Future of Augmented and Virtual Reality in Construction

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A series of virtual design contractors were interviewed regarding the future involvement of augmented and virtual reality software integration with construction processes. Within the construction industry, VDC specialists rely on Building Information Modeling (BIM) and Computer Aided Design (CAD) to create digital models that can be used to analyze the design of a building from all points of view. The interviewees responded to questions about software implementation advantages, and related user experiences. Six interviews were conducted, amongst three industry leading companies. Their assumptions of future AR and VR usage in construction were based on learned knowledge and prior field exploration. Interviewees determined that construction companies can gain more security in their day-to-day tasks through rigorous software implementation. Software adoption within a company carries minor costs, while paying off tenfold in years to come. More precision and efficiency will translate to increased cost savings. An interviewee mentioned, “VR visualization allows us to gain a comprehensive view of how the project will appear when complete, and how to handle it successfully”.

Key Words: Augmented reality, virtual reality, construction, architecture, software.

Introduction

Augmented reality and virtual reality are visualization technologies that are altering the way construction specialists interact with visual data. AR and VR software usage is becoming widespread, and the construction industry will be affected through certain software integration. Despite their huge potential, software adoption in the architecture, engineering, and construction sectors is still very low. How these sectors will evolve is unclear, but through the study of field user experiences, projections can be made. In the construction industry, a plethora of individuals use virtual technologies, however Virtual Design and Construction (VDC) specialists concentrate specifically on the subject. The VDC Engineer's primary responsibility is to develop 3D models used for proposal graphics and animations needed to construct large bridges, tunnels, highway interchanges, power plants, and other infrastructure systems (4 Corners Research 2023). It is essential for these virtual managers and engineers to ensure the coordination process is always ahead of the construction schedule, avoiding delays and non-expected issues on site. VDC expertise is key in determining how compatible AR and VR technology is with the construction industry right now and in years to come.

A total of six licensed contractors with experience in virtual design and management were put through an extensive interview process. Through in depth questioning and conversation, great insight was pulled from each interviewee. On a day-to-day basis they use virtual models to visualize and plan building designs, processes, schedules, and budgets. Everyone was questioned for an average of one hour per person, in order to grasp a better understanding of how AR and VR software is used in construction, and evaluate how they think it will contribute further to the future.

Literature Review

As part of the pre-interview process, background research was conducted to gather details and prompt specific questioning. Throughout project planning, project modification, team collaboration, and in efforts to ensure employees' safety, AR and VR can be described as efficient, beneficial, and profitable. Once all relevant information was discovered, in journals and articles, a questionnaire could be posed to the interviewees.

Project Planning

AR and VR systems display details of the construction plan and let users visualize working models, allowing for a deeper understanding of the project and the processes needed to build. With augmented reality in construction, it is also possible to take virtual tours before construction starts. VR is used in the planning phase for making effective decisions with the constraints of time (Ahmed 2019). Contractors can employ AR/VR technology to streamline the processes involved in most building projects, and decrease guesswork, thus saving time and money while providing substantial design insights to clients and architects (Pixel Plex 2022). Detailed and interactive models of building projects are implemented in much of project delivery, altering how the client would typically view a project. This allows clients to get a realistic view of project outcomes, and therefore make informed decisions on what changes need to be made before construction commences. Getting this level of client involvement early in the process helps prevent costly changes later and keeps clients engaged. Similarly, architects and designers can get a better sense of a space before it physically exists and can therefore better plan out their approach. Moreover, the technology allows firms to make a more compelling case when bidding for a new project: they can take the stakeholders on a virtual tour of the future space instead of presenting a 2D rendering or a model (VLATecknik 2017).

Project Modifications

Building plans and processes are constantly being altered to fit the needs of the client, site, and city. Changes are constantly being made, and virtual reality implementation reduces rework costs through workers being able to display interior and exterior views of a structure and make modifications to the virtual plans while keeping the original view intact (Delgado 2020). All alterations here can be kept on record for future review as well. Structural issues can be viewed, and modifications can be made with only a few commands on an AR-enabled device.

Through the use of digital twins, or “digital representations of a physical object, process, service or environment that behaves and looks like its counterpart in the real-world” (TWI n.d.), integrating real-time data is made possible. Whether the user is in the office or on-site, they can interact with the same model, at the same time. If a VR user adds a markup inside the simulation, the platform will push their “live” annotations to a shared issue tracker, and it will appear in real-time inside the BIM model for all to view. This will allow the engineers to remove any oversight, improve workflow and help to avoid wasting materials (Helmsing 2022). Rework is one of the main issues in the construction industry today, and probable solutions like virtual visualization can greatly diminish costs when it comes to client changes and worker error.

