

Emerging Trend of Virtual, Augmented and Mixed Reality in Civil Engineering

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Abstract— The world is changing drastically. New technologies are inventing worldwide. Many new trends are emerging in every trade. One of these trends is VR, AR and MR. Virtual (VR), Augmented (AR) and Mixed Reality (MR) mark the beginning of a new era of immersive technology. Open a random newspaper, and chances are high that you will find an article about at least one of those three new technologies. On top of that, the hardware you need becomes more affordable by the minute, meaning that more and more entrepreneurs and innovators will adopt reality technology in their businesses soon. One industry which can particularly profit from reality technologies is the construction industry. Computer-aided design software (CAD-software) has been used to plan new projects for years, and with the rise of Building Information Modeling all over the world, the uses for reality technologies are numerous.

Keywords: Virtual (VR), Augmented (AR) and Mixed Reality (MR), CAD-software

I. INTRODUCTION

The days of 3D glasses bringing things to life in the real world are long past, and in its place, virtual reality (VR) and augmented reality (AR) have taken over for more than just entertainment.

First, let's establish their differences. Virtual Reality offers a life-like experience by immersing the user in a computer-generated world. Augmented Reality works on the world around you. Construction is only one of the industries utilizing technology to improve work processes, but the applications for this industry are seemingly endless. AR and VR have the potential to reduce delays due to rework, improve estimation, and synergize jobsite relationships through transparent communication between all stakeholders.



To avoid any confusion, it is worth explaining the difference between the two terms.

VR refers to the creation of an entirely simulated environment and has a relatively long history in the

construction history, particularly in demonstrating how any project will look once completed.

AR involves superimposing computer-generated images and information on real-world images.

II. VIRTUAL REALITY

McCarthy saw the benefits of VR firsthand when constructing a new hospital.

Virtual Reality is all about creating immersive surroundings. You are placed in a virtual environment without any visual relation to the real world. This means that the actual space around you — your office, your living room, or wherever you put the VR glasses on — is not visible anymore. Instead, you completely dive into the virtual experience, which could be anything from flying a spaceship to walking over a construction site.

A. Why Virtual Reality is a Game-Changer?

Imagine being able to create a project from concept through completion in such fine detail that problems can be resolved before they occur.

VR lends the ultimate helping hand to design planning and project management through fully immersive technology. When clients want to make changes, you can now show them the effects on the structure, timeline, and budget almost instantly. Rework drastically decreases. Project planning and execution soars.

Another revolutionary benefit to VR? Training! Instead of simply using drills and hypotheticals to practice what to do IF a situation presents itself on the job, contractors can virtually experience jobsite dangers that require real-time reactions. While this may not be feasible for every construction company just yet, advancements in technology will enable companies to dip their toes into the virtual reality waters.

Here are three examples of how the new age of VR technology is solving old problems.

1) Scale Up Quickly

We are in construction body 2D & 3D modeling software makes it possible to create detailed models and share those models across teams.

Creating a 3D model of a construction site used to be a complex physical process that required space, time, and materials.

3D modeling software changed the game by making it possible not only to create a detailed, accurate model more quickly and cheaply, but also by making it possible to share those models across teams. VR takes it to a new level by making it possible for people to immerse themselves in the project as though they were actually there, and interact with the environment.



2) Streamline Collaboration

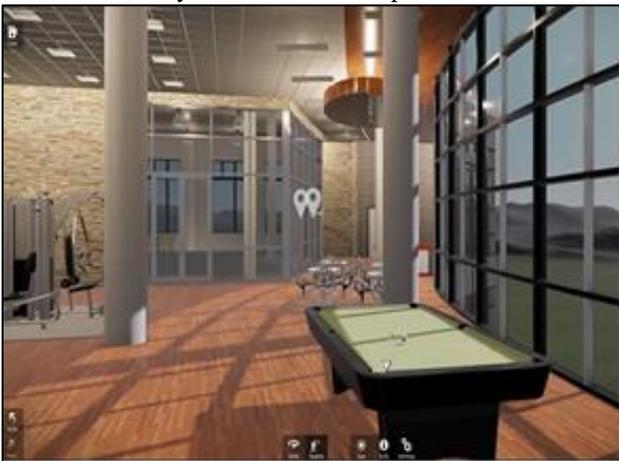
VR gives teams the ability to “see” a project site without traveling to it. This makes it easy for teams to collaborate in real time, within a shared environment, where they can literally point out details and issues, ask questions, and immediately make decisions about changes.

