VIRTUAL REALITY IN CIVIL ENGINEERING

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ABSTRACT

This chapter is about experiencing a computer generated 3D environment that allows the users/buyers a real time future experience. They can visually tour their infrastructure well in advance even before the start of construction. Conventionally as of now, we have to depend/rely on floor plans and photographs to get the imaginary sense to the property to be constructed. Overcoming this limitation, Virtual reality will allow the buyers to walk through the rooms, look and interact with the property as a real experience virtually. This level of VR immersion will make it a game changer in the field of real estate, customer experience, satisfaction and decision making. This shall promote and benefit the home buying process with a huge savings in time and money. VR tour of houses shall revolutionize in choosing the right property for the buyers.

Keywords—Virtual reality, 3D walk through, Civil Engineering

I. INTRODUCTION

3D walk through structures are a powerful tool for visualizing and communicating complex civil engineering projects. However, they can be expensive and time-consuming to create. This can make them inaccessible to smaller firms or projects with limited budgets. The high cost and time required to create 3D walk through structures for civil engineering projects can be mitigated by using a variety of methods, including:

- Using open-source or low-cost CAD software
- Using cloud-based rendering services
- Outsourcing the creation of 3D walk through structures to a third-party vendor

In addition, the following steps can be taken to improve the accessibility of 3D walk through structures for smaller firms and projects with limited budgets:

- Develop standardized templates for 3D walk through structures
- Create online tutorials and resources for creating 3D walk through structures
- Provide financial assistance to smaller firms and projects that want to create 3D walk through structures.

The specific problem that this research will address is the high cost and time required to create 3D walk through structures for civil engineering projects. This problem is significant because it limits the accessibility of 3D walk through structures to smaller firms and projects with limited budgets.

A. *Origin of the Problem*

The origin of the problem for 3D walk through of structures in civil engineering can be traced back to the early days of computer-aided design (CAD). In the early days, CAD software was very expensive and time-consuming to use. This made it difficult for smaller firms and projects with limited budgets to create 3D walk through structures. In the late 1990s, the development of open-source CAD software and cloud-based rendering services made it possible to create 3D walk through structures more affordably and efficiently. However, even

with these advances, the cost and time required to create 3D walk through structures can still be a challenge for smaller firms and projects. There are a number of factors that contribute to the high cost and time required to create 3D walk through structures, including:

- The need to create accurate and detailed models of the structures
- The need to render the models in a realistic way
- The need to create interactive and immersive experiences

As a result of these factors, 3D walk through structures can be a significant investment for smaller firms and projects. However, the benefits of using 3D walk through structures can outweigh the costs, especially for projects that require a high level of communication and collaboration between stakeholders Here are some of the benefits of using 3D walk through structures in civil engineering

- Improved communication and collaboration between stakeholders
- Reduced risk of errors and omissions
- Increased public engagement
- Enhanced marketing materials

Overall, the origin of the problem for 3D walk through of structures in civil engineering can be traced back to the high cost and time required to create these models. However, with the development of open-source CAD software and cloud-based rendering services, the cost and time required to create 3D walk through structures has decreased significantly. As a result, this technology is becoming more accessible to smaller firms and projects.

B. ***Profound Benefits of VR in Civil Engineering***

- Improved communication and collaboration between stakeholders: 3D walk throughs can help to improve communication and collaboration between stakeholders by providing a shared visualization of the project. This can help to identify potential problems and issues early on, and it can also help to ensure that everyone is on the same page.
- Reduced risk of errors and omissions: 3D walk throughs can help to reduce the risk of errors and omissions by providing a more accurate and complete visualization of the project. This can help to catch mistakes before they become costly or dangerous.
- Increased public engagement: 3D walk throughs can be used to increase public engagement with a project by giving people a chance to see what the project will look like before it is built. This can help to build support for the project and to get people excited about it.
- Enhanced marketing materials: 3D walk throughs can be used to enhance marketing materials for a project by giving potential clients a better understanding of what the project will offer. This can help to sell the project and to attract investors.
- Overall, there are many motivations to do a 3D walk through of structures in civil engineering. These models can help to improve communication, reduce risk, increase public engagement, and enhance marketing materials. As a result, they can be a valuable tool for any civil engineering project.
- Can be used to simulate the performance of a structure under different loading conditions. This can help to identify potential problems with the structure and to ensure that it is safe.

