USE OF AUGMENTED AND VIRTUAL REALITY IN THE FIELD OF ARCHITECTURE

Sanjog Arora, Rohit Verma, Mehtab Sheikh
E-Mail Id: sanjogarora20@gmail.com
School of Computer Science & Information Technology, Anand-ICE, Jaipur, Rajasthan, India

Abstract- This paper is based on the use of Augmented and Virtual Reality in the field of Architecture and how to use the resources available in present day to improve the vision of building great architectures and use this technology in other fields of science in order to more precisely understand the basic concepts behind everything. Augmented Reality can be of immense benefit to the architecture industry. The oft-cited benefits of AR in construction industry include real time visualization of projects, project monitoring by overlaying virtual models on actual built structures and onsite information retrieval. But this technology is restricted by the high cost and limited portability of the devices. Further, problems with real time and accurate tracking in a construction environment hinder its broader application. To enable utilization of augmented reality on a construction site, a low cost augmented reality framework based on the Google Cardboard visor is proposed. The current applications available for Google cardboard have several limitations in delivering an AR experience relevant to construction requirements. To overcome these limitations Unity game engine, with the help of Vuforia & Cardboard SDK, is used to develop an application environment which can be used for location and orientation specific visualization and planning of work at construction workface. The real world image is captured through the smart-phone camera input and blended with the stereo input of the 3D models to enable a full immersion experience. The application is currently limited to marker-based tracking where the 3D models are triggered onto the user's view upon scanning an image which is registered with a corresponding 3D model preloaded into the application. A gaze input user interface is proposed which enables the user to interact with the augmented models. Finally, usage of AR app while traversing the construction site is illustrated.

Keywords: Augmented Reality, Virtual Reality, Architecture, Trimble Connect, QR code tracking, Tekla Structures, HoloLens, Samsung Gear VR, Oculus Rift.

1. INTRODUCTION

Augmented reality is very common on mobile phones today. Future-oriented could be the devices developed by Microsoft and Google, "HoloLens" and "Google Glass". These are worn on the head. They have transparent screens that project virtual objects into the eyes of the user. Therefore, the devices' visual production are not real holograms. These devices use their position and rotation, user's hand gestures and a "clicker", and voice commands as input. The Microsoft HoloLens, as an augmented reality device, has multiple cameras that capture the environment, and with which images objects can be detected, and even their distance calculated. The device is carried upside down using two transparent displays in which virtual objects are projected into the user's eye through additive color mixing and prismatic light redirection. In addition, the HoloLens has speakers positioned over the ears without covering them, allowing the user to hear both real and applicational noise. The input is made by hand gestures in the field of view of the capturing cameras, the rotation and position of the head of the device, and voice commands. In addition, mice and keyboards are supported by default, as well as the so-called clicker. The clicker acts as a substitute for the „air tap"-gesture.

Fig. 1.1 Microsoft HoloLens

On the other hand, in currently standard virtual reality systems use either virtual reality headsets or multi-projected environments to generate realistic images, sounds and other sensations that simulate a user's physical presence in a virtual environment. A person using virtual reality equipment is able to look around the artificial

world, move around in it, and interact with virtual features or items. The effect is commonly created by VR headsets consisting of a head-mounted display with a small screen in front of the eyes, but can also be created through specially designed rooms with multiple large screens. Virtual reality typically incorporates auditory and video feedback, but may also allow other types of sensory and force feedback through haptic technology.

Fig. 1.2 Virtual Reality Headset

II Information based on use of augmented and virtual reality for improving architectural perspective.

1.1 Use of Augmented Reality (AR)

First of all we need to understand that how does this AR work with other softwares to implement its use:

1.1.1 Unity

The development environment Unity is widespread in the game industry. It allows you to create two or three-dimensional spaces that are filled with so-called gameobjects. Unity makes it possible to create games for a variety of platforms, including HoloLens. Since Unity is very beginner friendly and well documented, all HoloLens programs of this project are created with Unity. In Unity you can program your own scripts with MonoDevelop, or other development environments like Visual Studio, in C # or Java.

