International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Integration of Augmented Reality (AR) to BIM Construction Model

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A B S T R A C T

Though they haven't altered as much as the globe, our minds have. There are a lot of tools at our disposal that may help us live better and more simply with the aid of the technologies that are readily available in the modern world. Therefore, the building industry is comparable. The construction sector will profit from employing this augmented reality that has been integrated with the Revit Models, including customers, owners, masons, site engineers in charge of reproducing their own designs on site, and many more areas. The term "augmented reality," or "AR," refers to a technology that superimposes digital data, such as virtual objects, images, or objects, over the physical world.

Keywords: AR, VR, BIM

1. Introduction

The history of Augmented Reality (AR) integrated with Revit Models in the construction industry is a journey marked by significant technological developments and visionary innovations. It finds its origins in the evolution of computer-aided design (CAD) systems during the 1960s and 1970s, when architects and engineers began transitioning from traditional paper-based drawings to digital representations of their designs. This early adoption of CAD laid the groundwork for a digital transformation within the construction sector. Building Information Modeling (BIM) emerged as a pivotal milestone in this trajectory. These technological milestones, combined with visionary thinking and a growing awareness of the potential benefits, paved the way for the transformative fusion of AR with Revit Models in the construction industry. This integration promised not only enhanced visualization but also improved communication, collaboration, and overall efficiency in construction projects, heralding a new era in the way buildings are designed, constructed, and maintained.

1.1 Benefits of BIM

Improve Onsite Collaboration and Communication: Digital BIM models enable sharing, collaboration, and versioning in ways that paper drawing sets do not. BIM collaboration may occur fluidly across all disciplines within the project using cloud- based platforms such as Autodesk's BIM 360. The BIM 360 ecosystem enables teams to exchange project models and coordinate planning, ensuring that all design stakeholders have access to project information. Cloud access also allows project teams to take the office to the field. With apps such as Autodesk’s BIM 360 tools, teams can review drawings and models onsite and on their mobile devices, ensuring they have access to up-to-date project information at any time.

Model-Based Cost Estimation: Several AEC firms are learning that involving estimators early in the planning stage allows for more accurate construction cost estimation, which has resulted in the rise of model-based cost estimating (also known as 5D BIM). Utilizing BIM technologies like Autodesk's Revit and BIM 360 Documents streamlines the time-consuming work of quantifying and applying costs, freeing up estimators' time to focus on higher-value aspects like identifying construction assembly and considering hazards.

Visualize Projects in Preconstruction: By using BIM, you can plan and visualize the entire project during preconstruction, before the shovel hits the ground. Space-use simulations and 3D visualizations allow clients to experience what the space will look like offering the ability to make changes before construction start. Having a greater overview from the beginning minimizes expensive and time-consuming changes later.

Better Coordination and Clash Detection: BIM allows you to better coordinate trades and subcontractors, detecting any MEP, internal or external clashes before construction begins. It reduces the amount of rework needed on any given job by avoiding clashes. With BIM, you have the opportunity to plan it right before you build onsite. You can avoid last-minute changes and unforeseen issues by enabling easy reviewing and commenting across multiple disciplines.

Mitigate Risk and Reduce Cost: Greater coordination with contractors can result in reduced tender risk premiums, cheaper insurance costs, fewer total deviations, and fewer claims chances. A better understanding of the project before beginning enables greater prefabrication and avoids waste on unneeded resources. Rather of being produced on-site, prefabricated pieces may be readily bolted in place. Labor expenses associated with paperwork and miscommunications are eliminated. Numerous businesses are utilizing BIM and construction technologies to minimize costs and risk.

Improved Scheduling/Sequencing: Design and documentation may be done concurrently with BIM, and documentation can be quickly altered to respond to new information such as site circumstances. Schedules may be planned and communicated more precisely, and the enhanced coordination makes projects more likely to be finished on time or early. Increase Productivity with Prefabrication: BIM data may be utilized to rapidly produce manufacturing drawings or databases, enabling for greater usage of prefabrication and modular building technologies. You may eliminate waste, boost productivity, and save labour and material costs by planning, detailing, and building offshore in a controlled environment.

1.2 Levels of BIM

BIM Level 0: The most simplistic form of BIM level is LEVEL 0, it effectively means no collaboration. Only 2D CAD drafting is utilized, mainly for Production Information (RIBA Plan of Work 2013 stage 4). Output and administration are via paper or electronic prints, or a mixture of both. The majority of the industry is already well ahead of this now.

