WHY NOT VR ARCHITECTURE?

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DLACZEGO NIE WIRTUALNA ARCHITEKTURA?

Abstract
This article is an overlay of key aspects of virtual architecture and the VR world. Through the use of the entertainment market, virtual architecture gains a completely new area of expertise and the ability to shine in new realms. By comparing existing limitations and advantages of real world architecture and virtual architecture, the author notes the possible direction of evolution that architects may face as a result of new design thinking in the VR world.

Streszczenie
Artykuł przedstawia przełożenie kluczowych aspektów wirtualnej architektury oraz świata VR. Wykorzystując rynek mediów rozrywkowych, wirtualna architektura zyskuje całkowicie nowe pole do popisu oraz nowy zakres specjalizacji projektanta. Porównując obecne ograniczenia i przewagi projektowania architektonicznego oraz projektowania wirtualnej architektury, autor przedstawia możliwości technologicznego rozwoju sposobu projektowania architektonicznego jako wynik nieograniczonej inwencji w świecie VR.

Keywords: immersion; architectural design; virtual architecture; Virtual Reality

Słowa kluczowe: imersja; projektowanie architektoniczne; wirtualna architektura; wirtualna rzeczywistość

INTRODUCTION

Virtual reality is a composition of various computing processes that take place simultaneously and create immersive imagery. By immersive, one must understand the multiple singularities that provide the VR experience only in unison. Basically a step forward from the time of the flat image and a few steps away from pure cerebral image computation. The best way to explain what VR is all about is to compare it to a fully immersive display of 3d models right in front of the user's eyes, through the use of a special HMD, or a head mounted display with the ability to freely move around and interact with the scenery. Even simpler, a computer screen with special lenses fixed right in front of our face. This process is achieved through the use of graphic processing units such as GPU cards, as well as CPU processors that put it all together. Content that is displayed in VR is purely up to the designer's imagination, all within the limitations of time and processing power. Basically, one can view anything and everything in VR, provided that the content is created or owned. This goes anywhere from creating custom environments to buying existing solutions and combining it together. Some of these solutions can be 3D models of housing units made for making custom cities / neighborhoods, 3D models of plants and animals used in creating natural surroundings, or sci-fi models used in creating futuristic scenery. Custom content is relevant to the targeted design, which is also limited only to the desire and imagination of the creator / designer.

Now the question that might be floating around the readers mind is “What is VR used for?” and “Who uses it?” and “Why is it used?” These questions are quite extensive as there are many examples and ways to answer them, but basically VR is used by graphic artists and their clients to give another dimension of depth and realism to their projects [K. Świadek 2016, p. 842]. As mentioned, VR is an immersive tool used to display an object, shape, or environment with the ability to freely move around and look at it from different angles [B. Laurel 1993, p. 184]. This is mainly the case in architectural display with VR such as housing showcases, hotel advertisement, virtual museums and VR games. Most of these are shown during expos and certain events, but more often these are available for online use via smartphones and HMD systems. Some of the most widely known examples are the Takenaka Corporation [https://unrealengine.com/en-US/blog/takenaka-corporation], Hilton Hotel [https://hospitalitytech.com/hilton-waikiki-beach-launches-vr-mobile-app-attract-guests], and the Merrel brand Trailscape [https://framestore.com/work/trailscape**].** Although these examples are strictly limited to the events that held them, they could just as easily be available through the online use, provided that the user has hardware for the VR display.

Entertainment however, revolutionized the world of VR and gave it much more depth and meaning. Apart from just viewing the scenery, scripted interactions and game logic was implemented into scenes and thus was created the VR game. These games are readily available and sold on online markets for various platforms. Although many of these provide short thrills and simple quests, there are some that are primarily focused on the exploration and adoration of virtual architecture.

1. THE BEGINNING OF VR

Virtual reality started back in the first half of the 20th century, with the creation of the very first virtual reality flight simulator by Edwin A. Link in the 1920’s [https://www.simulationinformation.com/hall-of-fame/members/edwin-albert-link]. It consisted of a C-3 Aercona cockpit with most of the onboard controls, as well as a set of pneumatic bellows that would react to the trainees input and simulate turns, pitches and banks. This invention began the age of simulators as well as the later virtual reality. One of the first multimedia VR sets was the “Sensorama”, designed by Morton Heilig in 1957. This device consisted of a set of interactive elements such as a wide stereoscopic display, audio output and smell emission which would allow the user

