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Challenges Faced During Implementation of Digital Twin in Construction Project Monitoring

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Abstract: *Digital Twins (DTs) are gaining popularity because they provide precise digital copies of assets, processes, and systems. This is especially true when these DTs are paired with real-time simulation models that make use of modern technologies like machine learning, artificial intelligence, and data analytics. These combinations can provide a comprehensive and dynamic view of the monitored systems. Digital twin (DT) has shown tremendous potential to bring about revolutionary improvements in the field of construction site surveillance. There is, however, a notable paucity of empirical research identifying the constant elements affecting DT adoption in this industry. This research tries to fill that void by identifying the important elements that determine the usage of DT in construction. The study adopts a complete framework with the goal of increasing the use of DT in building site monitoring. The elements influencing the adoption and effectiveness of distributed ledger technology (DT) are divided into three categories: technological, organizational, and economic. Technological factors include the system's appropriateness and the robustness of the data infrastructure. Organizational considerations include the company's openness to innovation and leadership support. Economic aspects include things like return on investment (ROI) and cost-effectiveness. The research technique combines case studies and literature reviews to examine the benefits and drawbacks of DT in construction monitoring. This study's expected output is a comprehensive framework that aids construction businesses in optimizing the use of DT in site monitoring. This would allow for more efficient, data-driven, and forward-thinking processes. The study's ultimate purpose is to provide critical knowledge that will assist the building sector in adopting cutting-edge methods. The industry may better plan for the integration of this sophisticated technology into their operations by knowing the potential of DT and the variables driving its adoption. This, in turn, can lead to more efficiency, lower risks, and improved overall performance.*

Keywords: digital twin, site monitoring, adoption, ROI, monitoring

I. INTRODUCTION

(Lei,2020) suggests Digital Twins (DT) can improve construction safety through autonomous job synchronization. However, obstacles emerge as a result of dynamic operations, immature information processing, insufficient synchronization methods, costly sensors, threat mapping difficulties, and incorrect safety information distribution. Future research should look at SLAM technology, ontology, and the psychological impacts of warnings. (Mahmoud, 2020) investigate the origins, applications, and impact of the Digital Twin in manufacturing, logistics, and construction. They suggest a framework for its application, emphasizing its potential to improve goods, designs, and manufacturing while lowering logistics risks. In the growing Industry 4.0, the report emphasizes the importance of data flow integration and the deployment of new technologies such as Digital Twin. (De-Graft Joe Opoku, 2022) evaluated58 research on Digital Twin (DT) adoption in the construction industry were reviewed, demonstrating interest from both developed and developing nations. They found 50 drivers for DT adoption, which they classified as concept-oriented, operational success-driven, production-driven, and preservation-driven. This framework facilitates DT deployment and helps to understand DT uptake.(Tareq Salem, 2022)Investigate the potential of Digital Twin in building project

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management, concluding that its usefulness extends beyond the original economic domains. They propose a three-stage implementation strategy, with the current paradigm serving as Stage 2. According to the study, Digital Twins can improve construction planning and decision-making.(Rafael Sacks, 2020) Investigate the potential of Digital Twin in building project management, concluding that its usefulness extends beyond the original economic domains. They propose a three-stage implementation strategy, with the current paradigm serving as Stage 2. According to the study, Digital Twins can improve construction planning and decision-making. (Ashtarout Ammar, 2022) Define the Digital Twin of a construction project, highlighting its applications and issues through interviews and thematic analysis. They identify seven competencies and 34 implementation issues, emphasizing the importance of better data comprehension. According to the study, future research should concentrate on these difficulties and prototype development. (Maulshree, 2021) discusses the increasing use of Digital Twins (DT) in many industries, highlighting their potential benefits and the significance of understanding their properties before investing.

