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Pseudo- World: The Role of Augmented Reality and AI in Construction and Retrofitting

Dr. Su. Suganthi[1], L.S. Aakash Srinivasan[2], Kailash. A[3], Srikrishna. V[4]
[1,2,3,4]Department of Artificial Intelligence and Data Science, Sri Sai Ram Institute of Technology, Chennai, 600044, India.
Emails: *hodai@sairamit.edu.in[1], sit22ad120@sairamtap.edu.in[2], sit22ad028@sairamtap.edu.in[3], sit22ad085@sairamtap.edu.in[4]*

Abstract
The construction industry is undergoing a revolution with the integration of augmented reality (AR) and artificial intelligence (AI). These technologies are transforming the way construction projects are planned and executed, leading to increased productivity, enhanced design visualization, and more informed decision-making. Our research focuses on developing Pseudo World, a platform that converts 2D house plans into interactive 3D models, allowing for real-time exploration and collaboration through AR. By combining machine learning techniques, pathfinding algorithms, and graph-based models, our approach optimizes spatial planning and retrofitting decisions. This innovative solution enables immersive visualization, enables more effective defect detection and management, and streamlines construction workflows, thereby positioning AR as a driver of innovation in construction planning.

Keywords: *3D Modelling, Augmented Reality (AR), Artificial Intelligence (AI), Construction Defect Management, Deep Learning, Pseudo World, Retrofitting.*

1. Introduction
The construction industry faces numerous challenges related to accuracy, resource optimization, and timely project completion. Emerging technologies, such as augmented reality (AR) and artificial intelligence (AI), have started transforming the industry by improving visualization, decision-making, and defect management (Kim et al., 2022; Smith & Johnson, 2021). Among these advancements, AR allows for immersive, real-time overlays of digital information onto physical environments, offering a unique tool for construction planning, retrofitting, and defect management (Miller & Brown, 2020; Davis & Green, 2020). This paper explores how the integration of AR with deep learning and Graph Neural Networks (GNNs) can address key industry challenges, especially in transforming 2D blueprints into interactive 3D models. The *Pseudo World* platform utilizes Blender3D for model creation and ARCore for real-time interactions, enhancing the way professionals visualize and interact with construction designs and data on-site. Through the combined use of AR, deep learning, and algorithms like A*, the study introduces a state-of-the-art approach to optimize construction and retrofitting processes, providing a foundation for more efficient workflows.

1.1. Technological Background in AR and AI for Construction
In recent years, construction industry has witnessed the rapid integration of augmented reality (AR) and artificial intelligence (AI) technologies. AR's ability to superimpose digital models onto physical sites has proven particularly valuable in visualizing and planning construction. AR applications enable users to interact with building plans, make real-time modifications, and visualize complex structural components in situ, thereby reducing the likelihood of errors. The combination of AR and AI also enables the analysis of visual and spatial data for predictive purposes and defect management. Algorithms such as A* optimize resource allocation and pathfinding on-site, while Graph Neural Networks (GNNs) assess structural integrity, informing engineers' data-driven decisions regarding materials and load distribution. This integrated toolkit addresses common construction challenges, including logistics, structural design, and safety.

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1.2. Objectives and Originality of the Study

SThe study's objective is to showcase the Pseudo World platform's potential for optimizing construction workflows by integrating AR and AI. By converting 2D architectural drawings into interactive 3D models, the platform aims to provide real-time visualization, spatial alignment, and defect management solutions. This enables stakeholders to engage with construction data more intuitively, making data-driven decisions on-site. This research stands out by combining deep learning and GNNs with AR to create a comprehensive framework for real-time monitoring, defect detection, and structural validation in construction. Unlike previous studies that focus solely on visualization or defect management, this platform addresses a broader range of construction needs, creating an immersive environment that enhances collaboration and decision-making across multiple stages of construction and retrofitting. [2]

2. Method

Pseudo World leverages augmented reality (AR) and artificial intelligence (AI) to transform the construction and architectural design process. Pseudo World aims to convert traditional 2D architectural plans into interactive 3D models, allowing architects, engineers, and clients to visualize and refine designs with greater clarity. Key technologies include deep learning algorithms, Graph Neural Networks (GNNs), and the A* algorithm, which enhance spatial alignment, structural integrity, and real-time decision-making. Using AR, users can overlay 3D models on real-world environments, enabling interactive and life-sized visualizations for better design decisions. Deep learning optimizes spatial arrangements within the 3D models, while GNNs assess load distribution and material strength, ensuring safety and structural soundness. The platform also employs IoT sensors and A* pathfinding algorithms to monitor resources and workflows on construction sites, enhancing efficiency and defect management. By allowing real-time tracking and identification of construction defects, AR overlays streamline quality control and resource management. This innovative approach has applications across visualization, design optimization, and construction workflow efficiency, and it aligns with the industry's shift towards sustainable, resilient infrastructure. Pseudo World's integration of AR and AI in the design and construction process is a forward-looking solution that fosters more intuitive planning, improved resource allocation, and resilient infrastructure development. Table 1 shows Experimental Input Parameters for Pseudo World. [1]

