Digital Architectural Composition in Virtual Space

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The paper is divided into two main parts. The first part refers to the history of attempts to use VR technology in the process of architectural space creation in a dynamic way. The second part presents the experiment carried out at our Faculty, in which we implemented VR in the Digital Architectural Composition course. This experiment was divided into two parts. In the both parts Google Blocks software was used. In the first part we have used the first exercises which was completed by students during the first semester in a traditional way (a cardboard mock-up) and then in the third semester as a digital model in Cinema 4D. It was a Solid form with. In the second part of this experiment we asked students to create a sketch of walk through space and they can created their own shapes in their design. The analysis of the results allows to formulate the thesis that there is a qualitative revolution in the area of human-computer interface. The main conclusion is that Virtual Reality eliminates the boundaries between the spectator and the space and that the idea - Designing Become a Place" is still actual.

Keywords: Architectural composition, virtual reality, direct design

INTRODUCTION

Architects have been using computers for decades to increase productivity, solve seemingly insoluble problems, and create sophisticated presentations. They use computers not only as a tool, but also as creative devices capable of generating unconventional design ideas and forms for the built world. Our long-held conventions of architecture, space, and time are being challenged as the digital supersedes the real. Using VR tools' new spatial capabilities enables architects to challenge the most fundamental principles of structure, order, and human perception.

The pursuit of an object that can never be expressed in reality is not a new phenomenon. At the end of the 18th century the dramatic structures of Etienne-Louis Boulee were too gigantic to be realized. Similarly, the abstract art of Malevich recognizes magnetism, gravity, radio waves and other invisible forces and pulses in a world of objectless paintings. It is extremely difficult to imagine the space on the basis of the drawing or even inside a mock-up, and then evaluate the correctness of the solutions. Even great architects such as K. Melnikov considered that even the author of the project cannot predict all. His dream was to see how people will perceive the unusual form of internal space he created in his design of a Columbus monument. It was a trimmed cone, into which another similar but rotated cone was immersed at the top. K. Melnikov admitted that even he could not have had imagined what impression this interior would have on others (Khan-Magomedov, 1990).
Architects have always dreamed of seeing the unusual form of internal space they have designed. This was the reason for applying VR technology in the Digital Architectural Composition course. We decided to use the HTC Vive VR googles, which allow one to enter into the composition space. Usually VR is used for the presentation of completed projects. The model of the object made in 3D software should be transferred to the virtual space using additional software such as Unity or Unreal. This approach does not use the full potential of VR. Of course, even in this case the interaction with 3D forms present there is possible. But we are interested in the next level of interaction - interaction within the process of creation. The paper considers the possibility of implementing the idea of “direct design” formulated by the author in the late 90s.

HISTORICAL BACKGROUND

The idea of virtual reality was first presented by S. Lem, who considered the problem of creating artificial reality, identical with the real one. In 1964, S. Lem wrote in his book Summa Technologiae: “We are faced with the following problem: how do we create realities for the intelligent beings that exist in them, realities that are absolutely indistinguishable from the standard reality but that are subject to different laws? (...) We shall ask, Is it possible to create an artificial reality that is very similar to the actual one yet that cannot be distinguished from it in any way? The first topic focuses on the creation of worlds, the second on the creation of illusions. But we are talking about perfect illusions. I do not even know whether they can be called just illusions.” (Lem, 1964) Lem proposes creating a feedback between “artificial reality” and its participant. There is no “exit” from the world of illusion to the real world. As an example, he describes the hypothetical situation of placing a man in an illusory room in which, moving his head, he will see what he would see while in real space. The computer should respond immediately to any change in the position of the man. (Lem, 1964) It should be remembered that IBM produced an IBM PC / XT personal computer with a 16-bit Intel 80286 microprocessor working with a 6 MHz clock and 640 KB RAM only in March 1983. Year later, Jaron Lanier founded the company VPL Research (Visual Language Programming), which produced prototype equipment to be part of virtual reality - gloves used to manipulate objects visible on the computer screen. A VPL Research DataSuit, a full-body outfit with sensors for measuring the movement of arms, legs, and trunk was developed in 1989 and displayed at the Nissho Iwai showroom in Tokyo. According Lanier, VR is much broader than the idea of a computer. VR is a digitally generated, visual, acoustical and tangible multimedia environment, which surrounds the human body, supplying it with sensorial impressions. Systems of virtual reality are based on interactivity in the sense that the computers producing a simulation of the surrounding, in which the human is emerged, still transform the environment in accordance with the reaction of the human. Virtual reality is a medium which stimulates the feeling of presence owing the use of modern technology (Heilbrun, 1989).