II. LITERATURE REVIEW

(Lei, 2020) suggest that Digital Twins (DT) can enhance construction safety by synchronizing building tasks, but face challenges due to dynamic operations and immature information processing. Issues include inadequate synchronization methods, expensive sensors for variable environments, threat mapping difficulties, limited information processing, and flawed safety information delivery procedures. Future research should explore SLAM technology for dynamic synchronization, ontology for connection modelling, and the impact of warnings on worker behaviour through cognitive processes. **(**Rafael Sacks, 2020) discuss the accumulation of as-designed and as-planned information during construction, generating product and process information. They assign version identifiers to Project Intent Information (PII) and Knowledge (PIK), describing the project's as-built and as-performed states. The study emphasizes data standardization in data-centric building for dataset integrity and compatibility. It highlights the importance of the Data-Centric Engineering (DTC) workflow, including Design and Plan activities, and the use of specialized software for performance prediction. (Haibo feng, 2021) analyse 23 publications on digital twin technologies in construction, focusing on development steps and case studies. They highlight key processes: data acquisition, transmission, modelling, integration, and servicing. The potential of digital twins to enhance decision-making is emphasized, but challenges in data integration and security are identified. The study underscores the need for skilled personnel, adequate funding, and advanced technologies for successful digital twin development. (Nikita,2021)present digital twins as a novel quality management strategy for real-time monitoring, modeling, and optimization of complex systems. They categorize digital twins based on their representation: product, production, or process. Development of digital twins necessitates modern tools like SysML, AnyLogic, MES systems, big data, and AI. Digital twins contribute to economic and environmental benefits by reducing costs, enhancing efficiency, improving product quality, and promoting sustainability.(Angira Sharma, 2022) analyze Digital Twins (DT), identifying key components, features, and limitations. They highlight barriers to DT adoption, including rapid technology evolution, lack of a universal framework, domain dependence, security issues, absence of performance metrics, and reliance on other emerging technologies. Advancements in Machine Learning, IoT, and big data have enhanced DT capabilities like real-time monitoring and accurate forecasting. Despite this, research and operational limitations hinder wider DT adoption. The paper defines DT, demonstrates its uniqueness, presents case studies, and poses critical research questions. (Ashtarout Ammar, 2022) define a construction project's Digital Twin and explore its use and challenges through interviews with practitioners. They identify 40 applications, classified into seven capabilities, with Improved Information Transparency and Real-Time Monitoring being most discussed. The study includes a case study on integrating building authority into Digital Twins. They highlight 34 implementation problems, with Data Understanding, Preparation, and Usage as key issues, and suggest future research to assess Digital Twin benefits in constructionpropose a framework integrating Digital Twin and blockchain technology for building cooperation. (De-Graft Joe Opoku, 2022) evaluated 58 studies, revealing key drivers for Digital Twin (DT) adoption in construction. Interest is growing globally, with significant contributions from both developed and emerging countries. The study identified 50 drivers, categorized into concept-oriented, operational success, production-driven, and preservation-driven drivers. This framework guides successful DT deployment in construction, enhancing the understanding of DT adoption drivers, crucial for promoting DT in the industry. (Galyna Ryzhakova, 2022) suggest developing an information system model for creating digital twins in

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construction projects. This model would enable monitoring of changes, evolution, and modifications of calculation models, components, and options. It would also establish a clear connection between calculation options and their respective results. (Jiaying Zhang, 2022) study presents a framework for construction site management using digital twins and enhanced building information modelling (BIM). Validated by questionnaires and interviews, the framework addresses data management, project information, technical information, data cooperation, exchange, security, and privacy. It emphasizes process integration, collaboration, proper BIM training, and early planning as crucial for improving construction productivity, efficiency, and cost-effectiveness.(Milad, 2022) highlight key research topics, trends, gaps, and challenges in the field, along with significant publications, authors, countries, organizations, and funders. The study suggests future research directions, including the integration of BIM with Metaverse technology, AI, Metaheuristic algorithms for optimization, and the Circular Economy using IoT. (Obinna C. Madubuike, 2022) highlight the potential of Digital Twin technology in construction for facility design, building, operation, and maintenance. Despite its limited deployment in construction compared to other industries, it offers real-time data collection for asset monitoring, operation optimization, and life cycle forecasting. The study emphasizes the need for collaboration and the adoption of smart technologies like BIM, augmented reality, AI, machine learning, data analytics, and sensors. Future research could focus on tracking building progress, worker performance, and healthcare facility management. (Tareq Salem, 2022) explore the potential of integrating Digital Twin technology into building project management. They conclude from previous studies that this concept has significant applicability beyond its original domains. The paper proposes a three-stage approach for implementing Digital Twins in construction, with the current model serving as Stage 2. The findings suggest that Digital Twins can enhance construction project planning and decision-making processes. (Varun Kumar Reja, 2022) describesPMI-PMBOK framework outlines Digital Twin's potential in construction project management. Digital Twin, a high-fidelity digital counterpart of a real object, can enhance project efficiency, reduce costs, expedite approvals, and increase client satisfaction. It can automate and accelerate traditional procedures in building projects. The study explores its applications in planning, control, safety, quality, resource, procurement management, and execution. As technology advances, creating digital twins becomes more cost-effective, making them a popular tool for project management and planning. **(**Keyu, 2022)explore construction constraint management, proposing potential elements for a digital twin-based framework. The paper categorizes these elements into information technology, swarm intelligence and genetic algorithms, semantic web, and lean-based methodologies. Each category contributes to constraint modelling, analysis, monitoring, and elimination in different domains. The paper emphasizes the need for further research to elaborate on the digital twin-based structure and evaluate its effectiveness in the construction industry.(E.X. Cao, 2023) paper proposes a framework for using Digital Twin (DT) technology in design and construction phases of building projects, based on literature review, interviews, and a case study. The study shows the framework's potential to enhance safety, efficiency, quality, and environmental management in construction projects. It acknowledges limitations in case study generalizability and respondent selection and suggests future research to address these concerns. (De-Graft Joe Opoku, 2023) identified 50 drivers that were categorized into four major groups: concept-oriented drivers, operational success drivers, production-driven drivers, and preservation-driven drivers. The extensive content analysis of these driver categories gives useful information for the successful implementation of DT in the construction industry. (Dongmin Lee, 2023) The system design demonstrates data transaction flow and traceability. A simulated robotic building project illustrates the framework's operation. A dashboard logs data transactions, enhancing transparency and accountability. The framework improves collaboration, efficiency, and customer satisfaction. (Hossein Omrany, 2023)explore the applications of Digital Twin (DT) in the building industry, the necessary technologies for its operation, and the significant challenges associated with its use. The study provides an in-depth understanding of current DT implementations, presents an overview of enabling technologies, highlights problems, and offers recommendations for future advancements in the sector. (Nana Akua N, 2023) study offers insights into the current state and potential gaps in Digital Twin applications across construction lifecycle phases. It highlights a growing interest in Digital Twin research, especially during the construction phase. (Shuaiming Su, 2023) examine the construction industry, the characteristics of Digital Twin (DT), and propose a framework for its integration throughout the construction life cycle. They discuss potential challenges and benefits of DT. Using the Systematic Literature Review method, the study aims to provide a comprehensive overview of the construction sector and the potential applications of DT.