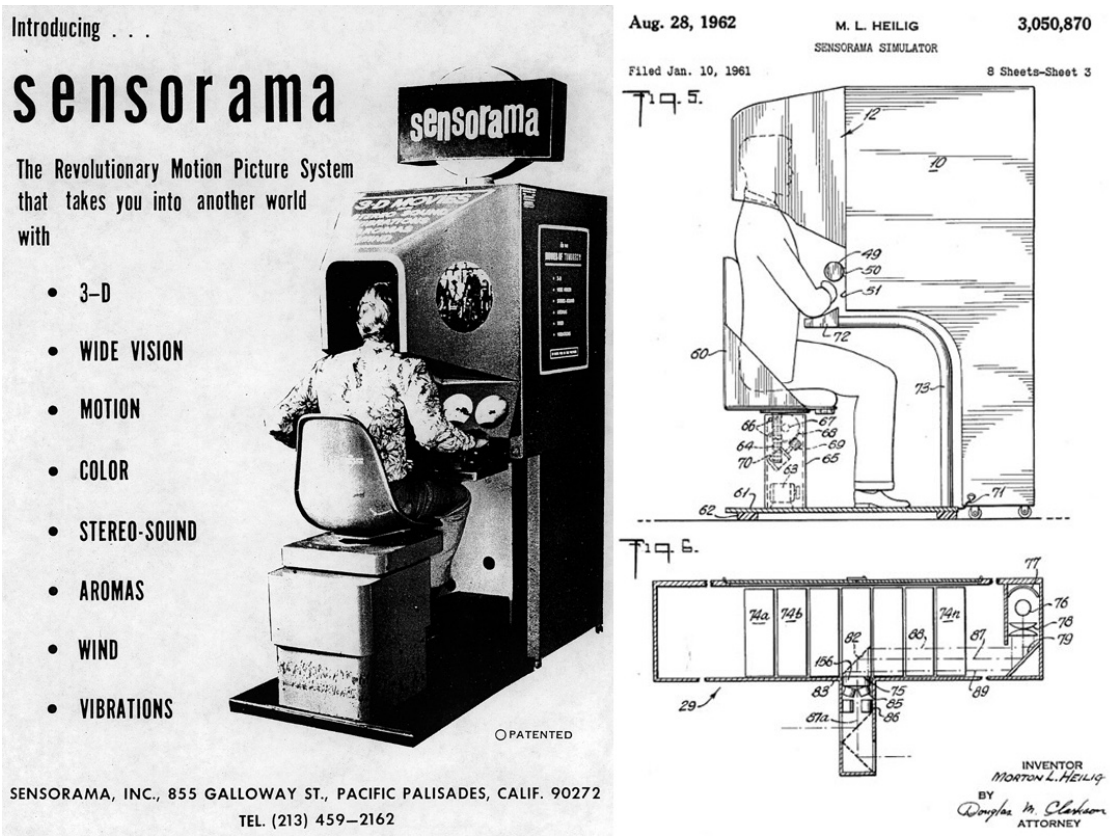

Fig. 1. Sensorama visor system schematics; source: https://vr-expert.nl/wp-content/uploads/2016/05/sensorama.jpeg

Fig. 2. Caterpillar CAVE system; source: https://peoriamagazines.com/files/u36/PM_CatTC_13.jpg

to see and experience images in more depth and from a different perspective [https://www.mortonheilig.com/InventorVR.html]. Focused on the simple yet at the time advanced form of imagery, the Sensorama was nothing more than a "for fun" type of amusements device. The real great grandfather of today's technology was the very first head mounted display system or HMD. Philco Corporation created "Headsight" which at the time served as an extended view of the night scenery for helicopter pilots.

The mentioned breakthroughs in VR development paved the way to much more recent developments, even in the 1990's and the implementation of VR into gaming and exploration. This was done by Jaron Lanier and the numerous patents made in collaboration with Tom Zimmerman. Most of the devices made at that time consisted of separate systems that focused on many key features found in today's technology. Included in them were audio, 3D vision, interactivity, and the coding process [https://glassdevelopment.wordpress.com/2014/04/17/hmd-history-and-objectives-of-inventions].

While head mounted devices were being developed, another kind of virtual environment had its fair share of success in the engineering and automotive industry. Through the use of multiple visual broadcasting devices such as screens and projectors, systems such as the CAVE virtual reality projection system offered by a US based company called WolrdViz. Along with the products from various other companies, the multiple screen projection systems have allowed designers to portray their designs in front of a large audience as well as have themselves be immersed in the concept at hand. One such company that uses the CAVE sys-

Fig. 3. Oculus Rift – classic gamepad setup; source: https://roadtovrlive-5ea0.kxcdn.com/wp-content/uploads/2016/03/oculus-rift-review-9.jpg

Fig. 4. HTC Vive – handheld wireless controllers; source: https://www.bhphotovideo.com/images/images2500x2500/htc_99haln002_00_vive_vr_system_1337110.jpg

tem is Caterpillar, a corporation designs and produces heavy construction machinery. Their VR system has been used in the design process as well as a training tool for assemblers and servicemen.

