

Future Development Trends in the Application of Virtual Reality (VR) Technologies in Construction Project Management

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Abstract

In the modern world, virtual technologies have found their application in various fields of activity, including construction. Virtual construction is the use of modern virtual and augmented reality technologies to create virtual models of buildings and facilities, which allows you to simulate and analyze construction and facility management processes at various stages, from design to operation. This approach helps increase the accuracy, efficiency, and quality of projects and reduce costs and risks. This approach helps increase the accuracy, efficiency, and quality of projects and reduce costs and risks. Improving the quality of life is also an important goal. Virtual construction helps to take into account the needs and interests of all stakeholders, which contributes to the formation of a more equitable and sustainable environment.

Keywords: Virtual reality, Construction, Project, Augmented reality, Simulation

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1. Introduction

Virtual construction involves the use of various technologies to create virtual models of facilities and simulate construction and management processes at various stages of the facility's life cycle. This process may start from the creation of 3D models of objects that are correct due to the usage of special software like CAD or BIM, which enables creating accurate models of objects.

The potential for developing virtual construction is quite high. Alongside the growth of technologies and an increase in the amount of data that can be used, there will appear new ways to create more accurate models of construction works will appear. Among the most crucial directions here, one can mention enhancing visualization, i.e., developing more realistic textures and lighting, and working within virtual reality. Besides, there will also be a need for integration of virtual construction and other types of technology, especially artificial intelligence.

Also, the development of cloud technologies and the ability to work with data in real time are of enormous importance. This will improve collaboration between different teams and increase the efficiency of the construction process (isicad.ru. (n.d.)).

2. Current Applications and Impact of Virtual Construction

The created model can then be used for various purposes, such as:

- Visualization (a virtual model can be used to create a realistic representation of an object and its environment) (Ponomareva et al., 2016; Ponomareva et al., 2019; Romanov, 2022).
- Simulation (using a virtual model, various construction and operation scenarios can be simulated);
- Project management (the virtual model can be used for project management at various stages of the

object's life cycle).

The main components of virtual construction are as follows:

1. Virtual reality (VR) is a technology that allows you to create virtual 3D models of objects and environments that can be interacted with in real time.
2. Augmented reality (AR) is a technology that allows virtual objects and information to be added to the real world via a smartphone camera or other devices.
3. Object modeling is the process of creating three-dimensional models of objects to be used in virtual construction.
4. Facility management is the use of virtual models to manage construction and operation processes at various stages of a facility's life cycle.
5. Designing is the creation of virtual projects of objects using special programs and technologies such as CAD (computer-aided design) and BIM (building information modeling).
6. Training is the use of virtual models of objects to train specialists in design, engineering, project management, and other areas of construction (Romanov, 2022; Gureev & Nagovitsyn, 2025).

Virtual construction has several advantages that can help improve the construction process. Some of the main advantages are the following:

Reduction in construction costs and duration: Virtual construction allows for more accurate and detailed work during the design phase, which reduces the number of errors and shortens the time spent on eliminating them during the construction process. This can also lead to reduced waste and material losses, ultimately lowering construction costs.

Improved visualization: Virtual construction helps create a more accurate and realistic visual representation of the future facility, allowing engineers to better imagine how the facility will look in real conditions.

Improved coordination: It creates more effective collaboration and interaction between the various project participants, reducing the likelihood of errors and conflicts.

Increasing security: It helps identify potentially hazardous situations on a construction site and develop safer work methods.

Increasing accuracy: Increases the accuracy of design and cost estimation.

Increased productivity: It reduces the time required to complete tasks on a construction site and increases the efficiency of resource use. This, in turn, increases the overall productivity of the construction company (Ponomareva et al., 2019; Softprom. (n.d.)).

However, virtual construction also has a number of disadvantages:

High costs for training: Using virtual construction requires specific training and preparation, which can lead to high costs for skills updating and training.

Limited accuracy: Although it allows for the creation of highly detailed models, virtual Construction cannot completely replace real construction in many cases because there are situations where such factors as weather conditions or material reaction to loading cannot be predicted properly in the virtual world.