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III. DATA TEXT ANALYSIS

The exploration of "Challenges Faced During Implementation of Digital Twin in Construction Project Monitoring" involves a detailed analysis of obstacles encountered in adopting digital twin technology for monitoring construction projects. Leveraging insights from existing literature, a Visualizing Output of Science (VOS) Viewer analysis was conducted to extract and examine relevant texts from scholarly articles, conference papers, and research publications related to digital twin implementation in construction. The analysis aimed to identify key challenges, influential authors, and the interconnectedness of concepts in the context of digital twin adoption for construction project monitoring. The VOS Viewer analysis revealed significant clusters representing themes such as "Digital Twin Technology," "Construction Project Monitoring," and "Implementation Challenges." The visualization highlighted influential authors and their collaborations, providing a comprehensive overview of the research landscape in this domain.Co-occurrence networks demonstrated the interconnectedness of key terms, emphasizing the relationships between challenges and the implementation of digital twin technology in construction. The data text analysis using VOS Viewer offers a clear understanding of the key challenges, influential authors, and relationships between concepts, providing a foundation for further exploration and the development of strategies to overcome obstacles in the adoption of digital twin technology for construction project monitoring. This study serves as a valuable resource for researchers, practitioners, and policymakers seeking to address challenges associated with the implementation of digital twin technology in construction. By examining the existing literature and visualizing the research landscape, this analysis contributes to a roadmap for enhancing the successful integration of digital twin technology in construction project monitoring and improving overall project outcomes.

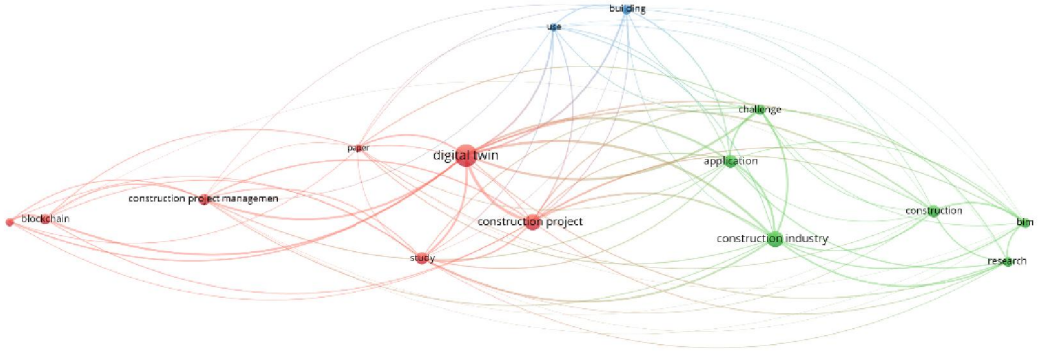

Fig 1. Text data analysis

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