Recently, the world of VR has received a significant boost in development as many markets opened up to innovative solutions and their implementation in fields such as military, medicine, design, marketing and pornography. The most known hardware providers are HTC and Oculus, both of which have their own systems like the Vive and Rift. Development of these devices was pretty much linear with one another, as release dates would almost overlap by a few weeks. Compact and simple, the primary target of these systems is the general population with the obvious use for entertainment and 3D gaming.

The past eight years in development of Vive and Rift focused on improving the screen resolution and interactivity of the player through the use of hand controllers and motion tracking. The first released Rift system, or the Oculus Rift DK1, targeted software developers and their ability to provide fast, cheap, working content for the latter DK2 in 2014 and Rift CV1 in 2016. HTC released their flagship hardware in 2016 and dominated the development market due to the fact that it had hand controllers. The Rift followed up with such in 2017.

Although there is a distinct array of other systems, they do not meet the standards of fully immersive VR, as they are limited to compressed performance levels of processing units, versatility and ergonomics. It is these last three aspects of VR that are crucial for fluent use in the creation process of Virtual Reality Architecture.

2. ADVANTAGES OF CONCEPTUAL VR

Knowing what VR is one might question the sole purpose of VR architecture in relation to the already existing imagery solutions such as 3D paper models, architectural visualizations, animations and self-explanatory floor plans. Even though the mentioned methods show the object / scene in a planned and orderly fashion, they do not give the desired effect of the building, such as emotion, space, thought and freedom. It is within these four aspects that VR architecture could dominate over the others.

3D paper models give off a great understanding of the design, with the ability to view the structure from certain vantage points and at any time, provided that you are standing right next to it [J. Janusz 2016, p.34-35]. The major down side is the cost, time and limited availability of the model. Of course, one can take pictures of it and share it online, but it would make more sense to create CGI renders. Another limitation is the unavailability to view the building from a user perspective, as well as view the interior space.

Architectural rendering and CGI work is a great tool for design and marketing, as these images or sequences could be shared online, printed in mass, or displayed in commercials and advertisements. Their downside however, sits in the limited views produced in the 3D modeling software. Animated sequences are

Fig. 5. Balsa wood and cardboard model of building; source: https://www.arch2o.com/wp-content/uploads/2017/02/Arch2O-Architectural-model.jpg

also limited to the planned views and do not offer any more than they show off. Their production is also time-consuming, as any changes in the design need to be re-rendered. Floor plans show of interior space and are usually accompanied by CGI renders, as well as some short animations. Mainly, they are used for technical display during the sales process, as well as some detailed explanatory means.

Production process for VR and architectural visualizations is quite similar. It begins with the creation of 3D models based on floor plans and technical data. Most of the main structural elements are created at this point, as well as certain decorative detail work. Basically anything that has mass and volume is brought into existence and arranged to form the building. This process is identical for both VR and CGI. Next, all of the coloring is brought into being, ranging from paint, carpeting, woodwork, lighting, greenery and the sort. Materials are placed onto 3D models, lights are set up to illuminate the scene, and finishing touches are created to give the space as much realism as possible. Yet again, this is also identical for both VR and CGI.

The last step is where the magic happens; rendering. Traditional CGI requires the setup of cameras, lighting effects, color correction, and the actual processing of the bundled data. Rendering can take anywhere between an hour to even an entire day, all depending on the complexity and final resolution. After the render is complete, the image goes through a stage of post-production, which adds anywhere from a few minutes to even an hour per image. However, while virtual reality does require some additional steps that resemble rendering, it does not need to render each view in the same time as CGI; it does it much quicker.

VR is basically an on-going 360 degree video game of the designed scenery, which allows the user to walk, run, jump, fly and do many more things in real time without the need to render each frame. While it requires more powerful graphic cards, it allows for almost the same realism and quality to be viewed instantly from every angle, at any time by any one. Like in a movie, the content is displayed as a series of images, known as frames, which are rendered instantly at the pace of anywhere between 30 to 120 frames per second. When using the HMD, each movement of the head and anything else that appears in motion triggers the rendering process to update the changed scenario. This means, that when we decide to look around or from a different angle, the content will be instantly displayed accordingly. Hand controllers are used to interact and move within

Fig. 6. CGI render of housing project; source: render by author

Fig. 7. CGI render of interior project; source: render by the author

the scenery, all in the constraints of the virtual world [A. Asanowicz 2012, p. 9]. Key to the world of VR is the metaphorical exploration, interaction and immersion, which in turn leads to the need for control and involvement. All of this is only virtual, but the need for further evolution of experience is what drives humans toward the data space realm [K. Kalitko 2005, p. 113-114]. For instance, if one was to enter the VR world of a subway station, they could walk around the platform, follow stair cases to different lines, and even take a stroll on the ever forbidden train tracks. If only desired, they could even try to squeeze in between the oncoming train and the bounding wall and get an exhilarating jolt of adrenaline. Of course all of this would be for entertainment purposes, but if done correctly, designers could check the interior of subway designs and discover flaws and design problems. They could also do something out of the ordinary, and forget about many constraints that reside in the real world and immerse themselves into the limitless world of virtual reality.

