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A Survey on the Effectiveness of Hololens and Augmented Reality in Education

Prasanna Sudhakar Paigude¹, Nuzhat. F. Shaikh²

^{1,2}Department Of Computer Engineering, MESCoE, Pune-01

Abstract: *Augmented Reality or AR is a largely used term since the invention of Microsoft Hololens and the use of AR in mobile applications. With the help of advanced AR, information about the real world of the user has become interactive and digitally manipulable. Augmented or mixed reality (AR or MR) has recently become easily accessible to professionals, with the release of Microsoft's Hololens. Hololens is an untethered, fully self-contained Windows 10 computer that rests comfortably on user's head and lets a user create holograms, that appear in the world around the user, just as if they are real objects. The user can interact with AR applications through head movements, gestures and voices. This survey paper is the starting phase of planning a project to do in educational field to enhance interests of computer engineering students using various existing application ideas in learning and hence analysing the effectiveness of Hololens for Augmented Reality applications in various interests of education.*

Keywords: *Augmented Reality, Mixed Reality, Holograms, Hololens, Education.*

I. INTRODUCTION

Augmented Reality (AR) technology has gained popularity within the past couple of years as developers have begun to integrate AR with mobile applications and with the recent device Hololens developed by Microsoft. Augmented reality is growing rapidly in popularity because it enriches the physical world around the user with additional useful virtual information, thus enhancing the things a user perceive, hear, and feel. Augmented reality is also tremendously being used with Hololens in various fields such as education, health-care, construction, gaming, entertainment, marketing, etc. In this survey, we are going to focus on the roles of both AR and Microsoft's Hololens in educational aspects to resolve problems of students in learning difficult concepts. AR and Hololens both can serve a number of purposes in helping students to acquire the concepts easily, process that information and remember those concepts with their visualizations. This technology is not limited for any single level of education rather it can be used well in all levels of schooling such as from pre-school to college education or even in offices and industries.

II. AUGMENTED REALITY

The term Augmented Reality originates from the word augment, which means to add or enhance something. In case of Augmented Reality, any computer-generated information such as texts, graphics, sounds, touch feedback and any kind of digital information can be added into our natural world to create an enhanced user experience. Information of the environment and its objects is overlaid on the real world. Usually, mobile phones, tablets and other wearable devices are used to support AR system. As it has enormous potentials, augmented reality technology is applied in many fields, including medicine, manufacturing, aeronautics, robotics, entertainment, tourism, and education [1].

A. Augmented Reality In Education

AR in designing curriculum, classroom teaching and learning strategies, user experience design for learners and educators are becoming very popular in the current educational scenario. Current generation students are best known as digital natives & are so comfortable and ease at using any technology; hence utilizing AR in the learning process has certainly enhanced enthusiasm, concentration, motivation, collaborative learning, excitement and retention of knowledge of students in learning activities [2].

1) *AR in Geometry:* Hong-Quan Le and Jee-In Kim [3] in their research has developed an AR application for learning 3D geometry using hand gestures. Their system enabled students to construct, manipulate and visualize both 2D and 3D geometrical shapes at the same time, directly control them by hand gestures which were recognized by Leap Motion controller in the 3D AR environment with the help of several AR markers. A webcam was used to detect and recognize the AR markers while the ARToolkit libraries overlays and displays the 3D virtual objects exactly on those physical AR markers in the AR environment. Its output was seen on a 2D monitor.