This improves timelines by facilitating feedback. It also reduces rework, by improving accuracy and the detail level of communications.

The benefits of VR for collaboration are especially relevant when building in difficult or remote sites, where teams may be communicating across substantial distances and site conditions make visits challenging.

3) Improve Customer Experience

Clients can now walk into a VR model and see for themselves what their project will look like when it's complete. Lack of transparency has been a common frustration for building owners and other stakeholders during the construction process. It used to be that they simply had to trust that the construction company was doing their job right, and hope that an occasional site visit would clear up any problems. Today's customer experience can be completely different. Instead of paper drawings and plans, clients can walk into a VR model and see for themselves what their project will look like when it's complete. This empowers clients to make smart decisions, and improves the contractor's ability to set and meet expectations.



III. AUGMENTED REALITY

Augmented Reality is widely used in the commercial sector to add a single piece of virtual information to a specific point in reality. This point is called “marker” and tells the

device (through which you are looking) that a specific virtual element belongs to this place. The virtual object will always be displayed there, on top of the marker, and you can walk around it to watch it from all angles. This technique is often used to place 3D models into the real world. A marker can be placed inside a catalog to visualize a product as a smaller scaled 3D model or to show it in real life size right where the marker is placed.

A. A Different Perspective: Augmented Reality

Augmented Reality allows workers to pull up blueprints in their field of vision through a heads-up type display. The DAQRI Smart Helmet is a wearable augmented reality system that allows builders to see through walls. Think of it as x-ray vision for your jobsite. Tools like this expedite the building process dramatically by reducing human error and costly mistakes.

AR aids the jobsite by:

- 1) Assisting project management efforts
- 2) Reducing time taken to resketch
- 3) Boosting safety through preventative measures
- 4) Incorporating client insights early
- 5) Boosting accuracy
- 6) Viewing spatial relationships between parts of buildings.

B. How Augmented Reality Works

Augmented reality overlays computer-generated video onto camera-captured video, so it appears in the exact location in the real world.

C. Augmented Reality in Construction

1) Project Planning

The use of augmented reality gives firms the ability to understand the building more in-depth. AR can display the environmental and social impacts of the project visually. It gives firms the ability to showcase the end-product (e.g., completed building) on a very detailed level and how the structure will benefit or impact its surroundings.

Morpholio is an example of an app that can be used by architects to design the project by incorporating CAD in the planning phase.

2) Measuring Accurately

Augmented reality gear and wearables like DAQRI's smart glasses and Microsoft's HoloLens can measure a space's physical elements, including depth, height, and width. Determining labor hours and materials needed will be more efficient by using augmented reality because it provides more accurate measurements.

3) On Job Site Revision

The best benefit of using augmented reality is the ability to see how features fit on the site. It gives project managers the visibility to see how everything fits on-site to scale before materials are ordered or the amount of labor needed for installation.

4) Safety and Inspection

Safety is a common challenge in the construction industry. In terms of safety, wearable smart glasses are used as safety equipment and for augmented reality's inspection works. An inspector can capture photos on demand, or retrieve notes from location sites. On-site, complicated areas, and serious

concerns become easier to recognize, identify, and can be shared instantly.

5) *Underground Construction*

In the excavation process, there is always a risk of potentially hitting a gas line or wrecking underground utilities. AugView is a mobile product that enables users to see things that are underground, such as trenches or buried cables. Augview uses map views from google maps to let users see hidden underground cables or layers.