3. THE CONCEPT OF PHYSICS IN VR

First and foremost, the world of virtual reality does not need to follow any rules what so ever. Whether it is creation or experience, the ether could be programmed and designed in any shape or form, with or without the use of the laws of physics, space and time, or irrational dimensions. Gravity could be shifted into a stronger or weaker form, shifted into another direction or turned off completely. What this means, is that when designing virtual architecture, the designer can decide which scenario suits him the most, and possibly alter it in the further process. This of course, plays a key factor in the design process and the form finding stage.

Let's take a look at a possible zero gravity world scenario in which the creator is allowed to use any form or objects as a base for construction. Traditionally, we would gather information about the investor, the budget, possible features and so on, only this time, the designers can decide all of these things by themselves. Without the restrictions of gravity, space and time, the site could be created floating in the middle of nowhere and everywhere, without the need for floors, stairs and the sort. Movement throughout the building could take place in any direction of any vector, allowing for the space to be assorted into irregular arrangements, sort of like the International Space Station floating above our skies. Large open areas could be linked by abnormally vast corridors, as well as sudden tight spaces in between key areas, all of which could be situated at different angles to one another. Experiencing such a building would require advanced knowledge of the use of VR hardware, and would also provide some levels of stress that would derive from the lack of "normal" space and form. Movement within such a building could be maintained by propelling the body though grappling, or with the use of a jet-pack like propulsion system, that would not be even visible to the user. All of this may sound like pure science fiction, but in reality, it is only the unhinging of the real world constraints that keep us from building such structures.

In the case of maintaining gravity in the virtual world, other physical traits can be altered or ignored what so ever. While creating a scene for a single user, the floor plan could resemble those of the real world, but the actual structure could be physically impossible to achieve with the current technology. A building without weight bearing elements such as beams and columns can be created to span hundreds of meters, while perfectly balancing on a needle. Vast underground-like caverns can be dug out without the fear of collapsing. Incredibly heavy blocks of concrete could be suspended in midair, without a single thread of support from above or below the object. While creating volume, these objects do not have mass, and as goes, can be lifted and moved without the faintest effort, making building susceptible to rapid and sometimes obsolete change. Entire segments of walls can be designed in a way that allows users to suspend them in mid-air and set them anywhere they want. This kind of freedom can be limited by the creator and in result made into a more passive experience.

4. PERCEPTUAL ENCLOSURE OF 3D FORMS IN VR

Through careful planning and design revision, VR architecture could be submitted to the general population under certain constraints. Whether it would be limited space or limited time, certain elements that would not be shown, would not be created at all. All of this depends on who is making the design, for what purpose and for how long would the building play a key role in the VR experience.

If one was to design and create a virtual school building, they would need to decide which areas would need to be shown up close, which segments would be visible from afar, and what areas would be totally unavailable to the viewer. The latter could be places like toilets, sanitation closets, storage space and so forth. Even though these areas could be scattered throughout the building, close to the main attraction areas, they could easily be blocked from entering, as easily as they are made unavailable to people by means of locking the door. Invisible barriers would prevent view-

Fig. 8. Alchemist workshop, minimal difference in size; source: https://i.imgur.com/CMlmW2F.jpg

