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Toward The New Mixed Reality Environment for Interior Design

Jan Janusz ¹

¹ UTP University of Science and Technology in Bydgoszcz, Al. prof. S. Kaliskiego 7, 85-796 Bydgoszcz, Poland

jan.janusz@utp.edu.pl

Abstract. The paper presents a computer-aided design (CAD) system for interior architecture design called Design3R. The main assumption of this project is the implementation of the achievements from the field of augmented reality (AR) and virtual reality (VR) in order to embed the design process in the first person perspective and perceptual scale. It allows to work with furniture and other interior elements in their real size, directly in the realistic view of the designed interior. Design3R is developed by the author of the paper as the cross-platform software, and what is more, as the cooperation in the field of research and development with 3R Studio Mobile company. Design3R project is aimed to take advantage of the possibilities offered by HTC Vive and Google Tango to create a design environment in which the real space of building interior and the emerging interior design are completely integrated. The paper claims that the presented methods support the design process and create a new, more intuitive perspective on the perception of the project.

1. Introduction

The continuous development of computer-aided design (CAD) systems is possible thanks to the technological progress of hardware and software environments. In the past, VR, AR and mixed reality methods required expensive equipment or allowed only for insufficient quality. Both limited their wide spread in design practices. At the same time, those methods have the potential to both improve the architectural presentation and also allow for effective, intuitive design. The paper is a report of developed CAD system for interior architecture design called Design3R. Its aim is to take advantage of the possibilities offered by HTC Vive and Google Tango to explore a new design environment in which the real space of building interior and the emerging interior design are completely integrated. The paper shows that chosen devices and platform allows to transfer the designer into a virtual reality for better presentation and exploration of the new first person design environment.

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2. VR and AR in design

The visions depicting engineers working in virtual reality helmets or using interfaces for augmented reality have been rather the domain of science-fiction movies until now. At the same time, such implementations have been successfully carried out in scientific research and development works for two decades, both in relation to AR [1] and VR [2]. Even then, the potential of such solutions was noticed in the design, presentation [3] and in the didactic process [4]. These two techniques can be implemented independently, so their meaning and application vary. Virtual reality is very importance in the reception of the project, because it allows for a more realistic perception of space. This issue, together with the impact of the tool on the emerging space, was discussed in 2016 [5]. The conclusion of the quoted paper can be summarized by the statement that a postcard-like image of a stable visualization disturbs the perception of space, limits the understanding of certain phenomena, including monumentalism. This is particularly dangerous for non-designers, because through proper capture, false lighting and materials, the recipient can be easily manipulated. Finally, it affects the quality of the architecture being created. On the other hand, the use of AR allows to show the context of the project in an authentic way and optimizes the workflow with new possibilities of presentation and design [6]. Both VR and AR create the effect of synergy. They not only improve the workflow, but also allow for more conscious design process. The question then remains, why are they not widely used in most design offices? One of the basic problems are hardware limitations. In the case of AR, advanced tracking methods are required. Wang presents case studies using various tracking systems, including GPS, Magnetic, acoustic, mechanical, laser and optical, eg ARKit [7]. Among the available optical tracking methods, Vuforia Augmented Reality deserves special attention [8]. Both ARKit and Vuforia are dedicated to mobile devices. This outlines the problems with implementation. In the past, it was the choice between a mobile device or a professional, often experimental, hardware environment. The first one was associated with low quality, the second one with high costs. In both cases, there was a lack of highly developed, popular CAD software. A similar problem applies to VR. In this case, the alternative was a mobile device with a headset or cardboard, or an expensive professional set, [9].

3. Integrating HTC Vive and Google Tango

Recently, new devices and platforms have appeared, including Microsoft HoloLens, HTC Vive, Occipital Bridge, Google Tango and ARCore, and many more. At the same time, software developers, including Graphisoft and Autodesk, introduce solutions that enable the use of virtual reality. At the same time, the space for work and further development is still extensive. The use of AR is usually neglected and VR implementations require the developed of interfaces in many cases. The project presented below aims to show the effect that can be obtained using the HTC Vive headset and Google Tango, as well as also ARCore in the future. Design3R stands out from the available case studies by direct adaptation of the interface to work in a VR environment with the use of AR. In this case, the AR is not limited to displaying models based on markers, but through space recognition system that allows to work with the real interior.

