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Review on Application of Augmented Reality in Civil Engineering

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Abstract: *This paper examines the concept of Augmented reality and its various applications in civil engineering. The concept envisages reducing, or rather eliminating errors that creep in during construction process due to human and other technical errors. The concept of AR helps in recreating the architectural and structural drawings in actual scale on the field. This uses the techniques of holographic projections and other mobile applications to create a 3D image of the drawing. The Concept is to create an image of the structure as envisaged on the basis of calculations and compare it in real time with the actual construction, which can help in identifying errors quickly and efficiently.*

Keywords*:* Augmented Reality, Error Reduction, Innovation.

INTRODUCTION

Augmented reality (AR) is a live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data. It is related to a more general concept called mediated reality, in which a view of reality is modified (possibly even diminished rather than augmented), by a computer. As a result, the technology functions by enhancing one's current perception of reality. By contrast, virtual reality replaces the real world with a simulated one. Augmentation is conventionally in real-time and in semantic context with environmental elements, such as sports scores on TV during a match. With the help of advanced AR technology (e.g. adding computer vision and object recognition) the information about the surrounding real world of the user becomes interactive and digitally manipulable. Artificial information about the environment and its objects can be overlaid on the real world.

The whole construction process is dynamic and consists of many parallel processes. It is affected by troubles, which appear within the construction sequence, and can influence the workflow of a whole chain of building vehicles. Here troubles can occur during the construction work, which cannot be anticipated during the planning phase. Not optimal co-operating teams of building vehicles are referred as disturbance of the workflow. Aggravatingly each building project is unique and a planning and control system does not exist. To address the mentioned issues building vehicles are equipped with sensors. This is not a GPS-receiver like a car sat, but rather a specific technology with increased accuracy. Additional sensors are able to collect the excavator bucket, shield tilting dozer position and orientation in an exact way. Furthermore technical data like maintenance interval, amount of diesel and pressure of engine oil are known, so that a huge data basis exists. This kind of continuity of 3D- and technical data may be supported by attempts like Building Information Modeling (BIM) and the 5D Initiative

AUGMENTED REALITY IN ARCHITECTURE, ENGINEERING AND CONSTRUCTION

The application of visualization techniques such as AR for planning, analysis, and design of Architecture, Engineering, and Construction (AEC) projects is relatively new compared to the sizeable amount of AR-related research conducted for diverse

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applications in fields such as manufacturing, medical operations, military, and gaming. A thorough statistical review of recent AR-related research studies in AEC and potential future trends in this area was recently conducted by Rankohi and Waugh [1]. Their work showed that field workers and project managers have high interest in using non-immersive and desktop standalone AR technologies during project construction phase mainly to monitor progress and detect defective work. In another study, the potential of AR applications in AEC including eight work tasks (i.e., layout, excavation, positioning, inspection, coordination, supervision, commenting, and strategizing) was discussed.

We can observe that over the years, the field of AEC has become more complex with the advent of various new technologies and materials. The designs are not confined to conventional strategies anymore. This is the reason AR is poised to become an important part of this sector in the times to come.

NEED OF AUGMENTED REALITY IN AEC

As mentioned earlier, the architects and designers have slowly moved away from conventional designs and are now exploring new avenues of designs and detailing. Across the world, we have many examples of unconventional architectures and the extreme engineering that has come into play in executing these structures. Designing a structure and its subsequent analysis using software has now become a norm. Regardless of the shape or the size, the analysis has become easier. But when it comes to executing those designs on the field, we still rely on human experience and intuition. Regardless of the control measures that are taken to ensure quality, it is rarely easy to sustain the level of perfection that a computer analysis can achieve.

Augmented Reality aims to bridge this gap. Currently, the engineers in the field rely on scaled drawings in all projects that are used for all practical purposes. And this is where human error tends to creep in the execution. Even if there is a slight difference in measurement and its subsequent application, it tends to multiply as the project progresses and may at times cause problems in later stages. With the concept of AR, the engineer can review the structure as it progresses with the drawings by projecting the drawing onto the field. This will help in identification of flaws and errors and rectification of the same in time.

Coming to a second aspect of the AEC industry, the client may or may not have a technical aspect and this causes a communication gap between the client and the concessionaire. With the use of AR, the client can be give a virtual tour of the project before it is built so that if any changes are required, they can be incorporated before the project work has commenced.