- 2) *AR in Engineering*: S E Bazarov and his team in [4] introduced an Augmented Reality application for teaching engineering students of electrical and technological branch in their practical classes. For development, softwares such as Unity 3D and Vuforia were used. The AR content consisted of 3D-models, images and animations, which were superimposed on real objects, by using smartphone, tablet PC or AR glasses for helping students to study specific tasks. The training system consisted of didactic material, which contained summarized theoretical knowledge of the course sections, description of practical trainings, along with the procedure for connecting and working using the stand.
- 3) *Mechanical Engineering*: AR can be used for teaching mechanical drawing by replacing actual educational materials with virtual ones on an augmented reality-based support system. The virtual educational materials constructed by using 3D-CAD were superimposed to a real-time camera image as AR objects. Students were able to see objects from various directions by using cubic-markers.
- 4) *Civil Engineering*: Computer-generated information of a structure can be superimposed into a real life local view of a property before the physical building is constructed. AR can also be employed within an architect's working area, rendering animated 3D visualizations of their 2D drawings. Sight-seeing of architectures can be enhanced with AR applications, allowing user to view a building's exterior virtually through its walls, viewing its interior objects and layout. With the continuous improvements to GPS accuracy, businesses are able to use AR for visualizing georeferenced models of underground structures, construction sites, cables and pipes using mobile devices. Augmented reality is applied to present new projects and to also solve on-site construction difficulties [8].
- 5) *Computer Engineering*: They proposed a system to integrate Microsoft HoloLens into a first-year course on data structures and algorithms to improve student engagement and learning outcomes. Students were assigned to implement A* algorithm and then given a chance to visualize their implementation using Microsoft HoloLens. Students learned how to use graphs in data structures to solve practical problem scenarios, represent graphs using matrices or linked lists, traverse graphs using depth-first and breadth-first approaches, and apply shortest-path algorithms to find shortest paths between graph nodes [5].

III. MICROSOFT HOLOLENS

Hololens is an augmented reality device which is fully untethered, see-through holographic computer. Hololens allows users to experience 3D holographic images as though they are a part of their real environment [9]. Hololens is also known as a mixed reality device as it blends the physical world with the digital world of the user and it has been only made possible due to the advancements in computer vision, graphical processing power, display technology, and input systems. The application of mixed reality goes beyond displays but also includes environmental input, spatial sound, and location [10]. Hololens lets a user create holograms, objects made of light and sound that appear in the world around the user, just as if they were real objects. Holograms respond to their gaze, gestures and voice commands, and can interact with real-world surfaces around them. With holograms, we can create digital objects that are part of our world [11].

A. Hololens In Education

Hololens in educational field also can be used for projecting information into our world and would create the effective interactions because it does not separate our physical world from the virtual world.

- 1) *Mathematics*: An application, called Holo FEM has been developed for solving Poisson's equation with the finite element method (FEM) using HoloLens. The aim was to set up and solve a partial differential equation (PDE) in the real world geometry surrounding the HoloLens user, and then visualize the computed solution on top of the real surroundings in mixed reality [7].
- 2) *Mechatronics*: A project to be applied in Mechatronics was proposed to improve quality of teaching using Hololens for graduates and specialists in technical study programs (Applied Mechatronics and Automotive Mechatronics) and their related automation areas of using latest ICT technologies, virtual reality and interactive learning in modelling, simulation and control. Visualization of the modelling and control processes of complex mechatronic systems, components and devices (e.g. cars, electric vehicles, mechatronic systems in consumer electronics, health care, etc.) in virtual and mixed realities will give students more insight and better understand the studied stuff compared with conventional learning methods [6].
- 3) *Medical*: Implementing HoloLens for medical education enables students to investigate, walk around, and put themselves in their subjects. HoloLens helps to increase students' involvement and understanding of the concepts. The holograms produced for HoloLens enable medical students to learn better than the traditional way of learning by dissecting the cadavers. Moreover, if something goes wrong in a medical simulation, nobody gets hurt because everything is overlaid in our real world rather being

real. Bodily organs can also be viewed and interacted within isolation from other parts of the body, helping students to learn how they look and function. Hence, if students want to study the heart of a person, HoloLens education app enables them to view it separately from the entire body [12].

- 4) *Chemistry*: MyLab is an MR educational app that lets us explore an interactive periodic table through the power of holograms. Spawn atoms around your environment, view their atomic structures and explore the various types of elements that are the building blocks of our world [13].

