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A Review of Collaborative Virtual Reality Systems for the Architecture and Engineering (Virtual Tour)

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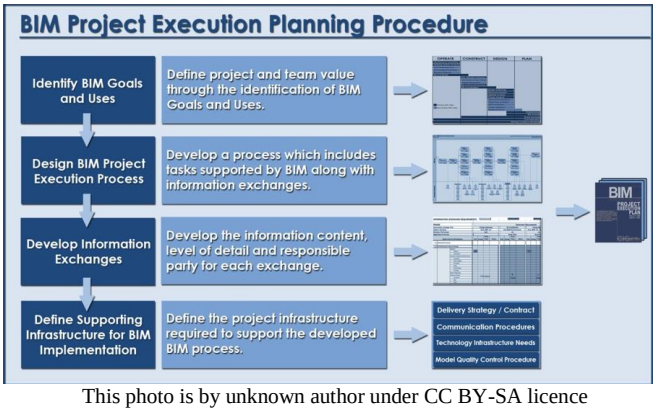
***Abstract*:- Augmented Reality (AR) and Virtual Reality (VR) bridge the digital and physical worlds. They allow you to require information and content visually, within the same way you're taking within the world. In the architecture, engineering and construction (AEC) industry, these technologies, which simulate a construction project in a multi-dimensional digital model and present multiple aspects of the project, can be an incredible help in all phases of the project. With its advanced proficiencies of immersive and interactive visualisation, virtual reality (VR) and Augmented reality (AR) has been encouraged to facilitate design, engineering, construction, and management for the built environment. This paper presents a study on the use of Augmented Reality (AR) and Virtual Reality (VR) in architecture, engineering and construction and recommends a revised framework to address existing gaps in required capabilities. This is an introductory study that validates and sorts the prevailing usage of AR and VR within the housing industry and provides a roadmap to guide future research efforts.**

Keywords: Augmented reality, Virtual reality, Visualisation

I. INTRODUCTION

In the AEC industry the professionals fully rely on the imagery for communication. Visual communication involves the utilisation of visual elements, like drawings, illustrations and electronic images, to convey ideas and knowledge to an audience. Augmented and computer games have the potential to supply a step-change in productivity during this industry. Augmented reality combines real and computer-based scenes and pictures to deliver a unified but enhanced view of the planet. The computer game (VR) is the computer-generated simulation of a three-dimensional image or environment which will be interacted with in an apparently real or physical manner by an individual using a special digital system, which includes a helmet with a monitor inside or gloves outfitted with sensors. AR and VR technologies have many applications that could benefit a project with accelerated training and jobsite safety, design development and communication with stakeholders from the owner to the worker, helping to exceed the owner's expectations and reduce project costs. The construction industry is one among the fastest-growing industries within the world. The AEC sector is still in the initial stages of its much-anticipated move from tradition to automation.



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Building information modelling (BIM) as a digital information management system is one of the most important and capable changes in the AEC industry. The adoption of BIM to manage construction projects and to supply data-rich models has helped the AEC industry shift from vision to realisation. VR enables an owner to experience a design first-hand. They can shop around the space and observe it as if it were a finished building – and importantly, you'll demonstrate the rationale for your decisions far more effectively. Not only does the client get that all-important wow factor; they're going to participate within the planning process, asking questions and making suggestions which can be explored in ways they're going to understand. With this collaborative approach, solving challenges and overcoming barriers down the thoroughfare could be much smoother.

An expert suggests that VR technologies are effective in construction safety training, project schedule control, and site layout optimization of construction projects. VR technologies can also provide an environment for better collaboration between participants, enable better understanding of complex designs, identify design issues, describe building geometry so that users can understand the project and make better design decisions, and assist in collaborative decision making.

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This photo is licensed under CC BY-SA AUGMENTED REALITY

AR for Architecture, Engineering and Construction and Facility Management (AEC/FM) projects, which can bring many benefits to enhance and improve representational techniques on the construction site. Rankohi and Waugh conducted a statistical review of recent AR research studies in AEC. This review showed which field workers and project managers (PMs) are highly interested in using non-immersive and desktop standalone AR technologies during the construction phase, especially to monitor progress and detect defective work. Shin and Dunston presented a comprehensive map to indicate AR application areas in industrial construction. They found that eight work tasks, layout, digging, location inspection, coordination, surveillance, commenting, and strategy, can potentially benefit from AR support. In another study, Behzadan did a general overview of the use of AR technology in construction management applications. Also, Rankohi and Waugh classified AR applications used in the AEC industry in seven categories: visualisation or simulation communication or collaboration information modelling; information access or evaluation; progress monitoring; education or training and safety or inspection. In the case of AR, this technology is more suitable for the visualisation of renovation and modernization works, as it combines the real environment with virtual objects. The study starts with a comprehensive literature review of related journals, conference papers, articles, blogs, books and WebPages. Then using some essential tools and applications, necessary VR and AR applications are developed.