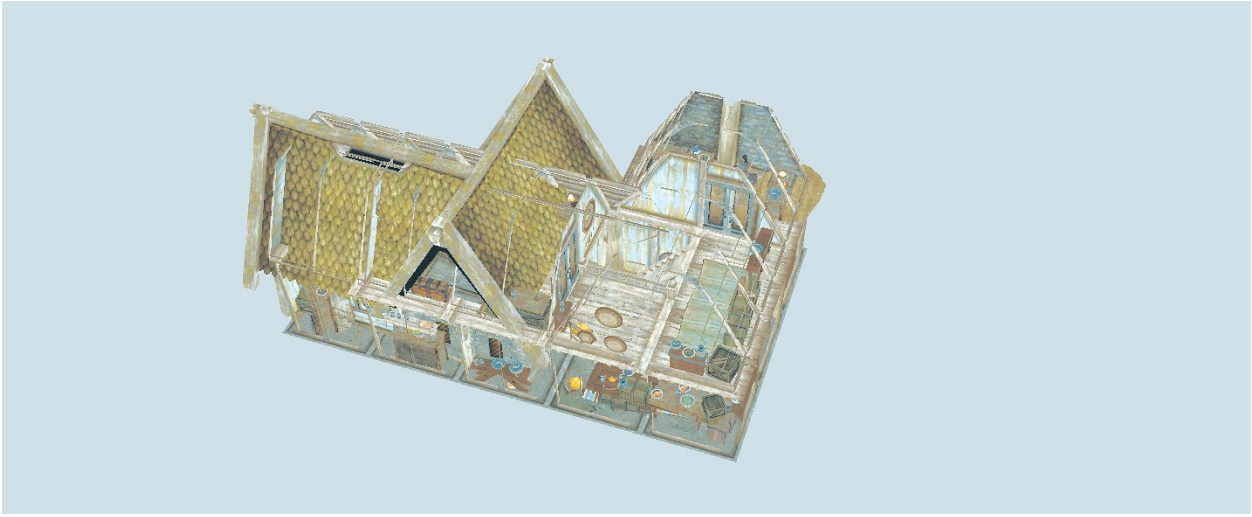

Fig. 9. House, noticable length difference on the right side; source: https://i.imgur.com/h2UjVAR.jpg

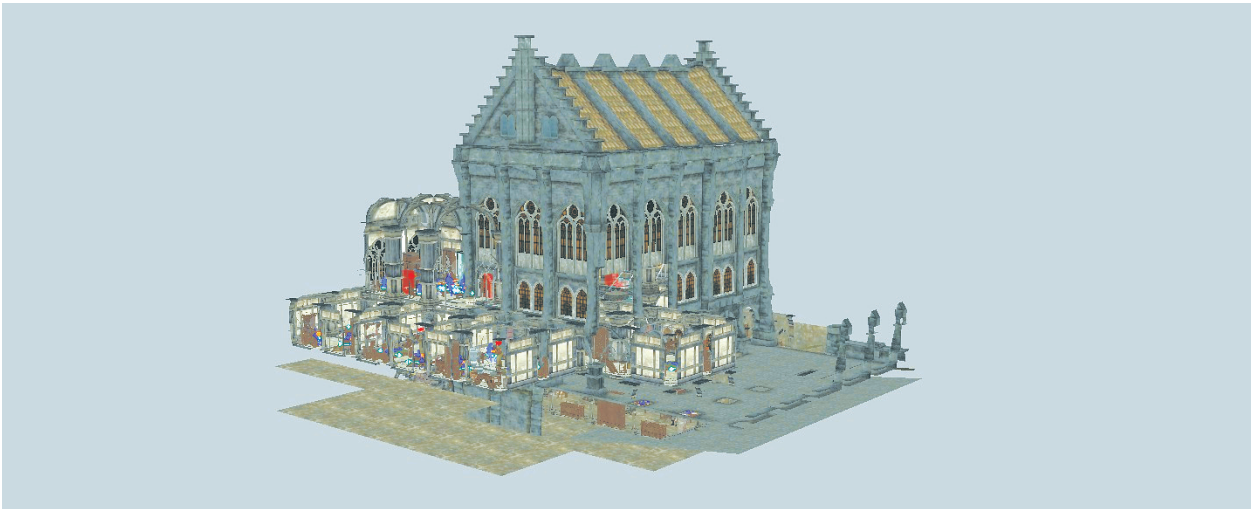

Fig. 10. Bard's College, completely different layout with non existant upper levels; source: https://i.imgur.com/bcNNuwW.jpg