IV. PROPOSED WORK

The proposed work will make use of Augmented Reality with HoloLens in computer engineering. The aim is to design and implement an interactive application for HoloLens to make difficult concepts from subjects such as engineering graphics i.e. visualization of isometric and orthographic views, Scheduling Algorithm (Round Robin Algorithm), data structures(e.g. linked lists, sorting), etc. easier to understand. The idea behind this project is to offer a canvas to imagine new modes of learning and new ways to collaborate with others beyond the frame of the screen for engineering students making useful the AR technology along with HoloLens using gaze, gesture and voice recognition capabilities. The motive for proposing this work is to provide students with eye-catching presentations so that they understand better and learn the subjects thoroughly through visualizations of the difficult concepts as the HoloLens is best known for providing interactive environment, hence their results would be appreciable.

A. Basic Setup Required For HoloLens Application Development

- 1) HoloLens or HoloLens Emulator
- 2) Windows 10
- 3) Visual Studio 2017
- 4) Windows 10 SDK
- 5) Unity long term support(LTS) version
- 6) Mixed Reality Toolkit(MRTK) for Unity

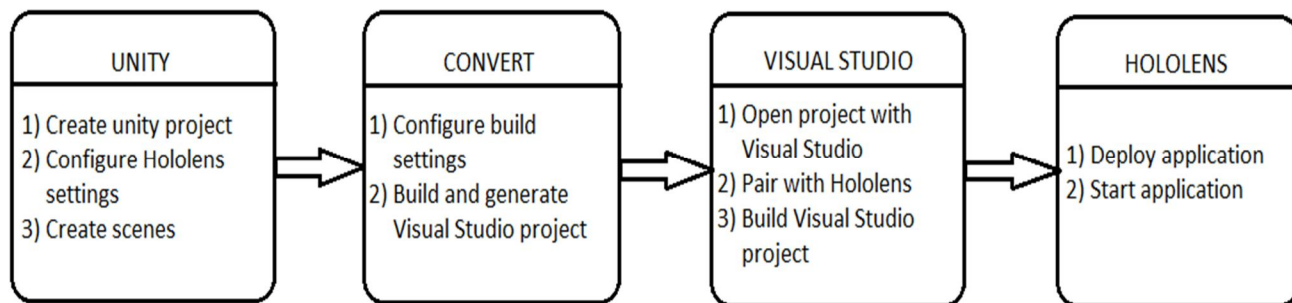


Fig. 1: Basic application development diagram for HoloLens

V. BENEFITS OF THE TECHNOLOGY

- A. AR has resulted in improved collaboration capabilities between the students.
- B. AR using HoloLens has proved to be safe and efficient in training medical students.
- C. This technology is universally applicable to any level/ standard of education.
- D. In education, the technology resulted in faster and more effective learning process.
- E. The AR system is highly interactive in nature and operates with real time environment simultaneously and also enhances user's interactions and perceptions with the real world.
- F. Augmented Reality using HoloLens has proved to have high potentials due to its holographic behavior and can be used in every field.

VI. LIMITATIONS

- A. The development and maintenance of AR based projects is expensive and the production of AR based devices is also costly.
- B. The AR device, HoloLens requires good and even lighting resources so that the holographic information is visible clearly.
- C. It can increase dependence of a user on the technology, and distractions at the workplace.

VII. CONCLUSION

Hololens using augmented reality applications (ARAs) are the innovations wanting to be explored yet in many more fields. The technologies have proved their benefits that how they are efficient and effective when used together in every aspect. The effectiveness of Hololens with augmented reality is seen accomplishing all the purposes of its users when used in various areas of applications with varying requirements. The main objective of the application is to improve quality of teaching for graduates in technical study programs using Unity Engine, Visual Studio, Virtual reality and interactive learning in modelling, simulation and control. With Hololens using Augmented Reality we can connect, create and explore like never before what we imagine and can also visualize our work. However, Hololens looks incredibly exciting in terms of what we have attained till now from this technology, which is just the glimpse of the near future. Currently various teams are working with creators and developers all over the world for creating new exciting holographic experiences for well development of our society using this technology to the fullest.

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