Fig. 1.3 Unity

1.1.2 Vuforia

Vuforia is a library for creating augmented reality programs. It allows additional tracking of markers in the real world that can be recognized and identified by their appearance. Examples for targets are images, several images in a special configuration, the so-called MultiTarget, or VuMarks, as used in this project. VuMarks contain not only artistic but also several data elements, which each represent a status of a binary bit by means of light-dark contrast. These can be decrypted using the database built into the program. Since version 2017.2 of Unity the Vuforia library is integrated in the development environment.

Fig. 1.4 Vuforia

1.1.3 Arduino

In order to implement a communication via Bluetooth, the project uses the hardware-related developer platform Arduino, in combination with the Bluetooth-enabled communication module "BlueSMiRF Gold" by Sparkfun. Arduino is beginner-friendly and is constantly being expanded as an open source project by both the manufacturer and users (see https://www.arduino.cc/), which leads to a high rate of usage. Code for Arduino is written in its own programming language based on C and C ++.

Fig. 1.5 Arduino

Combined with all these technologies available one can develop a system to detect surroundings and store information required to make the system work. Augmented reality supports QR code tracking and when combined with a software known as Trimble Connect produced by Tekla, it can generate the structure of the whole surrounding and we just need an empty room. Architectures can design their work in Tekla Structures and then they can implement that structure in the real surrounding with the help of HoloLens installed with Trimble Connect. Now-a-days this technology is coming into existence and how this HoloLens can be fixed on helmets of workers and they can visualize the whole structure by themselves and see how is it going to look when completed. They can also measure some features of pillars and the distance between them. Even the site manager can leave some notes on certain parts of the building that can be read by other workers as well. It improves productivity and enhances the future of Architecture.

1.2 Use of Virtual Reality (VR)

Virtual Reality also provides a new edge to the field of Architecture and as we know we have complete control over what we do in the virtual reality. We can build a complete house or some portion of it to visualize the placement of thing in different places to understand that in which way our house area would look great. And with the help of Virtual Reality we can move around in our house and lift and throw things and can actually interact with them. The best headset for this kind of work is HTC Vive, with the help of this headset we can create a total virtual environment with high resolution that can make things around you feel like they are real.

Fig. 1.6 HTC Vive Headser

This headset can be setup with all its sensors and measures the depth as well in order to make the experience realistic.

1.3 Which Reality is better?

With our research, we were able to figure out that for construction and architectural purposes we can say that Augmented Reality is better than Virtual Reality because it provides the visualization in real surrounding instead of creating your own surrounding like Virtual Reality. Now after mentioning that which Reality is better we can now have a l its mechanism.

2. METHODS

Over the years the AR technologies have evolved rapidly and today we are in the age of smart glasses. The likes of Google Glass and Microsoft HoloLens have emerged which are ubiquitous computing devices that project digital information directly onto the human eye. Fig. 2.1 shows how AR technologies have evolved throughout the years in various levels.

Fig. 2.1 Shows how AR Technologies have Evolved Throughout the Years in Various Levels

With reference to Figure above, Level 0 of AR is the simple hyper linking where we are directed to a particular website upon scanning a barcode tagged with an URL. Level 1 comprises of the major area where our proposed solution lies in. A large number of applications both for Hand-held and Head-mounted devices have been developed for marker based tracking which then evolved into Level 2- as tracking based on the natural features in the environment and geo location. The final level or Level 3 is the currently most concentrated area for development where even contact lenses with AR capability are aimed to be achieved. For the purpose of this discussion we stick to the 2D image target capability on a Smartphone with a Cardboard mount. The simple AR case is the user scans a target in the real world and the virtual model is invoked and aligned itself accordingly to give the augmented experience. There is a triggering event which occurs every time a target is scanned. This target can be an image or an object. Image targets represent those images which the SDK detects and tracks. The Vuforia SDK usually detects and tracks the features that are found in the image itself by comparing these natural features against a known target resource database. Once the Image Target is recognized from the database which contains correspondence information i.e. the corresponding 3D model to a particular image target, the SDK will track the image as long as the image lies in the camera's field of view. Object Targets are generated by creating a digital representation of the features and geometry of a real physical object. They are different from image based targets that require the use of a planar source image. Vuforia Object scanner generates object targets by scanning physical 3D objects. Object targets are ideal in cases of building rich interactive experiences with rigid 3D objects. They can be augmentations on toys, manuals overlaid on consumer products or triggering of new events on scanning a consumer product. For the application in construction site where one would like to augment building models or information onto their displays we have chosen image targets because of its ease of implementation and a variety of images can be created by the user to serve various purposes. One can use QR codes or floor or elevation plans or any other specific purpose images as targets. Figure 2 below shows the buildings being augmented onto the real world once the image (a cover page lying on the desk) is scanned with the AR app.