VR has added a new meaning to the notion of space. As a three-dimensional space for visualization of 3D digital space, VR seems perfect for architectural exploration.

The author’s first real contact with VR was in 1993, during the ECAADE Conference in Eindhoven, where a VR installation at the Calibre Institute at the Faculty of Architecture, Building, and Planning of Eindhoven University of Technology was presented. We had the opportunity of immersing ourselves in a model wearing a helmet and using a 3D pointer. Presented model of interior was a very simple and low-poly, but the impression that this space caused was unforgettable.

The first practical attempt to apply VR technology at early stages of design was also undertaken in Eindhoven, where a desktop-VR three-dimensional voxel sketch tool was elaborated. DDDoolz was developed in the Design Systems Group to explore the use of VR technology at the early design stage.
The main working modes of DDDoolz are Drawing and Navigation. Working in the Drawing mode, the designer uses a digital wand-manipulator to enter forms into the virtual space. The program works on the principle of interactive movement of voxels (minimal addressable three-dimensional space elements). The designer, placing them directly in the virtual space, creates a “volumetric sketch” (orthogonal or curvilinear forms). In the “navigation” mode, the designer can move through the space created by them (Achten, Vries de, Jessurun, 2000).

VR IN THE ARCHITECTURAL COMPOSITION

P.D. Plowright in his book “Revealing Architectural Design. Methods, Frameworks and Tools” has written: “The manipulation of form is, then, a primary aspect of architecture, and one of the main ways in which discipline is engaged. It is not the goal, however, but a means to an end.” (Plowright, 2014, p.18) This quotation defines the direction of VR technology usage in teaching of Architectural composition. Our main thesis is that direct creation of architectural forms in virtual space enables one to creatively use computer technology in the design process as the designer-computer communication becomes more natural for the designer.

In 1999 at the ECAADe Conference in Liverpool the author has formulated an idea of “Direct Design” in virtual environment. Architects often engage with the present, manipulate existing means and act in real time. Architectural designing in virtual environment has the potential of achieving direct manipulation with created forms and objects (Asanowicz, 1999).

Unfortunately, the weakness of VR technology at the time did not allow for the implementation of the idea. Only after 18 years we are now coming back to this idea in our “Architectural Composition in VR” course, which was developed on the basis of Digital Architectural Composition course established under the AVOCAAD program. This digital course was based on the same three exercises as the traditional course. The only difference is that in this course we permitted using any possible geometrical elements and surfaces with different colour and light. In the Digital Architectural composition course students prepare three exercises. The first is Façade - relief composition, which is viewed only from the front. The composition should be arranged on a 30 x 30 m field. The façade may be built of different types of cuboids. Their size and number depend on the conception. The second exercise is more complex. The students are asked to design a solid composition with a specific emotional value (dynamic, light, massive, and monumental). The composition size should not exceed 30 x 30 x 30 m. In this exercise we do not limit the type of forms used. As previously, the size and number of forms depend on the conception. Walk through space is the third exercise. The goal is to create a Walk through something important, something that has no beginning or end. When applying architectural forms, a linear composition should be designed within a 300 x 600 m space. Any geometric forms and materials can be used.

BLOCKS - THE TOOL FOR CREATION IN VIRTUAL SPACE

Google Blocks is simple a tool that lets you shape, paint, and change your creations without ever having to touch a mouse or keyboard. It gives the ability to craft a spatial composition in 3D space. Everything that is created can be viewed intuitively as in the real world. Blocks removes the need for sketches, parameterization and dimensioning - all of that is combined together so that the designer can focus on the creation instead of tweaking sketch constraints. Blocks enables to create a quick sketch and export it for animation, create 3D graphics or models for 3D printer.

Blocks’ interface relies on the motion-sensing controllers of either an HTC Vive or Oculus Rift. The interface itself has six basic tools: Shape, Stroke, Paint, Modify, Grab, Erase. These tools palette are placed on top of the left controller. In Shapes are located simple geometric forms (spheres, cubes, cones) that one can select from and implements with
the right controller, which also enables the modification of shapes (for example stretching faces and vertices). The UI is very simple, so basic in fact that there is almost no UI at all. The only visible UI is the descriptions that you toggle on items and the tooltips that pop up on the controllers when you hover over interactive items.