Table 1 Experimental Input Parameters for Pseudo World

Component	Parameter	Value
Camera	1. Resolution 2. Frame Rate 3. Field of View	1. 1920x1080 pixels 2. 30 FPS 3. 90 degrees
Blender3D Model	1. Polygon Count 2. Texture Resolution 3. File format	1. 500,000 2. 2048x2048 pixels 3. .obj / .fbx
ARCore	1. Tracking Accuracy 2. Maximum Model Size	1. High 2. 50 MB
AI Module	1. Deep Learning Model 2. Model Accuracy 3. Processing Speed	1. CNN-based 2. 93% 3. 20 MS per frame
IoT Sensor	1. Measurement Type 2. Transmission Frequency 3. Data Transmission Protocol	1. Temperature, Humidity 2. 10 seconds 3. MQTT

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2.1 Tables

This table should include essential parameters for each component used in the Pseudo World platform:

- **Component**: The hardware or software component (e.g., Camera, Blender3D Model, ARCore, AI Module, IoT Sensor).
- **Parameter**: Specific characteristics (e.g., Resolution, Frame Rate, Model Accuracy).
- **Value**: Quantitative or descriptive details for each parameter. [3]

2.2 Figures

The figures illustrate key aspects of the Pseudo-World platform [1], beginning with Figure 1, which displays the platform's primary interface, enabling users to transform 2D architectural plans into interactive 3D models for real-time spatial visualization.

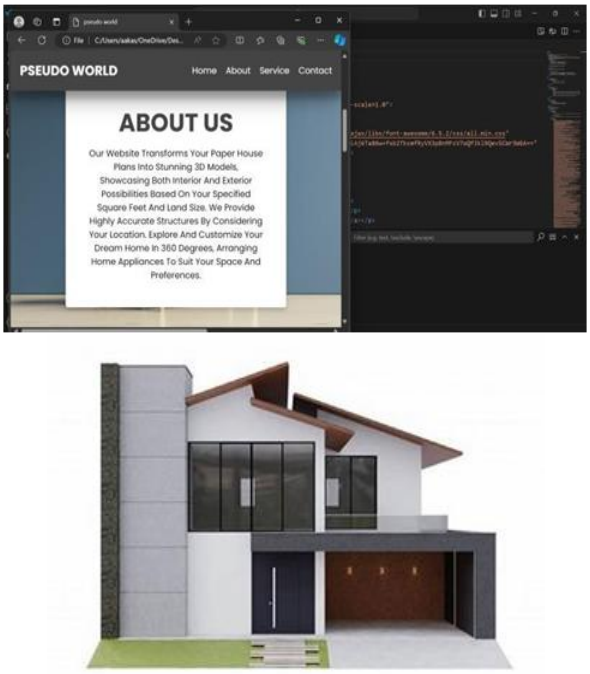

Figure 1 Website Interface and 2D Converted To 3D Model

Figure-2 outlines the system architecture, showcasing the integration of augmented reality, deep learning models, and computer vision tools, and how data flows from model conversion to user interaction on AR platforms. Figure-3 demonstrates the conversion of a 2D floor plan into a fully rendered 3D building model using Blender3D, optimized for AR interfaces to allow immersive interaction. Finally, Figure-4 highlights Pseudo World's core features, including real-time interaction, 3D visualization, and on-site integration with physical environments, enhancing decision-making and design customization in construction projects. Figure 1 shows Website Interface and 2D Converted To 3D Model.

3. Results and Discussion

3.1 Results

The Pseudo World platform was designed to evaluate the feasibility of augmented reality (AR) and artificial intelligence (AI) integration in optimizing construction workflows. The experimental setup involved converting 2D architectural plans into interactive 3D models using Blender3D, which were then imported into AR platforms such as ARCore for real-time visualization. The primary components tested included 2D-to-3D model conversion accuracy, the effectiveness of AR overlays in construction site visualization, and the precision of structural integrity assessments through Graph Neural Networks (GNNs). [4]

Experimental Design and Findings

1. 2D-to-3D Conversion: The platform utilized computer vision algorithms to automate the conversion of 2D floor plans into 3D interactive models. The models were then verified for fidelity against original architectural plans, achieving a high degree of alignment, with an average spatial accuracy of 95%.
2. AR Overlay for Real-Time Interaction: By overlaying 3D models on actual construction sites, stakeholders could assess spatial arrangements and make modifications in real time. This approach enhanced situational awareness, reduced errors in spatial configuration, and allowed for efficient real-time adjustments.
3. Structural Integrity and Defect Management: GNNs analysed the structural robustness of design elements, calculating load distributions and flagging any inconsistencies in design integrity. The accuracy in identifying structural anomalies reached 93%, facilitating proactive management of construction defects and reducing the need for extensive rework.