II. DISCUSSION

Virtual reality (VR) simulation is designed to generate immersive environments from which users can experience a unique view of how the real world works. The concept of VR was introduced more than fifty years ago, when the first immersive model of human-computer interaction (HCI) called "Man-Machine Graphical Communication System" was invented. The formal term VR was coined in 1989. Since then, researchers have created several taxonomies to explain where the exact concept of VR should remain on the reality-to-virtuality (RV) continuum. VR attempts to replace the user's perception of the surrounding world with a computer-generated artificial 3D environment. And such a virtual 3D environment is not necessary to be established based on a real one. VR represents effort in creating a virtual environment (VE) with visual and immersive aids to let users feel a “real” sense. On the other hand AR integrates images of virtual objects into a real world. By embedding virtually simulated prototypes into the real world and creating an augmented scene, AR technology could fulfil the goal of enhancing the perception of the virtual prototype by real entities. This gives the virtual world a better connection to the real world while maintaining the flexibility of the virtual world..

a. Background

BIM is a set of interacting processes, roles, policies and technologies that create virtual models based on information to manage data in a digital format used in the AEC industry. BIM is an established multi-dimensional (n-D) knowledge resource/model focused on equipment information that forms a reliable basis for decision-making throughout the equipment life cycle. BIM allows the exchange of information efficiently in real-time to enable users to realise the value of digital information management in practice. The goal is to design, construct, and maintain a project throughout its life cycle. The effort involved could include new and existing projects such as residential construction, commercial construction, industrial construction, heavy construction, infrastructure construction, and heritage construction. BIM, which is aimed at new projects, is created in a process in several phases of the life cycle: initiation, design, construction, maintenance, operation and demolition.
In existing buildings, depending on the availability of an existing BIM model, the BIM model can be either an updated model or a new model. The latest technological advances such as laser scanning, photogrammetry and drones are useful to create an accurate and fast BIM model of existing projects. Recently, more sophisticated modelling, in the form of, for example, Historic Building Information Modelling (HBIM), has emerged. This type of modelling develops full BIM models from remotely sensed data. HBIM consists of a new library of reusable parametric objects that are based on historical architectural data and a system for mapping this data to 2D/3D models. Bianchini and Nicastro discussed the potential outcomes, benefits and critical aspects related to HBIM systems and tested their findings in a comprehensive case study to clearly highlight the intrinsic features of the HBIM model.

Augmented reality (AR) is an overlay of computer-generated content on the real world that can superficially interact with the environment in real time. With AR, there is no occlusion that occurs between computer generated content and real world content. In most cases, computer-generated content is only viewable from a Smartphone or tablet device. Phone and tablet (i.e. iPad) based AR devices provide a very limited immersive viewing experience. Also, limited AR wearables such as the Meta 2 (with a 90-degree field of view) and Google Glass are designed for information objects and/or digital objects that overlap real-world context.

There are four types of AR: 1. maker-based AR (i.e., scanning a QR code); 2. Location-based AR (i.e., integrated with GPS for mapping directions); 3. Projection-based AR (ie, projecting artificial light onto real-world surfaces); and 4.

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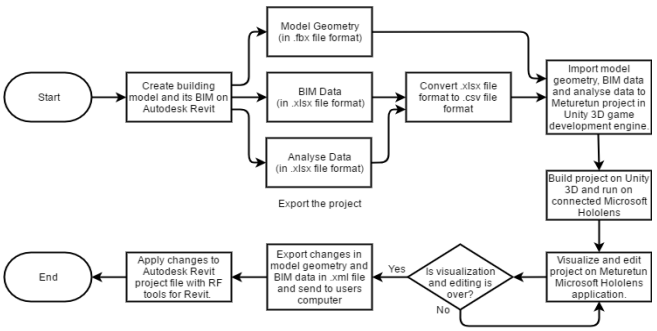
Superimposition-based AR (i.e., an AR type such as the IKEA app that places virtual furniture in a real environment).

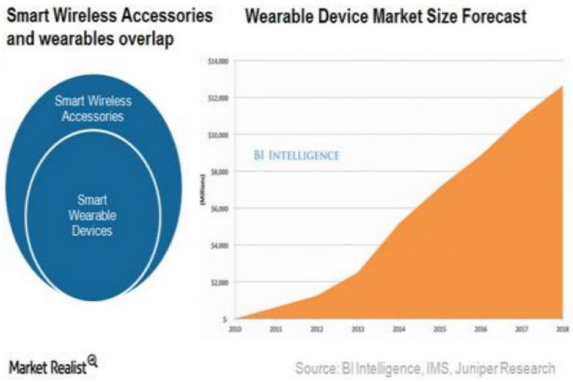
b. BIM-to-VR and BIM-to-AR implementation scenarios

This workflow begins by creating an information-rich 2D/3D-BIM model using Revit 2019. Revit is one of the BIM authoring tools that helped architects and engineers to create this model in a parametric environment. . BIM 360 cloud server/database used to provide an online storing space to give Real-time access to all team members for this project. In the next step, Fuzor plugin in Revit 2019, used to convert the BIM model to VR model. Finally, experiencing an exciting fully immersive BIM/VR of a given architectural model. It provides a substantial benefit because everyone involved can see and experience the multiple design scenarios, validate design decisions, and check for possible errors before any real action needs to be taken. Furthermore, all involved can see the details and also the big picture of project, make changes in BIM model, and see those changes reflected in the visualisation quickly and accurately; animate objects in the design to make the experience more realistic; deliver a powerful presentation experience that is simple to use and easy to understand. These advantages helped the team to understand all details, priorities, and issues to make better, more productive, and quicker decisions. The work flow is the same as BIM to VR for the BIM to AR.



c. What's the future of virtual reality and augmented reality?

