer. Time of implementation is now.

Notes

*The three universities participated in the survey were Nagoya Institute of Technology, University Teknologi Malaysia and Raffles University Iskandar.

[†] These were the products were used and test the VAD system in the development phase:

1. ASUS G56JR (Gaming Laptop)
2. iPhone 5C
3. Andoer CST-01 (VR Headset)
4. XBOX 360 Wireless Controller
5. Minecraft (VAD Software)
6. Splashtop App
7. Xinmapper

[‡] Three universities mentioned were University of Southampton Malaysian campus, University Teknologi Malaysia and Raffles University Iskandar.

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