TECHNOLOGIES AVAILABLE FOR AUGMENTED REALITY

Recent applications of AR technology in AEC domain have helped improve performance in areas such as virtual site visits, comparing as-built and as-planned status of projects, preempting work package schedule disputes, enhancing collaboration opportunities, and planning and training for similar projects [1, 2]. Examples of such application areas include but are not limited to a framework for analyzing, visualizing, and assessing architectural/ construction progress with unordered photo collections and 3D building models [3,4], a client/server AR system for viewing complex assembly models on mobile phones [5] , a tangible MR-based virtual design prototype as a distributed virtual environment (DVE) for the purpose of improving remote design review collaboration [6] , an AR interior design service which combines features of social media, AR and 3D modeling to ambient home design [7], an interactive speech and gesture recognition based, immersive AR model designed to visualize and interact with buildings and their thermal environments [8], an integrated AR based framework for indoor thermal performance data visualization that utilizes a mobile robot to generate environment maps [9] , a tabletop AR system for collaboratively visualizing computer- generated models [10], and a mobile AR application capable of delivering context-aware visual project information to students and trainees to improve the quality and pace of learning [11].

During the course of the literature review, the author came across few technologies that are attempting to introduce AR in the AEC industry.

Microsoft HoloLens is a wearable, self-contained holographic computer. The device features a see-through, holographic display and advanced sensors that map the physical environment. HoloLens enables users to interact with 3D holograms blended into the real world. In this Mixed Reality Environment, users can pin holograms to physical objects and interact with data using Gesture, gaze and voice commands.

Google Glass was another ambitious project in the field of AR that was discontinued.

ADVANTAGES OF AUGMENTED REALITY IN CIVIL ENGINEERING

Use of Augmented Reality in Civil Engineering has tremendous benefits for Civil Engineering. The following benefits can be reaped from the use of the technology:

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1. **Error Reduction**
   The most important advantage that this technology provides to the user is the reduction of errors that may take place during the construction proves. By providing a virtual design on the field, it becomes easier to control the different processes and achieve a better output.
2. **Better Marketing**
   Explaining a project to a person without a technical background is a problem that all projects have to face. Architectural drawings may be extraordinary but they are still on a smaller scale and generally 2-D. using the concept of AR, the client can be given a virtual tour of the project, with all the colors and the different views that he can observe from the project. This can lead to better marketing strategies for organizations.
3. **Review of the project**
   The drawings under consideration can be reviewed by the Project manager on a real scale, thus identifying small problems and errors that might have crept in or escaped the notice of the designer.
4. **Saving of Man-Hours**
   The use of AR aims to reduce errors that creep in while execution of civil engineering works due to various factors such as calculation errors, misreading of drawings etc. These can be avoided by continuous monitoring and review of the work using AR. This would help in reducing the work required for correction of those errors, hence saving the time required for error rectification.
5. **Cost Reduction**
   Since error rectification reduces, the cost of material and manpower utilized for that rectification is reduced, that helps in reducing the overall overheads of a project.

CHALLENGES IN IMPLEMENTING AUGMENTED REALITY IN CIVIL ENGINEERING

Cost of AR Technology

Being a relatively new concept, the initial costs of setting up an AR system in place can increase the costs of the projects. Yet the continuous reduction of costs in terms of the benefits, this extra cost can be adjusted.

1. **Spatial alignment of real and Virtual entities**
   The goal of spatial registration in AR is to properly align real world objects and superimposed virtual objects with respect to each other [12]. Without proper registration, the illusion that the two worlds coexist inside the augmented space will be compromised. The registration process typically consists of four major steps [13]:
   - Positioning the viewing volume of a user's eyes in the world coordinate system.
   - Positioning virtual objects in the world coordinate system.
   - Determining the shape of the viewing volume.
   - Converting virtual objects from the world coordinate system to the eye coordinate system.

2. **Development of Applications**
   The development of applications to incorporate AR into AEC is a challenge, with the field being very vast and diverse.

POSSIBLE APPLICATIONS OF AUGMENTED REALITY IN AEC

1. **Design and Development**
   The concept of AR can very well be used to optimize designs for better space utilization and wastage of space. Spatial models can help the designer identify the flaws and rectify them at the design stage itself. Also, it can help create innovative designs as the architect can see the structure in real time, which can help in various advantageous changes.

2. **Translation of drawings onto the field**
   The translation of drawings into a structure is not an easy task. It involves various steps of identification of different structural elements and subsequently constructing them. Since the project is envisaged in phases, it may so happen that errors might creep in during various stages. Since AR creates a virtual image of the structure, it helps in eliminating these errors.

CONCLUSION

As a concept, Augmented Reality can work wonders if applied practically in reality. Construction being a diverse field, AR can help in better and efficient designs and real scale modeling and subsequent changes which can enable the engineer to monitor and supervise the tasks easily. There are significant challenges in application of the concept in the field at present but subsequent research and analysis can lead to development of an effective tool for Construction Management, Designing and Marketing.

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