6) *Training*

In the construction industry, there is a lot of machinery involved in the building process, and it requires many hours of training. But in this technologically advanced generation, there is an augmented reality headset that allows workers to receive direct instructions, and then act accordingly. With the augmented reality headset, it reduces the training costs and downtime utilized because the instructions are more intuitive.

7) *Cost Savings*

AR can increase labor productivity, reduce costs and improve safety by using it throughout the project lifecycle. For example, timelines are more likely to be met using AR wearables glasses to show the workers what tasks need to be done and when they need to be completed.

IV. MIXED REALITY

A third category, often less talked about than VR and AR, is Mixed Reality (MR). It's predicted to be the next major disruptor of reality tech in construction, especially because of its ability to be combined with BIM.

MR works similarly to Augmented Reality in the sense that a virtual object is projected into a real space. However, Mixed Reality enables the virtual components to be anchored to specific points that are scaled to the size of the actual object.

An MR device allows you to 'anchor' objects in the real world, independent from any special marker. You could say that it is aware of its real world surroundings and can place any virtual object inside of it, which will be correctly positioned and permanently visible at this place.

As you can see, Mixed Reality combines the advantages of both VR and AR, as it allows you to manipulate your surroundings virtually.

A. *BIM + MR*

Mixed Reality combined with Building Information Modeling has the capability to propel construction to the next level. Models can be turned into holograms that are then overlaid onto the existing building environment and pinned into position (they won't move around, so you can actually walk through the model, much like you would in a VR environment). This eliminates the need for chalk lines, measurements, plan reviews, RFI submissions, etc.

Further, this integration has the capability to reflect changes made in the virtual environment back to the BIM model and vice versa.

V. SO, WHICH IS THE RIGHT FOR MY CONSTRUCTION PROJECT?

Augmented Reality can provide additional information right in your field of view. This can come in handy if you want to check on details in design documents without taking your phone out of your pocket and browsing through your files for the information needed. It has very limited uses for the construction process itself, though, as AR does not really 'understand' where you are and what you are doing. Especially on construction sites, where there are always people or vehicles moving, AR cannot always correctly display the information you need in the real world, as the devices can't contextually understand whether they see a wall or a person.

Mixed Reality is a promising technology, but it is still too young to be of much real use for the daily business right now. Generally, you could, for example, use such a solution to have a virtual overlay to your real surrounding which could help you detect measurement errors before it's too late. But there are no reliable commercial solutions available for the HoloLens at the moment, which means that using it on a construction site can become a pretty tricky job — at least for now (end of 2016).

Virtual Reality, on the other hand, is already here. It is an immersive approach, which means that your actual real world surroundings have no influence on how you experience it. Using VR solutions is a good idea if you want to create virtual walk-throughs through the blueprints of your building, or if remote co-workers want to see how the building process is going. Another big plus is that it has become easy to create own 360°-content, for example of your construction site.

On the downside, VR can cause dizziness for some. Though, so you should try out if you can work in VR, for example by buying an inexpensive Google Cardboard. Another possible disadvantage is that many existing high-end VR-devices are somewhat costly and need a powerful hardware setup — you can read more about that in our comparison of VR headsets.

VI. VIRTUALLY BUILDING THE FUTURE

The possibilities for AR/VR/MR are far-reaching. Being able to save time, prevent waste, and expedite building all help solve chronic issues in the construction world. These tools are poised to be secret weapon for productivity in future.

VII. CONCLUSION

Each of the three different reality technologies has its own pros and cons, but for us, Virtual Reality has the most advantages for the time being: the creation of own 360°-content is becoming increasingly easy, and so is the sharing and collaborating with it. Tools like HoloBuilder allow users with little to no training to create their own digital job walks as virtual walk-throughs and enrich them with additional information. So it is up to you to decide when you would like to start with bringing your projects virtual representation online and start to benefit from cutting-edge technology.

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