3. EXPLORATION CONDUCTED IN CONSTRUCTION SCOTLAND INNOVATION CENTRE (CSIC), SCOTLAND

In this AR/VR Exploration we went to Construction Scotland Innovation Centre (CSIC) located in Hamilton. This organization mainly focuses on evolving technologies to work on different fields and mainly in Construction fields. Their main focus is how to use the present technology to build more efficient structures without the help of manpower. We met people working there on VR and AR and how they can be used in Construction field. They have build some interesting software in VR that includes a whole room in which you can wander around and feel everything. You can even lift and throw things away in that Virtual Room and they look so realistic like you are in an actual room. Then we got to use their AR headset which shows the Virtual pillar structures of a building in a real world. We also got to know that they are working on a Robot hand that in collaboration with the AR technology build a structure made of bricks that we build in our Hololens in the virtual world. The hand can also be programmed manually to work according to our needs. It actually scans QR codes and track them to lift one brick from one place and put it into another place.

4. RESULTS

As we have discussed above, the company that came forward to take Augmented Reality in the field of Architecture is Tekla Structures. This firm introduced its own software that is known as Trimble Connect that is mainly designed for Augmented Reality headsets. This app is easy to install and to be worked with. The steps included to get your design working in the actual surrounding with Augmented Reality are:

- First of all we install Trimble Connect app from the Microsoft store into our HoloLens.
- Then we open the app and login into the software.
- After logging in we can view each of our projects made, for now Trimble Connect do not provide any demo projects to look upon.
- You will need to have a building structure setup according to your actual building.
- You can then calibrate your virtual structure in HoloLens with the actual walls and pillars present in the real building.
- After completing these steps, you can observe the whole structure in Augmented Reality and get its load and other calculations in seconds.

You can also calibrate your device with every edge and pillars of your actual structure.

CONCLUSION

Working further in this field is quite expensive, hence it is mandatory to keep in mind that we put our resources in development of these kind of futuristic things that can improve human knowledge and the way of thinking.
Augmented Reality is more likely to influence this field than Virtual Reality but still we need to work continuously on umproving both technologies.
Tekla is working on implementing Trimble Connect in VR as well and they will come with better solutions in near future. More companies are also jumping in the competition. Microsoft is soon going to release the new HoloLens 2 that is going to change the future of Augmented Reality as it is introducing new features like grabbing buttons, sliders, palm detection, hand tracking and many more.

Investment in any kind of technology needs a detailed assessment of the value and the potential return on investment. One might deem that implementing advanced technology at construction site would simply increase the cost of construction and early adopters of new technology take a large risk. . Although AR is a technology in its infant stage, the projected utility is enormous that no one can ignore it and preparing for its adoption is a must. Low investment efforts such as this enables decision makers to experience and evaluate the benefits of AR with minimal financial risk. As full scale deployments of AR technologies in construction become feasible the impact on the productivity should be significant. The cost effective AR platforms is also expected to contribute to the widespread adoption of the technology. While there is need for expensive and sophisticated technologies such as the Microsoft HoloLens, it is the availability for inexpensive and familiar platforms which will propel the widespread usage. Though there are certain limitations to this technology, as a starter these technologies can be used for training workers on site, visualization purposes that gives a clear understanding of the product they are working on. From preliminary initiatives like these the technology can be taken to a full-fledged adoption once it is observed that the results are fruitful.

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