Team Collaboration

Post COVID-19, many construction executives and managers were not able to follow up with their daily tasks, as much of the world went remote. COVID-19 brought an unprecedented obstacle of being distant from the project team, causing difficulties in collaboration. As a result, Zoom and other companies hit the market with their new ways of being able to communicate efficiently with the user's team. In construction, Zoom and other conferencing software can be used to a certain extent. Standalone, AR technologies are beneficial to the user, but post-pandemic, the construction industry made major moves toward adopting AR systems into many of their processes. AR can streamline collaboration in remote environments by letting teams share 3D images and videos with team members who are not on-site (Delgado 2020). Thanks to augmented reality, stakeholders can view images or videos in greater detail so they can identify errors or issues without having to be in the actual building location. This includes taking and sending 3D videos and photos of issues to remote workers. The entire team can view details such as HVAC systems, pipes, windows, and doors. They then can compare the details to those of the building plan, thus reducing time spent on fixing both minor and major errors (BluEnt Engineering 2021). A successful collaboration ensures that a project is completed on time and according to the proposed budget.

Safety

Worker safety is paramount in construction. Liability and costs associated with litigation prove to be significant motivators in maintaining safety on a jobsite. Hazard avoidance is a key initiative that risk mitigators deal with on a regular basis. Stopping a major fault before it happens is the most beneficial advantage to AR and VR adoption. It helps workers reduce risks and carry out tasks in a safer manner. AR enables workers to improve identification of field safety risks, improve risk recognition, and enhance real time communication between the construction manager and workers (Delgado 2020). Safety inspections, hazard identification, and encompassing safety training can be controlled through AR manipulation (Delgado 2020). AR training simulations are quite interactive, testing if workers know what to do in dangerous situations without putting the user in actual danger. For example, simulations of heavy machinery can be used to test operational knowledge before interacting with the real thing. Another key component regarding site safety pertains to overlays and "tags". An overlay on the actual construction site can be used to see the completed building in its final location but also to see specific aspects of the building plans superimposed over what is already there (Henze 2022). Here "tags" are placed on hazardous instances, indicating a fix or avoidance in these "danger zones". AR software provides premier location accuracy, virtually displaying exactly where an incident will occur or already has (Zeile 2019).

Methodology

Following preliminary research, a systematic qualitative interview process took place. Through a series of brief communications, subject matter experts were secured to discuss the "Future of AR and VR in Construction". The survey below was sent via email to the recipients, allowing them to grasp the analysis needed from them. Once confirmation was secured, each Zoom conferencing session was scheduled per interviewee, averaging an hour per person. A total of six Virtual Design and Construction specialists were interviewed over the course of one week. Questions pertained to how AR and VR affects the industry today and in years to come. All six interviews were recorded with

permission to do so. Following the interview process, response consolidation and analysis was performed. As a result, three categories were created to house their responses: background, current user advantages, and future usage analysis.

Survey

Survey Introduction:
AR and VR systems have entered the industry and are continuing to gain more traction. You have been in and around construction for some time now, with a background in building and intriguing insights about construction AR and VR integration. This survey is looking to explore your perspective on AR and VR viability. Based on your career experience, while looking a few years into the future, what is your consensus on the following questions?

General:

1. Who are you (credentials), and how do you view augmented reality and virtual reality in construction?
2. How long and in what ways have you worked with AR and VR systems?
3. Why are VR and AR used in construction?
    a. Precision?
    b. Safety?
    c. Cost?
    d. Rework?
    e. Oversight?
4. Why is VR and AR systems integration considered progressive?
5. What do you consider to be the most beneficial aspect of implementing VR and AR observation techniques?
6. What is one portion of the construction process that would benefit the most if the transition to AR and VR were made? If a company were to make the transition, where should the focus be put on?
7. How do you see AR and VR usage in construction for years to come?
8. What is the compatibility extent of AR software in construction?
    a. What do you believe could be changed?
    b. How do you think it will change in the future?
9. What software is predominantly used now? And what new innovations are growing in popularity?