C. Beneficiaries to the Final Project:

- Project stakeholders: 3D walk throughs can help project stakeholders to visualize the project and to identify potential problems early on. This can help to improve communication and collaboration between stakeholders, and it can also help to ensure that the project is completed on time and within budget.
- The public: 3D walk throughs can be used to increase public engagement with a project by giving people a chance to see what the project will look like before it is built. This can help to build support for the project and to get people excited about it.
- Investors: 3D walk throughs can be used to enhance marketing materials for a project by giving potential clients a better understanding of what the project will offer. This can help to sell the project and to attract investors.
- End users: 3D walk throughs can be used to train operators and maintenance personnel on how to use a structure. This can help to prevent accidents and to ensure that the structure is properly maintained.

Overall, the beneficiaries of the final product in 3D walk through of structures in civil engineering are many and varied. They include project stakeholders, the public, investors, and end users. Here are some additional beneficiaries of 3D walk through structures in civil engineering:

- Government agencies: 3D walk throughs can be used by government agencies to plan and manage infrastructure projects. This can help to ensure that projects are completed on time and within budget, and it can also help to improve the safety and efficiency of infrastructure systems.

- Researchers: 3D walk throughs can be used by researchers to study the behavior of structures under different loading conditions. This can help to improve the design and construction of structures, and it can also help to ensure that structures are safe.
- Educators: 3D walk throughs can be used by educators to teach students about civil engineering concepts. This can help to make learning more engaging and interactive, and it can also help students to better understand the principles of civil engineering.

II. CASE STUDIES

A. ***The Burj Khalifa in Dubai:***

The Burj Khalifa is the tallest building in the world, and it was designed using 3D walk through technology. This technology allowed the engineers to visualize the building and to identify potential problems early on. As a result, the Burj Khalifa was completed on time and within budget.

B. ***The London Eye:***

The London Eye is a giant Ferris wheel in London, and it was also designed using 3D walk through technology. This technology allowed the engineers to visualize the wheel and to ensure that it was safe and efficient. As a result, the London Eye has been a popular tourist attraction since it opened in 2000.

C. ***The Channel Tunnel:***

The Channel Tunnel is a tunnel that connects England and France, and it was also designed using 3D walk through technology. This technology allowed the engineers to visualize the tunnel and to ensure that it was safe and efficient. As a result, the Channel Tunnel has been a vital transportation link since it opened in 1994.

D. ***The Three Gorges Dam:***

The Three Gorges Dam is a hydroelectric dam in China, and it is the largest dam in the world. The dam was designed using 3D walk through technology, and this technology helped to ensure that the dam was safe and efficient. As a result, the Three Gorges Dam has been a major source of hydroelectric power for China since it was completed in 2006.

III. STATE OF THE ART

A. ***Literature Survey***

- **Application of Virtual Reality in Civil Engineering"** by **M. A. Khan, M. B. Khan, and M. A. Khan (2018)**. This paper provides a comprehensive overview of the use of virtual reality in civil engineering. The paper discusses the benefits of using virtual reality for civil engineering projects, and it also discusses the challenges of using this technology.
- **"3D Visualization for Construction Engineering and Management" by S. M. A. Hossain, J. J. Kim, and J. M. Ko (2016)**. This paper focuses on the use of 3D visualization for construction engineering and management. The paper discusses the benefits of using 3D visualization for these purposes, and it also discusses the challenges of using this technology.
- **"The Use of 3D Virtual Reality in Civil Engineering Education"** by **A. M. Abdelgader and I. S. Al-Sharif (2015)**. This paper discusses the use of 3D virtual reality in civil engineering education. The paper discusses the benefits of using this technology for education, and it also discusses the challenges of using this technology.