As a part of the following description of the original application, the new solutions will be presented. The environment used to create the application was Unity with C# programming language. The idea of using HTC Vive was related to the quality that can be achieved by this headset and the ability to use controllers that allow to create a VR interface. In addition to aesthetic issues, the functions provided within the application include inserting furniture and other interior equipment in the real space. One of the provided feature was the simulation of physical collisions with both the real space and the design elements. Moreover, the spatial recognition of interior elements was also assumed; floors, walls, ceilings and furniture. This was necessary due to the function of changing the material of a given surface (wall or floor) and for the display order, which is a significant problem in AR solutions. Such goals require a real time space recognition, which was based on the Google Tango platform. Devices that support this platform provide access to such functions as effective motion tracking, area learning and depth perception. In addition, it allows the device to obtain information about the shape of the

room in real time in the form of a point cloud or mesh and to locate the device in this room. [10] Such possibilities have enabled the intended functions to be implemented.

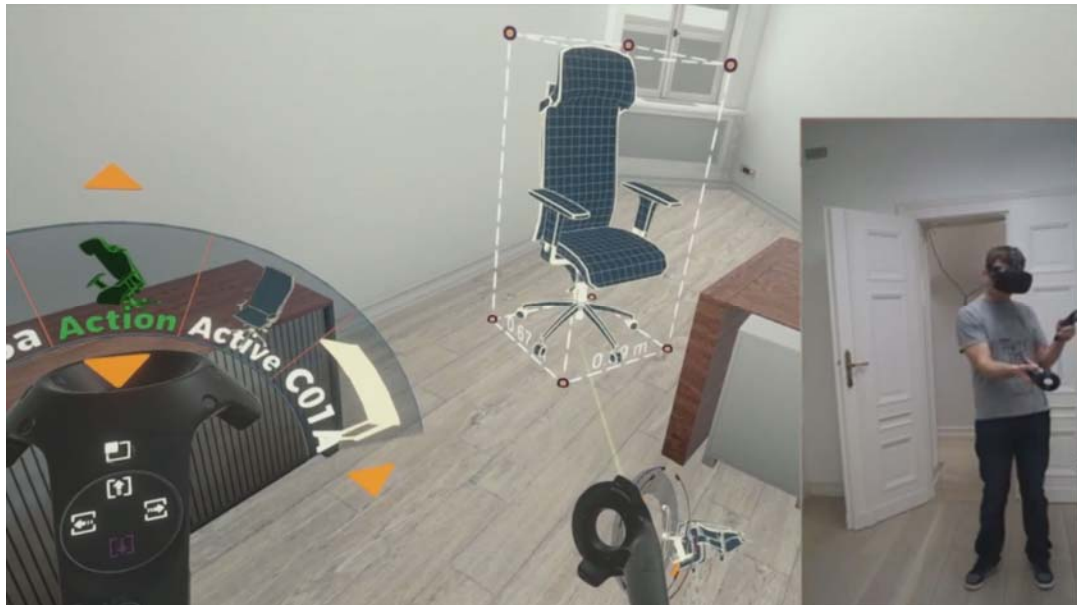


Figure 1. Vive interface for furniture creation and manipulation

Detecting the face of the actual wall allows for the insertion of the new material on it. Detection of deeper elements allows for windows insertion.