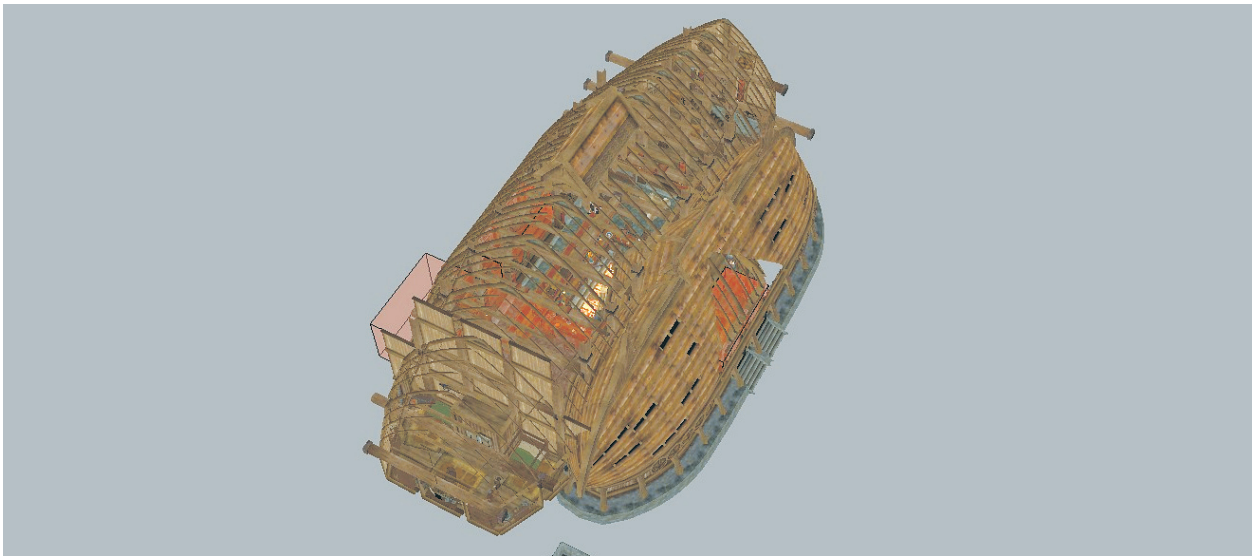

Fig. 11. Jorrvaskr, similar shape but in offset and noticable size dialation; source: https://i.imgur.com20ZgpH2.jpg

ers from even getting near these places, with decorative signs that could read "out of order". Of course, this is just a trivial example, but in the case of shopping malls or other large sites, most of the enclosed spaces would be made unavailable just for the sake of time and sense. Creating an entire building and making every square centimeter available is impractical, and commonly thought of as useless. If such things would take place, the desired experience would dwindle on the curiosity of viewers to see unimportant fragments of the building and in turn would prove to be simply boring. Just like in any form of entertainment, leading lines and areas of focus guide the viewer into the main event and make the experience more controlled and in turn pleasant.

Key to the vr architecture world is the fact, that 3D models of buildings are in fact only shallow shells which are set up for a specific "tour" of the building. In some cases, buildings are visible from a single area like the front, in others the building may be available from all four sides, but does not have an interior. In other cases, the building is visible only from the interior. All of this depends on the planned outcome, in which the designer decides if they want a viewer to be able to walk into neighboring buildings or not. This is greatly revised and seen in open-world 3D games available on the mass market. One of these is *The Elder Scrolls V: Skyrim*, made by Bethesda Game Studios. Most of the buildings available to the player are not coherent with their indoor and outdoor models, as the size, layout, orientation and general look does not match. This has been noticed by the gaming community and even described by the user *Veltoss* in a short article on *imgur.* By extracting the 3D model from the game file and overlaying the interior and exterior, a comparison of inconsistence had been created for a few example buildings.

5. THE FUTURE WAS YESTERDAY

Deviating from technical information and technological procedures, virtual architecture is a new haven for forgotten and ill-timed historical designs. Anything from impossible structures (at the time), to unfinished grand designs from all over the world and timeline could be reintroduced to daylight via the virtual world. Three dimensional reconstructions have their limitations of course, as they mainly reside on educated guesses, and consist of estimated fragments to the whole.

The process of creating a virtual reconstruction is based on existing content, in this case drawings, plans, photographs, paintings and written descriptions in things like literature. As it is the case with most historical sites, this data could be close to non-existent, and the following process of 3D modeling could resemble or basically be identical to those of archeological studies. Fragments of information are fused together with possible outcomes, research based context is warped around the site and key details are then inserted in a mix and match format. Research is then preformed on the sum outcome, resulting in changes to estimates, revisions of collected data, or even the abolishment of past theories concerning architectural designs.

Over time, scientists and engineers have developed numerous methods of reinvigorating the old and forgotten designs, some of which have been mentioned by researcher Dr. Maria Helenowska-Peschke in her article about the phenomenon of virtual reality in architecture. Her focus resided mostly on the analysis of

virtual reconstructions of historic sites, most of which have been completely destroyed by wars and time. In addition to historical reconstructions, non-existent designs have also been mentioned, such as the work of Louis I. Kahn done in the virtual environment by K. Larson [M. Helenowska-Peschke 2011, p. 143-145].

The topic of the virtual reconstruction of historic and uncreated designs is immensely deep, as there are many examples of such work, which continue to grow in number every day. Along with the advancements in aerial 3D scanning and satellite imagery, educated guesses would be narrowed to more accurate assumptions and their outcomes would provide more detailed answers to researchers.

6. INSTABILITY OF SET FORM

Programming has been an essential part of virtual reality since the very beginning, as most of the early examples were created by pure code input. Thousands of lines of code generated volume, color and space, along with simple forms of interaction. Nowadays, visual programming methods have evolved to a point where advanced knowledge of software programming languages is not needed. Methods such as the blueprint coding language in Unreal Engine 4 have made it possible for architects and designers to engineer certain traits of a building to make it more appealing to viewers. Through the use of templates and samples, UE4 users can generate blocks of code by copying and pasting fragments from existing examples and create their own version of interactivity.

