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Insights of Digital Twins with its application in BIM

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ABSTRACT :

A Digital Twin (DT) is a virtual representation of physical assets, processes, or systems that continuously updates using real-time data, advanced analytics, artificial intelligence, and machine learning. In civil engineering, DTs offer a dynamic tool for monitoring, predicting, and optimizing the performance of infrastructure throughout its lifecycle. Despite its potential, DT adoption is still in its early stages, with challenges like distinguishing DT from related technologies such as Building Information Modeling (BIM) and Cyber-Physical Systems (CPS). Additionally, the constituents and applications of DT in civil engineering are not fully defined, particularly during the operation and maintenance (O&M) phase, which is critical for asset longevity. A clear framework and architecture, supported by real-world case studies, are necessary to advance the implementation of DTs, improve decision-making, and enable more efficient asset management across the construction and infrastructure sectors.

Keywords: Building information modelling (BIM), Digital Twin (DT), Monitoring, Operation and Maintenance.

INTRODUCTION :

The modern building construction industry is subject to numerous technological, functional, and qualitative changes and the stage for a discussion on the importance of BIM and digital twins in addressing these challenges and improving the design and operation of smart buildings. “Digital twin application in the construction industry outlines several key points regarding the construction industry's current state and the potential impact of digital twin (DT) technology. Digital twin technology, which simulates physical products in a digital environment, has the potential to transform the construction industry. It was first introduced by Michael Grieves in 2003 and has been successfully implemented in other sectors like manufacturing.

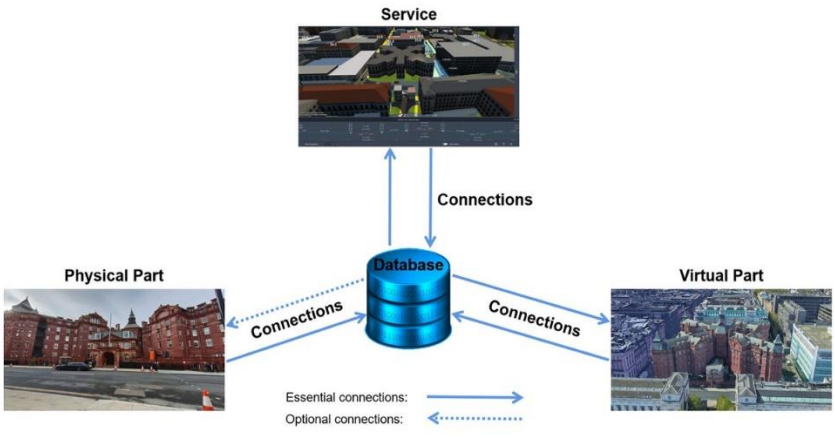
Traditional methods of assessing the environmental impacts of buildings often overlook critical social aspects and fail to provide accurate estimates of actual performance compared to design predictions. The extensive research on digital twins in other industries, there is limited application and understanding of this technology within the construction sector and provide a comprehensive review of the current state of digital twin applications in construction, focusing on its lifecycle phases and potential benefits. To overcome the challenges like Economic Contribution, Challenges in Productivity, Need for Technological Advancement, Slow Adoption of Technology digital twins is precise and accurate technology in construction industries.

Understanding the actual operation strategies is crucial to bridge the information gap regarding building performance, and digital twins are being explored to identify operational and design issues. integrating digital and physical aspects of construction, leading to inefficiencies and fragmentation of information. building design and operation, given the alarming rate at which natural resources are being exploited and the significant environmental impacts associated with the construction industry.

Literature Review :

Feng Jiang Et Al (2021) reported that; In civil engineering, the term "Digital Twins" (DT) refers to the process of producing digital twins of real structures, such as buildings and bridges. This study explores this idea. It emphasizes that although while digital twins have a lot of promise to enhance the processes involved in design, construction, and maintenance, there are still a few obstacles to be solved. misunderstanding Other Concepts. There may be misconceptions regarding the distinct advantages of digital twins as a result of their frequent confusion with related ideas like cyber-physical systems (CPS) and building information modeling (BIM).

FIG: FIVE-PART STRUCTURE OF DT



Qiuchen Lu At El (2020) investigated that; The paper highlights challenges in managing data, such as ensuring it is accurate and synchronized from different sources. These challenges need to be addressed for DTs to be effective. The paper is about using technology to create digital versions of real places to help manage them better, while also recognizing the challenges and areas for improvement in this approach. The study aims to evaluate the performance of the proposed Digital Twin system and its impact on organizational productivity and city services, such as power, waste, and transport management The problem highlights the complexities involved in developing effective Digital Twins at both building and city levels, emphasizing the need for comprehensive solutions to enhance data management and operational efficiency.