BIM Level 1: This typically incorporates a blend of 3D CAD for concept work, and 2D for drafting of sanctioned documentation and Production Information. CAD standards are managed to BS 1192:2007, and digital distribution of data is carried out from a common data environment (CDE), often managed by the constructor.

BIM Level 2: Level 2 BIM is prescribed by the UK Government for public sector projects. This level promotes collaborative working by giving each of the stakeholders its own 3D CAD model. Collaborative working is the distinguishing aspect of this level and Level 2 requires streamlined information exchange related to a project and seamless coordination between all the systems and the stakeholders. All the parties work on their local 3D CAD models and information is exchanged through a common file format. Such a system allows organizations to combine external data with their own model to create a federated BIM Model.

Fig. 1 Levels of BIM

1.3 Integration of Augmented Reality (AR) and BIM

The integration of Building Information Modelling (BIM) and Augmented Reality (AR) marks a transformative revolution in the construction industry. BIM, as a digital representation of a building's characteristics, forms the bedrock upon which construction projects are conceived and executed. Its collaborative potential has already streamlined design and planning processes, but when merged with Augmented Reality, it gains a new dimension. Augmented Reality, with its ability to overlay digital information onto the physical world, enhances visualization by superimposing BIM data directly onto construction sites. This integration empowers stakeholders to visualize and interact with digital models in the real world, offering a comprehensive understanding of the project's intricacies. Decision-making becomes more informed, errors are minimized, and construction aligns seamlessly with design intent. Furthermore, the synergy of BIM and AR fosters improved communication and collaboration throughout construction projects. Teams on-site can access BIM data overlaid onto their surroundings using AR devices, ensuring that everyone works from the same digital source. This real-time access to information enhances coordination and minimizes errors, facilitating a smoother construction process. Architects, engineers, and contractors can collectively explore and discuss project details, making design reviews more efficient and effective. The collaborative environment extends to remote stakeholders as well, as AR-powered virtual meetings enable dispersed teams to participate in design discussions and project coordination. Consequently, the integration of BIM and AR not only enhances visualization but also transforms the way construction professionals communicate and collaborate, promoting a more efficient and transparent project ecosystem.

1.4 Signification of the study

The study and implementation of Augmented Reality (AR) within the construction industry hold profound significance for numerous compelling reasons. AR technology empowers construction professionals with the ability to enhance visualization and communication by overlaying complex architectural designs, building plans, and Building Information Modelling (BIM) data onto physical construction sites. This immersive visualization not only fosters improved communication among project stakeholders but also acts as a common visual language that bridges the gap between technical experts and non-technical participants. Furthermore, AR significantly contributes to error reduction and quality control by allowing for early error detection, leading to higher precision and a reduction in costly rework. It also facilitates on-site decision-making by providing real-time access to crucial data, resulting in construction progress aligned with design specifications. This technology translates into cost savings, safer work environments, streamlined collaboration, and efficient facility management, all of which are vital elements in modern construction practices. Beyond these immediate benefits, AR holds the potential to foster sustainable construction practices, enhance client engagement, and bolster industry competitiveness. As AR technology continues to evolve, its integration within the construction sector remains pivotal for driving efficiency, innovation, and excellence throughout the project lifecycle.

1.5 Softwares usedAutodesk Revit:

Autodesk Revit is a building information modelling software tool for architects, landscape architects, structural engineers, mechanical, electrical, and plumbing (MEP) engineers, designers and contractors. The software allows users to design a building and structure and its components in 3D, annotate the model with 2D drafting elements, and access building information from the building model's database. Revit is 4D building information modelling application capable with tools to plan and track various stages in the building's lifecycle, from concept to construction and later maintenance and/or demolition. The Revit work environment allows users to manipulate whole buildings or assemblies (in the project environment) or individual 3D shapes (in the family editor environment). Modelling tools can be used with pre-made solid objects or imported geometric mode. Revit families can be created as parametric models with dimensions and properties. This lets users modify a given component by changing predefined parameters such as height, width or number in the case of an array. In this way a family defines a geometry that is controlled by parameters, each combination of parameters can be saved as a type, and each occurrence (instance in Revit) of a type can also contain further variations.

STAAD Pro:

Modern visualization tools, a well-built analysis and design programmed with advanced finite elements and dynamic analysis capabilities are all features of STAAD Pro from model creation, analysis and design to visualization tools and result verification. STAAD Pro is frequently used for the design of multi-story buildings, factories, tunnels, bridges and other structures made of steel, concrete, aluminum and cold-framed steel. A structural engineer must gather data on loads on the structure, geometry, support conditions and material properties in order to conduct a thorough analysis. Such study often yields displacements, stresses, and support reaction data. Thereafter, this data is examined in light of the standards that point to the reasons for failure. The achievement of an acceptable probability that buildings produced will work satisfactorily during their design life is the goal of design. For the design goals to be met, there must be agreement with clearly stated standards for the construction, workmanship, materials, maintenance, and use of the building in service. The minimum requirements determine the structure's design standards recommended by the Indian standard codes. The minimal design loads that must be used to construct a structure in order to meet the minimum requirements for structural safety include dead loads, live loads and other external loads.