Fewer possibilities for change management: If something changes in the course of project implementation, there might be some extra work to do when changing the virtual model of the building under construction.

Less customer involvement: Although the concept is good as regards demonstrating various ideas, it is not always easy to transmit the atmosphere of the building.

Limited availability: Virtual construction requires special equipment and software that can be too costly for some enterprises.

Lack of interdepartmental cooperation: In the course of implementing a construction project, specialists from such areas as architecture, engineering, designing, and building participate in it, and all of them usually work with their own programs (Primenenie, opyt i perspektivy (n.d.); Gamma AR. (n.d.)).

Virtual construction may also be implemented to create models for the reconstruction of historic places, including the Colosseum in Rome, the Parthenon Temple in Athens, and the tomb of Tutankhamun. With the help of virtual construction, one can get an idea of how the buildings looked in the old days and get information about their structure and characteristics (Mordor Intelligence. (n.d.)).

New era of client interaction and AR in construction. Modern technologies of augmented reality (AR) change approaches to client interaction, providing the opportunity to use virtual constructions in order to present a project and discuss all details with the customer. AR technology makes it possible to overlay virtual images on the real world around us and create interactive 3D models of construction facilities.

Using AR, one may see the project in its real environment and make sure that everything will be built properly and in time. Moreover, in complex construction cases, it is important to provide a detailed demonstration of each element of a building.

Advantages of AR in comparison with traditional methods include better visualization and interaction opportunities. It is difficult to show the whole size of the facility or its place in the surrounding area through sketches; AR is preferable.

AR Applications by Animar Media. Animar Media has created several AR applications that show real-world examples of using AR for various purposes in construction, including educational. One of such applications includes augmented reality quest games to let users experience interactive quests (Mordor Intelligence. (n.d.); isicad.ru. (n.d.); Forum-100. (n.d.)).

Another useful tool created by Animar Media involves the visualization of repair processes. In this way, it becomes possible to let customers see how renovation works at their place. It is possible to visualize changes to the interior of the house, such as installing new windows, doors, walls, or floors. It allows interacting more effectively with customers and showing the result based on their preferences.

Using AR technology to increase sales. The usage of AR in construction allows for increasing sales and making clients more satisfied with their purchases. It is easier for clients to make decisions with the help of AR technology. AR's interactive visualizations give buyers a clear idea of the project, helping them better understand the impact of their choices on the final result. As a result, customer trust and satisfaction levels increase, brand loyalty is strengthened, and the likelihood of repeat purchases increases.

3. The Future of AR in Construction

In the future, AR is expected to further develop in the construction industry and provide more advanced solutions. Increasing the accuracy and realism of visualizations, as well as integration with technologies such as artificial intelligence and machine learning, is likely to lead to the creation of more dynamic and adaptive models. New trends may also include the use of AR to improve planning and construction processes, as well as to train and educate field professionals.

Virtual construction can also help achieve sustainable development goals in the construction industry. For example, reducing waste and minimizing environmental impact. It is possible to reduce energy consumption and greenhouse gas emissions by optimizing in the early stages of design. Improving the quality of life is also an important goal. It allows considering the interests and requirements of all stakeholders, thus helping to create a more balanced environment.

4. Conclusion

Therefore, virtual construction is an invaluable tool that will contribute to meeting different sustainable development objectives and plays a crucial role in the field of construction. All in all, the perspectives of virtual construction look very promising, and this technology can revolutionize many aspects of construction in the coming years. Hence, virtual construction is an invaluable tool for construction design at present, while it also has the potential to evolve in the future.

Augmented reality (AR) technologies are making new opportunities available in many areas, and the construction business is one of them. AR helps designers and construction businesses imagine future facilities in a real environment, while customers receive an unparalleled chance to "see" and assess a project prior to its implementation. The increasing role of AR in the construction field not only improves the efficiency of specialists but also revolutionizes the ways of interacting with clients. Construction businesses can make their presentations more vivid and effective, which makes a great contribution to the sales process of projects. AR technologies create new possibilities for construction businesses to establish more successful communication with their clients.

Author Contributions

Both authors contributed equally to this work and approved the final manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

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