With this, virtual reality can allow the viewer to be able to interact with the environment in ways such as changing the color, turning on lights, moving and rotating objects, altering gravity, shifting sunlight direction and even completely destroying given objects. The array of possibilities is limitless, as is the imagination of a designer, which may be assorted to the limitations of the hardware. What this means, is that when creating an urban scene in VR for the mobile platform, the designer has to be wary of the limitations that will take place. Movement will not resemble that of the Vive or Oculus devices, as well as computing power of the special effects. With that in mind, designers first need to specify how much data can be shown in a given scenario, and what type of interaction is best suited for the given hardware.

Hardware such as Oculus Rift and HTC Vive run on the performance of the desktop computer or laptop. High end graphic processing units, or GPU cards, allow for more realistic and calculation heavy effects, which can in turn, create a more immersive experience for the viewer. A well programmed interior space can be altered in ways such as moving furniture, changing the color and material of walls and floors, altering

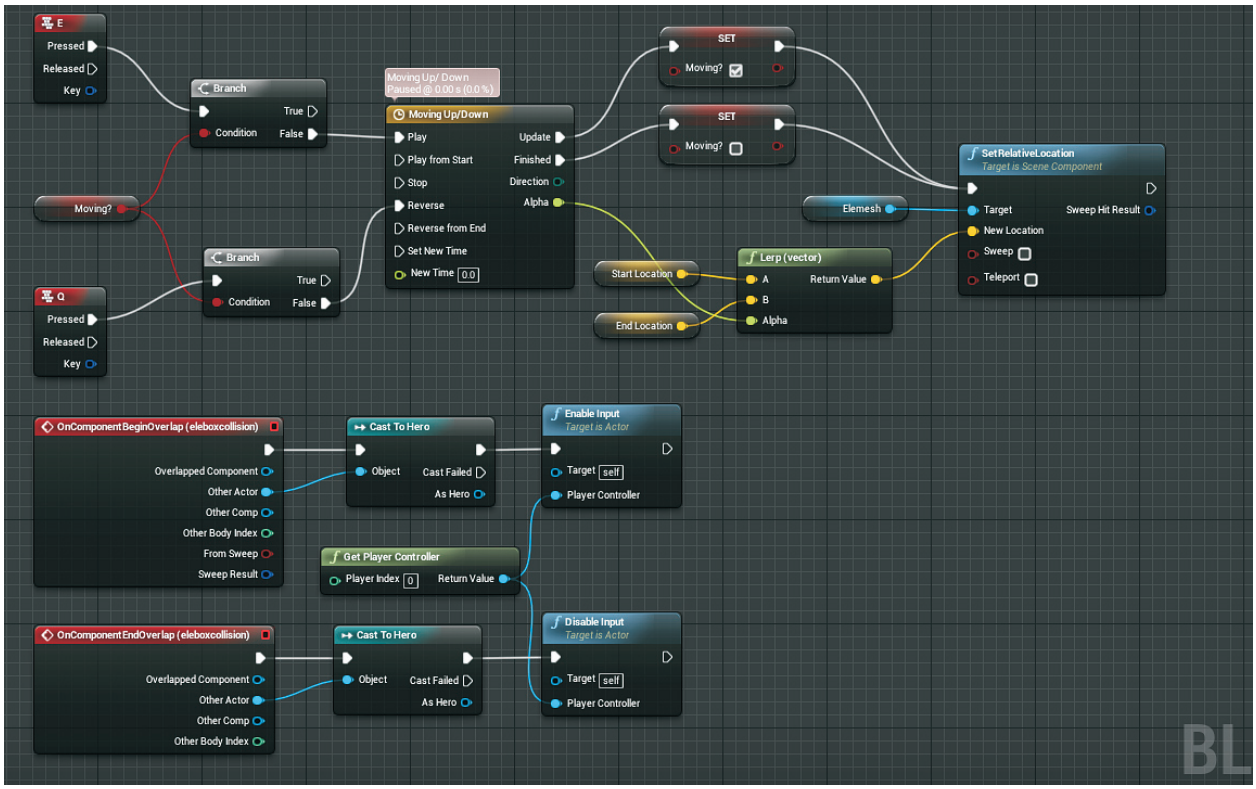

Fig. 12. Fragment of an example blueprint schematic code from UnrealEngine4; source: screenshot of author's work in UE4

Fig. 13. Schematic example of VR interaction; source: render and graphics by the author

Fig. 14. Free version of a victorian themed 3D model set; source: render by author, 3D models from www.kitbash3d.com

lighting set ups, viewing the space in day/night mode, and etc. The exterior scene of a building can even allow for the alteration of the entire form, with things like changing the roof type, wall height, window arrangement, greenery replacement and movement, season change and etc.