FIG: Digital modeling layer development of the city DT at the west Cambridge site

Sihan Huang Et Al (2022) study that; A virtual representation of a real machine is called a digital twin. It facilitates the analysis and simulation of the machine's operation without requiring any physical modifications. This helps to test and enhance the functionality of the system. Machine tools that are reconfigurable are essential as they allow for easy modifications to accommodate varying production requirements. In contemporary manufacturing, where needs are subject to sudden changes, this flexibility is essential.\

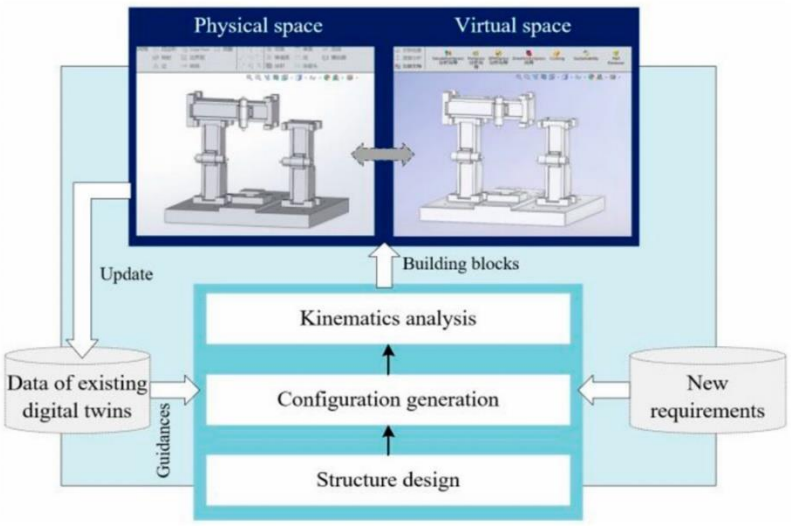


FIG: Procedure of Digital twin of RMT

Anders Clausen Et Al (2021) explained that; The framework tracks the number of individuals and their whereabouts within a building using sensors. Based on actual consumption, this information helps improve lighting, heating, and cooling. Model Predictive Control (MPC) is a technique that uses forecasts to modify building systems in real time to save energy and ensure comfort.

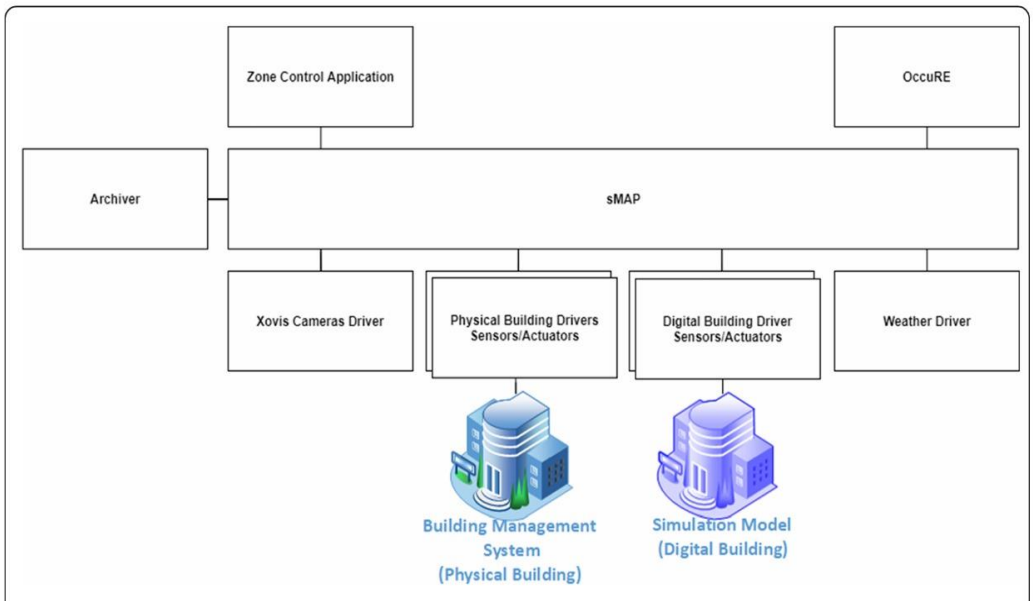


FIG: Overview of the Digital Twin Framework design

Jianfeng Zhao Et Al (2022) Focused that; Integrating real-time sensor data with different systems, like Building Management Systems (BMS), Asset Management Systems (ASM), and Space Management Systems (SMS), is one of the major issues. The successful administration and upkeep of buildings depends on this integration. The lack of standards directing the development of DT technology causes problems with information quality and data integration. This mismatch may make it more difficult to apply DT effectively in building operations.

CONCLUSION :

In conclusion, this paper provides a comprehensive overview of the current state of digital twin (DT) applications in the construction industry, highlighting key technologies, opportunities, and challenges. The analysis shows that while digital twin has been successfully implemented in industries like manufacturing and automotive, its adoption in construction is still in its early stages, primarily focused on the design and engineering phases. However, the potential of DT to revolutionize the construction sector is immense, especially when integrated with Building Information Modelling (BIM). This integration can enhance project lifecycle management, energy efficiency, and operational transparency. The study emphasizes the need for a clearer definition of digital twin in construction, the development of better tools, and the expansion of its application to underexplored areas such as the demolition and recovery phases. Furthermore, the research proposes a conceptual framework for integrating BIM and DT to support sustainability, automation, and smart building functions. To stay competitive and meet modern construction demands, the industry must embrace these technologies and their synergies across all lifecycle stages. Future research is essential to enhance the integration of DT and BIM, expanding their applications for comprehensive sustainability assessments and improved decision-making in building design, construction, and operations.

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