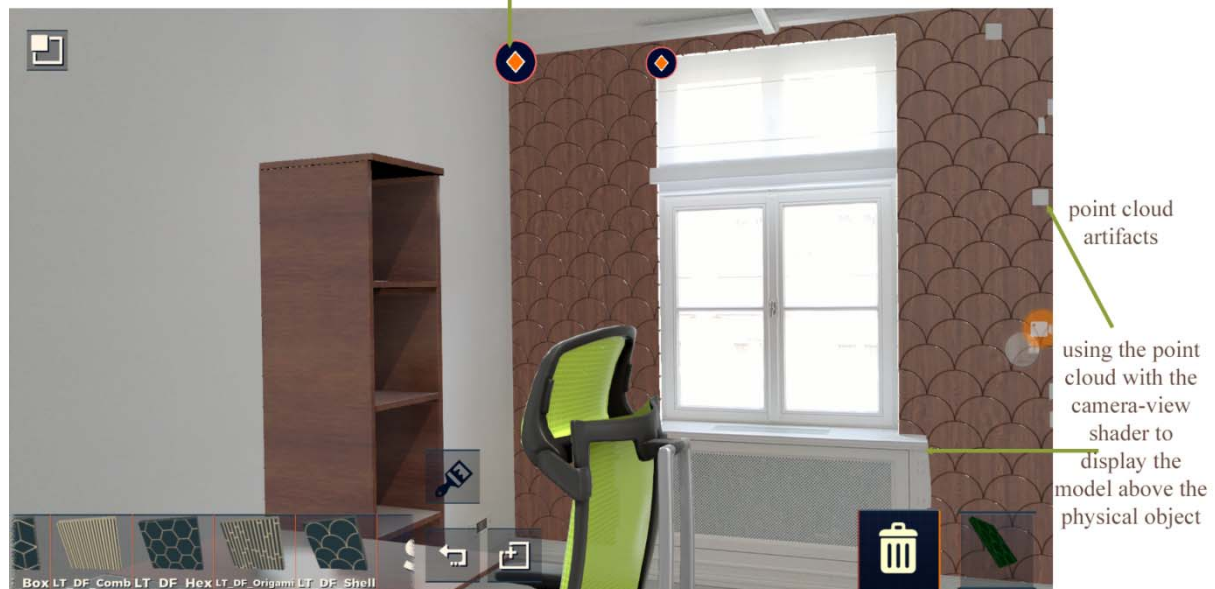


Figure 2. Change of the physical wall material and point clouds system for displaying real elements above virtual

The next basic function was the insertion of virtual objects in the physical space. In Tango, such an action can be based at least with two methods. It can use a real-time scan of the space or a method that allows calculating a virtual plane with a ray-cast basing on the point cloud. The second of them turned out to be much more effective and accurate. This allowed for the implementation of several of the

assumed functions. With this method, it was possible to arrange the furniture in space and physically collide with the existing elements shown in the illustration below.

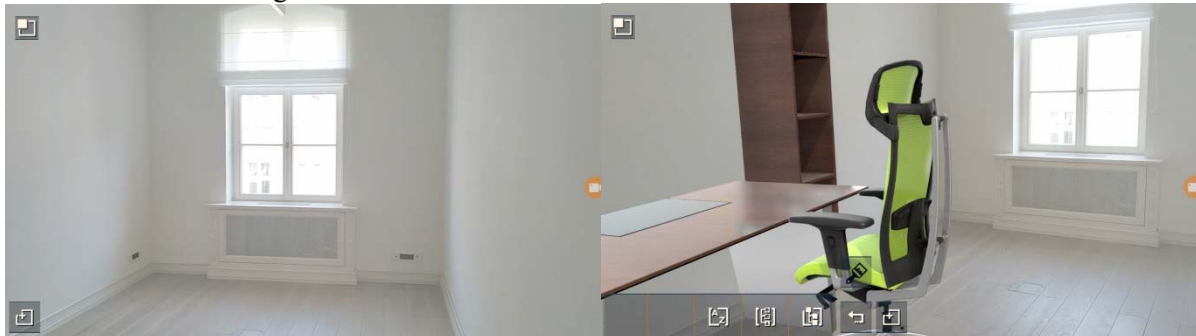


Figure 3. Left: Empty space of the room, Right: space after inserting virtual furniture

Furthermore, the virtual plane method allows for changing the material of walls and floors by applying a virtual model in front of them. The point cloud system enables displaying of elements closer to the user, while openings in the wall can be detected through raycast. The last function, connected with Tango, is to save and load a project in a given interior. This has been achieved through the Area Description File (ADF). In terms of VR interface, Design3R was based on the use of HTC Vive controllers. Through the controllers, it was possible to select and modify furniture, including moving, rotating and changing materials. Basically, two approaches are implemented; direct touch (collision) and ray-cast.



Figure 4. Design3R VR interface based on HTC Vive

4. Summary and perspectives

The above case study report shows that currently available tools allow for the effective transfer of interior design to the AR, VR environment. The quality obtained in real time is sufficient for both design and presentation purposes. Moreover, the use of motion tracking, area learning and depth perception improves the workflow and embed it in the real interior. The widespread availability of products selected for implementation creates perspectives for promulgation in the design practice. The next step considered, is the transfer to the ARCore platform, which is available on many high-performance mobile devices. This is a necessary action, because the Tango Project has been completed, however there are other devices allowing for analogous implementation, including the Occipital Bridge.

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