With the mentioned tools, architects received an entirely new pallet of design possibilities, many of which could be based on human intervention. Designs could incorporate room for change or even be entirely dependent on interactivity. Kaleidoscope like facades have been already introduced in real world architecture just like in the Pineapple towers in Abu Dhabi, United Arab Emirates. Their interactive exterior panels are equipped with rotary motors which allow the entire façade to change at the press of a button. This would be analogical to what is achievable in virtual reality, only on a larger scale. Viewers could alter entire sections of a building via rotation by the push of a lever or simply by waving their hand.

Such alterations would need to be planned out first, in order for the experience to go smoothly and accordingly. Total freedom and random alterations could be innovative, but may prove to be disruptive in the process of creation and turn out entirely useless. Guided interactions that represent partial free will may prove boring and unsatisfactory. Just like in 3D games, players react differently to various in game interactions and tend to have a strong sense of right and wrong. As history has shown, this reaction could even mean the abandonment of a game all together, which in correlation would mean the lack of skill in an architect.

7. SPATIAL MODULARITY IN VR

Having already mentioned the possibility to alter virtual designs, interactivity in VR can also be mentioned as complete creation. Graphic designers use modular systems known as *Kit Bash,* or asset packs for 3D modeling and texturing. Sets of numerous elements would be given to a designer to build their scene with limitless possibilities. The items found in such kits could include sections of wall, several different doors, roof segments, stairs, details, industrial elements and more. Most kits are designed in a specific style, with modular dimensions, and matching "sockets". Designers would chose sets that match their desired style and create structures by duplicating and stacking chosen elements. These kits are made available online through 3D design marketplaces such as *UE4 Marketplace, Unity Asset Store, Turbosquid, CGTrader* and more. Others can be found on dedicated websites like *www.kitbash3d.com*, where several urban themed kit bashes can be bought. Although they consist of readymade buildings, they're a great tool in virtual urban design.

The mentioned method of creating virtual architecture through kits and asset packs resembles the human nature that has recently evolved due to the high paced lifestyle. Market mentality, as Christine Boyer mentioned, is "short-term advantages and high turnover rates" (13), which in this context defy the need for readymade elements for quick designs that produce great results. Although the author made reference to the information age of large cities in the real world, her perception greatly adheres to the human activity in the virtual world.

SUMMARY

In all of its meanings and forms, VR and virtual architecture are being driven into ever evolving forms of entertainment and culture. While large scale 3D gaming projects drive the trend toward interactivity and freedom of form and design, institutional use nudges VR into historically accurate depictions of nonexistent buildings. Both of these give future designers an enormous field of maneuvering with various skills in various fields. This means that real world architectural styles could derive from future 3D gaming worlds, anywhere from interior designs to large scale housing projects. Historical reconstructions and the research that accompanies it could provide real world architects with new information about ergonomics, structural integrity, and historical value.

Entertainment providers still require their 3D artists and designers to be educated in the field of architecture and historical knowledge as well as be skilled manually in 3D model creation. Just like in the modern world, urban design for the virtual world has its rules that allow the game of movie to look genuine, "correct", and well planned, even if the setting takes place in outer space or in a fantasy realm. Without this, content would be of low quality and would not gain the popularity and revenues that it currently boasts. Games would seem bland and unplayable, movies would lack setting and character and the economy would suffer in terms of technological development and ground breaking research.

The virtual world still has some serious limitations that mainly reside in technological advancements and economical strategies. Most virtual worlds require serious hardware that unfortunately is not available to most designers mainly due to the costs. Graphic cards that could provide necessary tools for the evolution of VR and virtual architecture are extremely expensive, and only their downgraded versions are priced just enough so that the average customer could afford one.

Existing technology offers new alterations of the virtual world, just as it is in the case of augmented reality. AR is the real time mix of the real world and a virtual overlay of the cyber world. Available technology allows for the placement of 3D models in real world space and its viewing via a smartphone or a tablet, as well as more advanced technologies such as the google glass. While this is still under heavy development, the potential could be seen as examples in sci-fi movies. Integrated and interactive holograms placed onto everyday objects, animated building facades with the ever evolving advertisements, and even cerebral implants with augmented visual perception. Of course this would revolutionize the way we see the world and offer a vast array of possibilities in terms of urban design and architectural composition, as seemingly bland facades could become packed with interactive virtual elements seen only through the use of technology.

Whether we like it or not, architecture is beginning to sprout a new branch of possibilities, including augmented implementation, pure virtual design, and historical revitalization. These fields could prove to be very useful to the economy and to the common user, as ergonomics, visual presentation and subconscious traits could undergo serious development in the upcoming years. Virtual analysis could breed new structural developments that might change the way we build. It is only up to us now, whether we choose to use the new tools for creation, or decide to leave things where they currently are

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