The founder of Oculus VR has warned that it could be a decade before virtual reality headsets become cheap and portable enough to replace smartphones as the tech industry's dominant computing platform. "Virtual reality is the only technology that can give you the feeling of being with another person in virtual space, even if you are thousands of kilometres apart.," Mr. Luckey said. "If you could actually simulate anything you might do in real life and not have to obey the physical laws of reality, that seems incredible to me that you wouldn't be able to come up with just one killer app, but many, many killer apps.."



- The combined augmented reality and virtual reality markets were worth $12 billion in 2020 with a massive annual growth of 54%, resulting in a projected value of $72.8 billion by 2024 (IDC, 2020).
- Meanwhile, another report from Research and Markets pegged the virtual reality market at $6.1 billion in 2020, with an annual growth rate of 27.9%, expected to reach $20.9 billion by 2025 (Research and Markets, 2020).
- In the same research, the augmented reality market was valued at USD 15.3 billion in 2020, with an annual growth rate of 38.1%. It is projected to reach $77 billion by 2025 (Research and Markets, 2020).
- In terms of VR spending by sector, consumer spending leads the way at 53%, followed by distribution and services (15.8%), manufacturing and resources (13.8%), public sector (12.7%), and infrastructure (3.2%) (IDC, 2020).
- In terms of AR/VR spending in 2020 by region, China leads the world with $5.8 billion, followed by the US ($5.1 billion), Western Europe ($3.3 billion), and Japan ($1.8 billion). Meanwhile, the rest of the world spent $2.8 billion on AR/VR (IDC, 2019).
- China accounted for 38.3% of the global AR/VR share in 2020. It will increase to 56% in 2021 (China Internet Watch, 2021).
- However, the IDC sees China's share decline to around 36% by 2024 while the US and Europe close in with CAGRs of 75.1% and 72.8% through 2024, respectively (IDC, 2020).
- Meanwhile, the commercial use cases that are foreseen to obtain the biggest investments in 2024 are training ($4.1 billion), industrial maintenance ($4.1 billion), and retail showcasing ($2.7 billion) (IDC, 2020).

The future of virtual reality is uncertain, but only in the sense that it is impossible to predict where virtual reality will take the construction industry and all the other industries it can

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improve. There is no doubt that virtual reality will make a huge difference when it comes to construction; just no one knows how far technology will take us. It is very likely that in the near future, virtual reality will be the standard by which all construction projects are designed and built. No construction project will be started or finalised until it has been built in virtual space first. But there is much more to it.

Currently, not many companies are using virtual reality to improve their construction business, at least not in a meaningful way. Not so many architects and engineers use this technology yet. But that is expected to change very soon. Businesses are just beginning to understand the value of this technology, which is one reason why the response has been slow. Another reason why companies are slow to adopt virtual reality is that the technology is not yet perfect. But that will all change in the next 5 years as the fidelity of the technology catches up with mainstream rendering. In the future, it will be almost perfect and everyone will use it for an unforeseen number of applications.

III. CONCLUSION

Construction is one of the largest industries in the world. An incredible change is going on from the beginning of the history of the construction industry. Among the many changes, Augmented and Virtual Reality is bringing out an unimaginable modification and advancement in various construction issues. The principal purpose of this study is to explore the changes in the construction industry that are resulting from Augmented and Virtual Reality technologies and their contribution to overcome various construction issues from the last some decades. It is revealed from the study that these incredible improvements in AR and VR technologies are having a great impact on the construction industry in a couple of ways. In this study various uses of VR and AR technologies are shown. Augmented Reality is used in project scheduling and project progress tracking in the modern construction process. For the effective and less time-consuming communication between different project participants AR and VR are proven technologies. AR and VR are also useful and automated systems for quality and defects management in construction projects. AR and VR technologies are hugely used in construction safety management and worker training from many past years. Project parametric model visualisation and walking through into the project before the starting of the actual project with the feeling of the real world is another great characteristic of AR and VR technologies. Although AR and VR technologies seem to be a vital tool in the construction industry, there are several disadvantages of these technologies. There some limitations and drawbacks are appearing to implement the AR and VR technologies in the construction industry. Those drawbacks and limitations are quickly broken by the upcoming generations and the sustained and continual advancement in technology around the world. Assuming that AR and VR technologies will improve with safety, quality, visualisation, workforce management and time management, it's far nearly sure that such technologies will play more important roles in construction for future years. However, this mechanism is not possible without having an effective integration of generating, storing, managing, exchanging, and sharing data.

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