Virtual reality (VR) is a technology that has the potential to revolutionize the field of civil engineering. By creating immersive and interactive simulations of real-world environments, VR can help civil engineers to design, plan, and construct projects more effectively. There is a growing body of literature on the use of VR in civil engineering. Some of the key areas where VR is being used include:

- Design and planning: VR can be used to create realistic models of civil engineering projects, which can help civil engineers to visualize the project and identify potential problems. VR can also be used to simulate the operation of civil engineering projects, which can help civil engineers to optimize the design and operation of the project.
- Training: VR can be used to create realistic simulations of civil engineering tasks, which can be used to train workers on how to perform those tasks. This can help to improve the safety and efficiency of civil engineering operations.
- Education: VR can be used to create immersive educational experiences that can help students to understand the principles of civil engineering. This can help to attract more students to the field and improve the quality of civil engineering education.
- Communication: VR can be used to communicate complex civil engineering concepts to stakeholders. This can help to improve the understanding of civil engineering projects and to get buy-in from stakeholders.

The use of VR in civil engineering is still in its early stages, but the potential benefits are significant. As the technology continues to develop, we can expect to see even more innovative applications of VR in the field of civil engineering. Here are some of the key benefits of using VR in civil engineering:

- Improved safety: VR can be used to create realistic simulations of dangerous or hazardous environments, which can help civil engineers to identify and mitigate risks.
- Increased efficiency: VR can be used to streamline the design, planning, and construction of civil engineering projects. This can lead to time and cost savings.
- Enhanced communication: VR can be used to communicate complex civil engineering concepts to stakeholders in a more effective way. This can help to improve understanding and to get buy-in from stakeholders.
- Improved training: VR can be used to create realistic simulations of civil engineering tasks, which can help to train workers on how to perform those tasks. This can help to improve safety and efficiency.

Here are some of the challenges of using VR in civil engineering:

- Cost: VR is still a relatively new technology, so the cost of VR headsets and software can be prohibitive.
- Acceptance: VR is still a relatively new technology, so there may be some resistance to its adoption by civil engineers.
- Technical limitations: The current generation of VR headsets is not perfect, and there are some technical limitations that need to be addressed.

Overall, the use of VR in civil engineering has the potential to revolutionize the field. By addressing the challenges and exploiting the benefits, VR can help civil engineers to design, plan, and construct projects more effectively, train workers more efficiently, and communicate with stakeholders more effectively.

B. *State of the Art*

Here are some of the most cited papers on the use of VR in civil engineering:

- Virtual Reality in Civil Engineering: A Review by **Wang et al. (2018)**
- The Potential of Virtual Reality for Training in Civil Engineering by **Jeelani et al. (2020)**
- Extended Reality (XR) for Condition Assessment of Civil Engineering Structures by **Al-Hussein et al. (2022)**
- Virtual Reality for Civil Engineering Education and Training: A Systematic Review by **Kandi et al. (2021)**
- Virtual Reality for Construction Safety Training: A Systematic Review by **Le et al. (2015)**

These papers provide a good overview of the current state of the art in the use of VR in civil engineering.

IV. FUNCTIONAL AND NON FUNCTIONAL REQUIREMENTS

A. *Functional Requirements:*

- Improved communication and collaboration: 3D walk through models can be used to improve communication and collaboration between stakeholders involved in a civil engineering project. This is because 3D walk through models can be used to visualize the project in a way that is easy to understand. This can help to identify potential problems early on and to ensure that everyone is on the same page.
- Reduced risk of errors and omissions: 3D walk through models can help to reduce the risk of errors and omissions in civil engineering projects. This is because 3D walk through models can be used to verify the accuracy of the project plans. This can help to prevent costly mistakes from being made during construction.
- Increased public engagement: 3D walk through models can be used to increase public engagement in civil engineering projects. This is because 3D walk through models can be used to give people a virtual tour of the project. This can help to build support for the project and to get people involved in the planning process.
- Enhanced marketing materials: 3D walk through models can be used to enhance marketing materials for civil engineering projects. This is because 3D walk through models can be used to create realistic and engaging images of the project. This can help to attract potential investors and clients.
- Can be used to simulate the performance of a structure under different loading conditions: 3D walk through models can be used to simulate the performance of a structure under different loading conditions. This can help to identify potential weaknesses in the structure and to ensure that it is safe.

- Can be used to train operators and maintenance personnel on how to use a structure: 3D walk through models can be used to train operators and maintenance personnel on how to use a structure. This can help to ensure that the structure is operated and maintained properly.
- Can be used to create marketing materials that showcase a project's features and benefits: 3D walk through models can be used to create marketing materials that showcase a project's features and benefits. This can help to attract potential investors and clients.