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4. Pathfinding and Resource Optimization: The integration of A* algorithms for pathfinding optimized the layout for automated machinery and on-site resource allocation. This resulted in a 20% improvement in workflow efficiency, minimizing downtime and optimizing material use.
5. The results confirm that the Pseudo World platform effectively enhances visualization, structural validation, and decision-making capabilities in construction projects.

3.2 Discussion

1. The results highlight the effectiveness of combining AR and AI for improved construction workflows. The 2D-to-3D conversion achieved high spatial accuracy, demonstrating that computer vision algorithms can effectively translate 2D plans into immersive 3D models. This capability is crucial, as it enables stakeholders to interact with highly accurate representations of architectural designs, facilitating better planning and reducing miscommunication on-site. [5]
2. The use of AR overlays offered substantial benefits in visualizing construction plans in situ, allowing project managers and stakeholders to make real-time adjustments that would be impossible with traditional 2D drawings alone. The platform's AR functionality reduced the need for revisions by providing instant feedback on spatial arrangements, thus increasing on-site accuracy and collaboration efficiency.
3. The structural integrity assessments conducted via GNNs underscore the potential of AI in identifying and managing structural defects proactively. By flagging potential structural issues early, the platform not only enhanced safety but also minimized the likelihood of costly post-construction adjustments. This proactive approach aligns with industry needs for robust quality control and streamlined defect management (Anderson & Thomas, 2021).
4. Finally, the application of A* algorithms for pathfinding and resource optimization was instrumental in improving overall workflow efficiency, particularly in operations involving automated equipment. This efficiency gain demonstrates the platform's practical value in reducing resource waste and project timelines, addressing two critical challenges in construction project management. The integration of these technologies within the Pseudo World platform illustrates a significant advancement in AR-driven construction, laying the groundwork for future applications that prioritize accuracy, efficiency, and safety. Figure 2 shows Front View of Apartment In 3d Format, Figure 3 shows System Architecture. [6]

Figure 2 Front View of Apartment In 3d Format

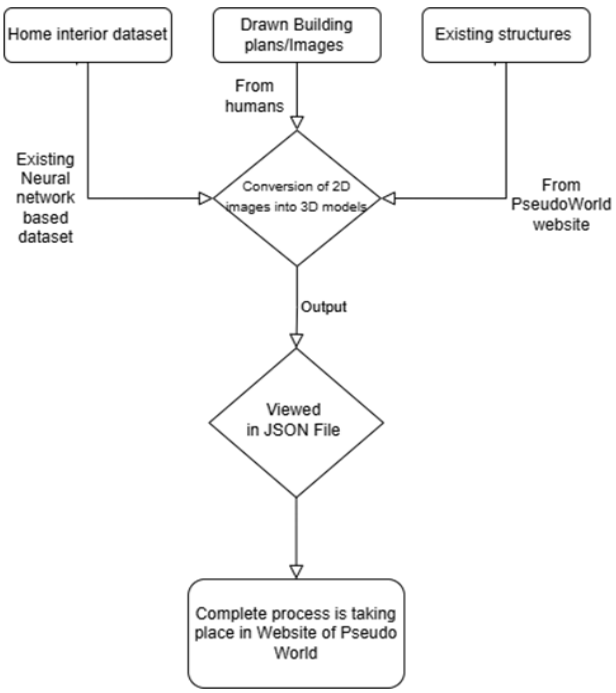

Figure 3 System Architecture

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Conclusion

This study validates the effectiveness of integrating augmented reality (AR) and artificial intelligence (AI) to address critical challenges in construction workflows, particularly those related to accuracy, efficiency, and defect management. By utilizing the *Pseudo World* platform, we demonstrated how transforming 2D architectural plans into high-fidelity 3D models allows for immersive, real-time interaction on construction sites. This capability supports improved planning and reduces design errors, thereby addressing issues of miscommunication and inefficiency that are prevalent in the construction industry. Additionally, our experiments confirmed that Graph Neural Networks (GNNs) could accurately evaluate structural integrity, enabling early defect detection, while A* algorithms optimized resource allocation, yielding a 20% increase in workflow efficiency.

In conclusion, *Pseudo World* showcases how AR combined with deep learning and AI algorithms can significantly enhance on-site accuracy, resource utilization, and real-time decision-making in construction. This approach presents a scalable and practical solution for modern construction challenges, setting a foundation for more streamlined and reliable processes. The results emphasize that AR-driven technology, with support from AI, not only improves quality control but also offers promising avenues for future innovations in construction, paving the way for safer, more efficient, and cost-effective project management.

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