Augin:

The Augin application represents a dynamic leap into the world of Augmented Reality (AR), offering users a gateway to a realm where the virtual and real coalesce seamlessly. This innovative application harnesses the power of AR to enhance our daily experiences, bridging the gap between the physical and digital worlds in new and exciting ways. Whether it's enriching entertainment, revolutionizing education, or redefining how we navigate the world, Augin is at the forefront of this transformative technology. In this introduction, we'll explore the fascinating realm of the Augin application, delving into its features, significance, and the myriad ways it's poised to change the way we interact with our surroundings and information.

2. Literature Review

2.1

Details of the maskless photolithography process used to create a flip-flop lamp, mini power supply, and alarm. Results and discussion of the study, including the successful integration of BIM and AR and the potential applications in the construction industry\ Conclusion and future work, including the need for further research and development in the field of AR-BIM integration. Description of the Structure Sensor, Unity 3D, and C# software used to create the AR-BIM system. Details of the maskless photolithography process used to create the flip-flop lamp, mini power supply, and alarm. Discussion of the data collection process, including the use of surveys and interviews with construction professionals. Description of the data analysis process, including the use of statistical analysis to evaluate the results Discussion of the limitations of the study and potential areas for future research. BIM is compatible with the AR platform, opening up new possibilities for fieldwork in the construction industry. The AR-BIM system can be used as a project inspection tool, allowing engineers to inspect project sites without the need for large drawings. The AR-BIM system can be used for facility management, allowing the facility management team to easily identify inner piping without referring to complicated as-built drawings. The AR-BIM system has the potential to convey real-time maintenance information, increase the efficiency and accuracy of plans in the field, and ease collaboration between key project members when drawing up construction plans.

2.2

To develop a multi-user collaborative BIM-AR system that can support remote collaboration and improve efficiency in the construction industry. To design a user-friendly system that can facilitate real-time data sharing and collaboration among geographically dispersed teams. To integrate marker-based AR technology to recognize image targets and display 3D models with minimal latency. To test the system using a focus group session to elicit feedback from end-users and identify potential areas for improvement. To explore the potential applications of the BIM-AR system in the construction industry and identify future avenues for enhancement. The system was designed to integrate with a cloud-based database to enable real-time data sharing and collaboration among geographically dispersed teams. The system was tested using a focus group session, which involved an interactive demonstration of the system, followed by a semi-structured open forum to elicit feedback from the participants. The focus group approach was taken because it offers a fast and cost-effective way to obtain qualitative insights and feedback from practitioners. The methodology aimed to develop a functional and user-friendly system that could improve collaboration and efficiency in the construction industry. The multi-user collaborative BIM-AR system developed has the potential to improve collaboration and efficiency in the construction industry. The system was found to be user-friendly and effective in facilitating remote collaboration among geographically dispersed teams. The use of marker-based AR technology was found to be reliable and efficient in recognizing image targets and displaying 3D models with minimal latency. The focus group session revealed that the system was well-received by the participants, who provided positive feedback on its functionality and potential applications. The BIM-AR system has the potential to transform the way construction projects are designed and executed, by enabling more efficient and collaborative workflows.

2.3

Develop a proof-of-concept framework that comprehensively improves first responders' situational awareness during building fire emergencies Integrate BIM, IoT, and VR/AR technologies to develop a situation awareness system. Explore whether the training system can improve situational awareness of humans in the virtual environment. Present a review of the relevant research in these areas. The aim was to investigate whether the developed pathfinding functions can help trainees to maintain a high level of situational awareness and to study trainees' pathfinding behaviour in the simulated fire environment. Two test groups were designed: an experimental group that adopted digital pathfinding indication as visual clues, and a control group that was only provided with a paper-based floor plan indicating the location of the fire. The order of the training was randomized for each trainee to minimize possible order effects. 5. Thirty trainees were recruited from the university to participate in the tests. The paper collected data through a questionnaire that all trainees completed after the entire test was completed. The digital pathfinding indication can provide more intuitive instructions to remedy the lack of situational awareness The experimental group had smoother moving trajectories with the help of the wayfinding instructions, while the control group had much unnecessary travel after the collapsed wall blocked the corridor. Trainees with the visual clues could find the shortcut to the location of fire even if they were not familiar with the environment. The overall system performance is acceptable, and the simulation of smoke gained positive feedback because the trainees had a better understanding of how smoke affects the visibility of the surrounding environment.