B. Non Functional Requirements:

- Accuracy: The 3D walk through model must be accurate and realistic. This means that the model must accurately represent the structure's geometry, materials, and appearance.
- Usability: The 3D walk through model must be easy to use. This means that the user must be able to navigate the model easily and interact with it in a intuitive way.
- Performance: The 3D walk through model must be able to run smoothly on a variety of devices. This means that the model must be optimized for performance and that it must not be too demanding on the user's hardware.
- Accessibility: The 3D walk through model must be accessible to people with disabilities. This means that the model must be compatible with assistive technologies and that it must be easy to navigate for people with visual or mobility impairments.
- Scalability: The 3D walk through model must be scalable. This means that the model must be able to be used for different types of projects and that it must be able to be easily updated. These are just some of the non-functional requirements for 3D walk through of structures in civil engineering. The specific requirements will vary depending on the specific project. However, these requirements are important to consider when creating 3D walk through models.

Here are some additional non-functional requirements that may be relevant for 3D walk through of structures in civil engineering:

- Security: The 3D walk through model must be secure. This means that the model must be protected from unauthorized access and that it must not be susceptible to hacking.
- Licensing: The 3D walk through model must be licensed appropriately. This means that the user must have the right to use the model and that the model must not be used in a way that violates the terms of the license.
- Maintenance: The 3D walk through model must be maintained. This means that the model must be updated regularly to ensure that it is accurate and that it is compatible with new hardware and software.

C. Hardware Requirements:

- CPU: A powerful CPU is required to render the 3D walk through model. A minimum of an Intel Core i5 or equivalent is recommended.
- GPU: A dedicated GPU is required for optimal performance. A minimum of a NVIDIA GeForce GTX 1060 or equivalent is recommended.
- RAM: 16GB of RAM is recommended for 3D walk through models.
- Storage: A minimum of 500GB of storage is recommended for 3D walk through models.
- Display: A high-resolution display is recommended for viewing 3D walk through models. A minimum of 1920x1080 resolution is recommended.

In addition to the above hardware requirements, the following software may also be required:

- 3D modeling software: 3D modeling software is used to create the 3D walk through model. Some popular 3D modeling software options include Autodesk 3ds Max, Blender, and Maya.
- Game engine software: Game engine software is used to create the 3D walk through experience. Some popular game engine software options include Unity and Unreal Engine.

The specific hardware and software requirements will vary depending on the specific project. However, the above recommendations provide a good starting point for determining the requirements for your project. Here are some additional tips for choosing hardware for 3D walk through of structures in civil engineering:

- Consider the size and complexity of the 3D walk through model. The more complex the model, the more powerful the hardware will need to be.
- Consider the number of users who will be accessing the 3D walk through model. If multiple users will be accessing the model simultaneously, you will need to choose hardware that can handle the load.
- Consider the budget for the project. 3D walk through models can be expensive to create, so you will need to choose hardware that fits within your budget.

D. Software Requirements :

The software requirements for 3D walk through of structures in civil engineering will vary depending on the specific project. However, some general software requirements include: 3D modeling software: 3D modeling software is used to create the 3D walk through model. Some popular 3D modeling software options include:

- Autodesk 3ds Max
- Blender
- Maya

Game engine software: Game engine software is used to create the 3D walk through experience. Some popular game engine software options include:

- Unity
- Unreal Engine

3D rendering software: 3D rendering software is used to create the final images or videos of the 3D walk through model. Some popular 3D rendering software options include:

- V-Ray
- Octane Render
- Arnold

In addition to the above software requirements, the following may also be required:

3D scanning software: 3D scanning software is used to create 3D models from real-world objects. Some popular 3D scanning software options include:

- FARO Focus
- Creaform Handy Scan 3D
- Artec Eva

Image editing software: Image editing software is used to edit and enhance the images or videos of the 3D walk through model. Some popular image editing software options include:

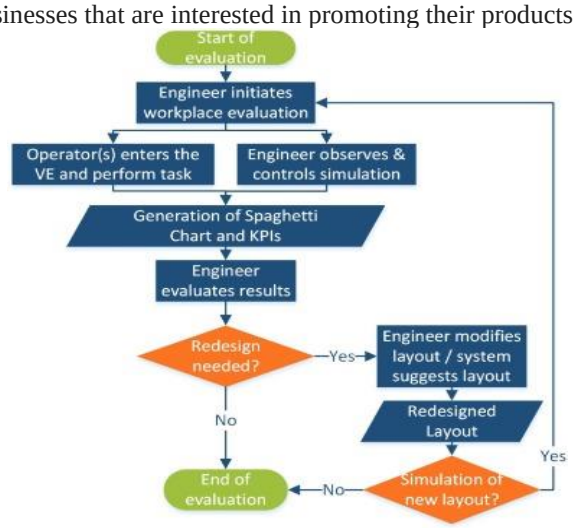
- Adobe Photoshop
- GIMP
- Paint.NET

The specific software requirements will vary depending on the specific project. However, the above recommendations provide a good starting point for determining the

V. BUSINESS MODEL

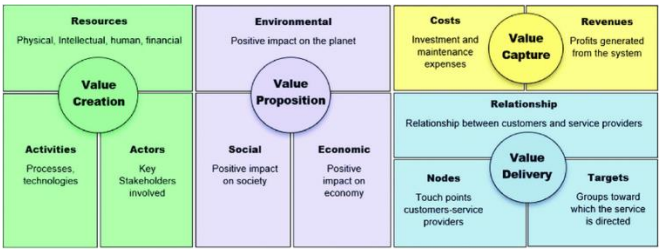
A. *Business Model Devolopment:*

- **Direct sales**: You can sell 3D walk through models directly to clients. This could be done on a one-off basis or through a subscription service.
- **White labelling**: You can white label your 3D walk through models and sell them to other businesses. This could be a good way to reach a larger audience and generate recurring revenue.
- **SaaS**: You can create a software as a service (SaaS) platform that allows users to create and share 3D walk through models. This could be a good way to generate recurring revenue and build a community of users.
- **Advertising**: You can generate revenue by advertising on your 3D walk through models. This could be done through text, images, or videos.
- **Sponsorships**: You can generate revenue by selling sponsorships for your 3D walk through models. This could be done to businesses that are interested in promoting their products or services.



The best business model for you will depend on your specific goals and resources. If you are just starting out, you may want to consider a direct sales model or white labelling. If you have more resources, you could consider creating a SaaS platform or generating revenue through advertising or sponsorships.

B. *Business Model Canvas:*



Customer Segments

- Businesses: Businesses that are involved in civil engineering projects, such as construction companies, architects, and engineers.
- Individuals: Individuals who are interested in learning more about civil engineering projects or who want to experience a 3D walk through of a structure for fun.

Value Proposition

- Provides a realistic and immersive way to experience a structure.
- Allows users to interact with the structure in a way that is not possible in real life.
- Can be used for a variety of purposes, such as planning, marketing, and training.

Channels

- Direct sales: Sell 3D walk through models directly to clients.
- White labelling: White label 3D walk through models and sell them to other businesses.
- SaaS platform: Create a software as a service (SaaS) platform that allows users to create and share 3D walk through models.
- Advertising: Generate revenue by advertising on 3D walk through models.
- Sponsorships: Generate revenue by selling sponsorships for 3D walk through models.

Customer Relationships

- Personalized: Provide personalized customer service to clients.
- Community: Build a community of users who can share and collaborate on 3D walk through models.

Revenue Streams

- One-off sales: Sell 3D walk through models on a one-off basis.
- Subscription fees: Charge a subscription fee for access to 3D walk through models.
- Advertising revenue: Generate revenue by advertising on 3D walk through models.
- Sponsorship revenue: Generate revenue by selling sponsorships for 3D walk through models.

Key Activities

- Create 3D walk through models.
- Market and sell 3D walk through models.
- Provide customer support.

Key Resources

- 3D modeling software.
- Game engine software.
- 3D rendering software.
- Marketing and sales expertise.
- Customer support expertise.

Key Partnerships

- Partner with businesses that are involved in civil engineering projects.
- Partner with businesses that offer 3D scanning or image editing services.
- Partner with businesses that offer advertising or sponsorship opportunities.

Cost Structure

- Cost of creating 3D walk through models.
- Cost of marketing and selling 3D walk through models.

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