Specified:

1. How would virtual walkthroughs benefit the pre-construction phase and OAC oversight?
    a. Regarding estimating, scheduling, materials, labor hours, equipment?
2. How are AR software systems integration financially feasible in a construction setting (limited budget)?
3. Would you consider real time rendering and collaboration as a standard for every project?
    a. If so, how is this helpful?
    b. If not, what is a better alternative?
4. How can VR and AR integration mitigate risk?
    a. Save money?
    b. Keep laborers safe?
    c. Create a more dependable plan?
    d. Better logistical analysis?

Results

All six interviewees had similar responses to the questions asked. They seemed to use similar technology as well. These VDC managers and engineers have a great understanding of how AR and VR is used now and how it should be used in the future. With relevant experiences and opinions, the interviewees generated a series of current user advantages and future user analysis.

Current User Advantages

Categorized here is information about how the interviewees performed tasks using AR and VR systems. Foremost, AR adoption makes project analysis extremely easy. It streamlines everything. During construction, it is difficult to manage all the logistical outliers while constructing an intricate building. On-site there are many moving parts, and augmented modeling software puts all those moving parts onto a single computer screen. This allows for solutions to be posed in a decisive manner. Every stakeholder also has access to these models, allowing for improved oversight. As more individuals have access to a complete digital model, less mistakes are made, rework is minimal, thus vastly reducing construction costs. Mitigating safety risks is also a major upside. Interviewees mentioned how safe their workers feel when they themselves can view a digital overlay to see hazards they need to avoid. Most large commercial contracting companies have incorporated VDC and the use of AR and VR. They realize its extensive benefits and how it most definitely outweighs the monetary cost of software systems implementation. A commonality in software usage reports as models created through BIM in Revit, while being overlaid on the site by technology like GAMMA AR, Unreal Engine 4, or Lumion. One of the interviewed subject matter experts determined that AR and VR correlate with the complexity of a project. The more complicated processes needed to build, the more AR and VR is used on that project. For example, an interviewee was on a project where they were implementing a monorail for a package distribution system, and the owner was out of state. The owner could only visit the site once a month, as they were managing other accounts around the country. This interviewee discussed how difficult it would have been to take pictures and videos while describing the intricacies of the monorail to the owner. Instead, during OAC, a 3D overlay was presented and shared with the owner, giving them access to real-time visualization of what is being built and how. The owner was then able to approve each step in the monorail addition from a virtual location.

Future Usage Analysis

As stated by an interviewee, “I could try to predict what will happen, but with innovations in rapid growth, anything could happen”. Take into consideration: the future is volatile, but expert user insight provides a close articulation as to what future AR innovators will want their software to consist of. The biggest obstacle with broad AR and VR usage and adaptation is its social acceptability and accessibility challenges. Many view these systems as being too difficult to learn and understand. To efficiently use and manage AR and VR software, employees must go through extensive training to be effective. In years to come, AR integration courses will be improved, and more individuals will join VDC. The interviewees stated how beneficial online AR model collaboration is, and how we will soon be able to manage the entirety of design and construction from home. Steps in that direction have already been made. For example, in an Owner-Architect-Contractor (OAC) meeting the contractor can provide the owner with a digital model of their building before, during and after construction. An interviewee mentioned the “clunkiness” of AR goggles and the faulty internet

connection that is sometimes shared between devices. They noted that the modeling and visualization software is sound, but the viewing apparatuses could be further improved. While onsite they have trouble with special awareness which is a safety issue. They recommend goggles and other wearable devices be smaller and more transparent, compatible with construction site personal protective equipment (PPE). Right now, AR goggles are not being designed for construction field use, but my interviewees indicated that new designs are in the works. Regarding the internet connection, users have had trouble finding a viable connection when onsite in certain geographical locations. A major improvement to be made is establishing a secure internet connection site wide, eliminating disconnections, and improving workability.

Conclusion

AR and VR systems adoption stands to streamline all construction processes. Bringing all pertinent building data to a single forum improves communication, safety, planning and rework. Although smaller contracting firms do not use AR and VR systems, many industry leaders do. Larger companies have the resources and need to adopt such technology. As AR and VR begin to shift from an observational device to an interactive design platform, acquisition rates increase. More and more companies are implementing these systems, and as a result there is an increasing number of VDC job openings. General contractors and design firms are now beginning to understand and appreciate the benefits of AR and VR technology. The future of construction industry is fickle. Construction has been evolving since its early years, but now with advanced technology, the construction industry will never be the same. Processes are changing rapidly, and it is hard for many to keep up. AR and VR can help assist the user with complicated building types and processes. Big projects can be made small, allowing for closeup analysis. AR and VR technology is valuable to everyone, and especially beneficial for stakeholders.

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