2.4

Minimize fragmentation in the literature on BIM-AR platforms - Identify the key functions that represent the essential capabilities of BIM-AR platforms. Provide an evaluation framework to assist practitioners, developers, and researchers with assessing the requirements of the targeted application area. Emphasize the importance of industrial-academic collaboration in BIM-AR research. Suggest prospects for automation through the application of artificial intelligence. The authors employed a systematic approach to identify, categorize, and discuss the key functions of BIM-AR platforms. The analysis phase consisted of three steps: thematic analysis, discussion of results, and drawing conclusions. The thematic analysis involved assessing the constructed categories to demonstrate their application across lifecycle stages. The reporting phase involved presenting and discussing the results. The structure of the paper and the description of its main elements are based on the PRISMA checklist for literature reviews. The paper identifies six key functions of BIM-AR platforms: positioning (P), interaction (I), visualization (V), collaboration (C), automation (A), and integration (T).These key functions act as the foundation for an evaluation framework that can assist practitioners, developers, and researchers with assessing the requirements of the targeted application area. The paper emphasizes the importance of industrial-academic collaboration in BIM-AR research. The paper suggests prospects for automation through the application of artificial intelligence. The authors propose using PIVCAT as sections or sub-sections in future BIM-based AR research to facilitate future literature reviews and enable more guided research.

3. METHODOLOGY:

Steps for designing a mode in Revit:

1) Preliminary Layout creation:

Choose a suitable template to use, then decide on the project's units. A finite plane can be enhanced using grids or levels to help define the project's surroundings. For each known storey or other architectural reference in the building, make a level. The building's column plan is created by including the grid lines.

2) Add Fundamental Building Components:

i. Create Walls:

Go to the architecture tab, choose a wall, then select the properties toolbar, click on edit type, duplicate, and then ok. Next click on edit, specify the wall's thickness and unconnected height, and then click apply.

ii. Include doors, windows and necessary components:

The element of doors is adaptable to any kind of wall. Plan, section, elevation, and 3D views all have the option to insert doors. You can import many kinds of doors from the Autodesk Revit family. With the edit type menu, the door's attributes can be changed. To add skylights to a roof or windows to a wall, use the Windows tool. Choose the window type from the Type Picker. Modify a window's construction style, materials. dimensions, and other features. Components are typically supplied and installed on-site building items including furniture and plumbing equipment. First go to the necessary level, then choose the component for doors, windows, and other architectural features using the panel bar, select the load family option to one level, click choose the folder twice. Decide which elements are necessary. Place on the necessary area after clicking "Open".

iii. Design Roof:

Make a roof out of an extrusion or the footprint of the structure. Roofs may be designed in a variety of ways using Revit. Choose the strategy that best meets the requirements of your project design.

iv. Create Floors:

Choose Architecture. Choose the floor from the built panel, your floor level, the line From the draw panel, a value for the plinth offset, draw the line at the outer boundaries of the wall, and then choose Finish Edit Mode: Choose floor, then properties tool bar, now click on edit type, now choose duplicate, provide duplicate name, click on edit, then choose second row floor thickness, and finally click on ok and again on ok.

The adopted floor plan is shown in figure 4(a) shows the floor plan structure adopted for the building. The entire building is a G+3 construction, with the first, second, and third floors all having the identical floor plan that was created using Revit software. The ground floor is entirely reserved for parking spaces.

For the building which are under construction or didn't even started construction, we can make use of avatars which can be seen in figure 13, is a digital human element which can be sent into the building such that we can experience the real time monitoring of the building. The interiors, entrance and staircase of the building model can be seen .

Augin generates a unique QR for the BIM models developed and uploaded via Augin application. Figure shows the generated QR by Augin application.

Conclusion:

In conclusion, the integration of Augmented Reality (AR) into Building Information Modelling (BIM) construction models represents a significant leap forward in the construction industry. This project has illuminated the immense potential of AR technology in transforming the way construction professionals interact with digital models on real-world construction sites. By bridging the gap between the virtual and physical worlds, AR has not only improved the efficiency and accuracy of on-site construction tasks but has also enhanced the overall user experience. Construction professionals, including customers, owners, masons, and site engineers, now have a powerful tool at their disposal to visualize and execute construction plans more effectively. This project has underscored the importance of embracing technological advancements in the construction sector.

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