Designed models may be shared via fbx, obj export, or as an animated gif. The Block Gallery, Poly, also allows to download and re-purpose the creations of others. Additionally, it can be used alongside other VR apps like Google Tilt Brush or modelling software as Cinema 4D or Blender.

**EXPERIMENTAL COURSE OF ARCHITECTURAL COMPOSITION IN VR**

This year we start our experimental course Digital Architectural Composition in VR. We decided to use two of the exercises completed by the students during the first semester in a traditional way (a cardboard mock-up, see figure 1) and then in the third semester as a digital model in Cinema 4D: a Solid form with a specific formal value and a Walk through. The composition size should not exceed 30x30x30 m. The composition is viewed from different perception points located around the object. The only limitation is the possibility of using only simple geometric shapes. Their size and number are limited by a library of primitive contents. (See figure 2) We decided to choose these exercises as they may illustrate the full potential of direct modelling in virtual space.

This experiment was divided into two parts. In the first part, Google Blocks software was used in a very simple way for creating the Solid model, because of limited time. (See figure 3) Fortunately, students are familiar with the design subjects and they may concentrate on the new tool. In this part we asked the students to build the form using a set of primitives prepared by us, because we were worried about the difficulty of using previously unknown
software. The set of 25 primitives was created in Blocks (5 groups of 5 elements each). Afterwards we exported matrix to Poly - a library of free 3D objects for augmented and virtual reality applications. Poly allows to quickly find 3D objects and scenes for use in Blocks, and it was built from the ground up with AR and VR development in mind. It’s fully integrated with Tilt Brush and Blocks, and it also allows direct .obj file upload. In the process of creation of the composition students can find the elements they need in Poly. When the composition was created we asked students to publish it to Poly, enabling the objects to be imported dynamically across desktop, mobile, virtual reality, and augmented reality. (See figure 4) From Poly, it’s easy to view the composition, as all you need to do is open a link in your browser or view in VR googles. We asked the students to create their simple compositions in “Malevitch arkhivektors style”. It turned out that using Blocks was extremely simple and after only a few minutes we could see the first results.

In the second part of this experiment students have created their own shapes as part of their design. In this design they could use all software modelling options to create the Walk through space. We observed that due to the simplicity of the interface there was no “correct” way to create the model. The constraints of its limited toolset have a way of stoking the imagination. Students emphasised that Blocks offers a possibility to create designs with unusual forms and immediately evaluate their visual end cognitive effects. Another interesting observation is the students’ reaction to the forms they view in the virtual space. We could see it when the student was bending or moving left or right to avoid virtual obstacles.

CONCLUSION
The emergence of virtual reality has serious implications for architectural design. There is a possibility to
use virtual reality technology to set up an environment of creation of spatial forms. It is possible to “design Direct” in which creation and visualization of design solutions takes place directly in the virtual space. This idea is based on the principle of full immersion of the designer into the environment they design. The architect, located inside the designed space, determines the directions of changes and interactively implements them, moving the forms in a virtual space.

Blocks provides a good platform to show students a new way of using VR in the early stages of design. Students used Blocks for preparing conceptual 3D sketches of the spatial form. This way of work was recognized by them as an added value of direct projection of the work in VR. Most of the students considered that this application had strong benefits over traditional 3D CAAD representations because it provided dynamic insight into the composition created. In general, the interface seems to support a fast learning curve. Therefore, the results of the experiment were very promising despite some imperfections of the software. There is a lot of missing features – scaling faces and edges, in-game snapshot, expanded colour palette, etc. Grid snap mode is also problematic, so work is hampered by the lack of precision. But at the same time its simplicity (comparing to Medium, Oculus’ powerful VR sculpting app) makes it vastly more approachable, especially for non-experienced VR users. The big advantage of the program is the small number of polygons from which 3D objects are created, enabling to run Blocks not only on powerful VR headsets like Vive or Rift, but also...
cheaper, phone-based rigs like Google Cardboard.

Currently, analysis of the results allows to formulate the thesis that there is a qualitative revolution in the area of human-computer interface. The first conclusion is that Virtual Reality eliminates the boundaries between the spectator and the space. The second is that the idea of a new design environment, first identified in 2000 as a part of the application of “ACCOLADE - Architecture Collaboration Design - Designing Become a Place”, (Verbeke, et al., 2001) the main objective of which was “to build a bridge between the world of computation and the world of experience”, is still current.

In the near future, we intend to introduce an Architectural Game Design course as optional classes. Therefore, in the next experiment we plan to bring Blocks’ model into Unreal or Unity Engine to add some interactivity to it and take it from a static visual
to a dynamic experience.

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