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모듈러 구축의 시설 관리를 위한 BIM-IoT-GIS 통합 디지털 트윈 기술 활용

The utilization of BIM-IoT-GIS integrated digital twin technology in the context of modular construction for facility management

응우옌 당 호앙 낫 쯔엉* . 원호안트* . 천유진* . 김우재** . 안용한***
Nguyen, D. H. N. Truong* . Nguyen, Ho Anh Thu* . Chon, Yujin* . Kim, Woo-Jae** . Ahn, Yong-han***

Abstract

The implementation of Building Information Modeling (BIM), Internet of Things (IoT), and Geographic Information Systems (GIS) in the context of modular construction has gained significant attention due to its potential to enhance project efficiency, data integration, and decision-making processes. This paper presents a comprehensive overview of the implementation of a BIM-IoT-GIS integrated digital twin for modular construction projects. The paper discusses the technical challenges and considerations involved in implementing the BIM-IoT-GIS integrated digital twin for modular construction, including data interoperability, sensor integration, cybersecurity, and scalability. The paper contributes to the growing body of knowledge on the application of digital technologies in modular construction and highlights the potential for widespread adoption of BIM-IoT-GIS integrated digital twins to drive innovation and efficiency in the construction industry.

키워드 : 모듈러 건설, 빌딩정보모델링 (BIM), 사물인터넷 (IoT), 지리정보시스템 (GIS), 디지털트윈 (DT)
Keywords : Modular construction, Building information modeling (BIM), internet of things (IoT), geographic information system (GIS), digital twins (DT)

1. Introduction

Facility management plays a critical role in ensuring the optimal performance, functionality, and sustainability of built environments within the construction industry. It encompasses a wide range of activities, including maintenance, operations, space management, asset tracking, and occupant comfort [1]. Effective facility management not only enhances the lifespan of buildings but also contributes to operational efficiency and cost-effectiveness over time. Modular construction, also known as off-site or prefabricated construction, has gained prominence as a viable alternative to traditional on-site construction methods. This approach involves the fabrication of building components in a controlled factory setting, followed by transportation to the construction site for assembly [2]. Modular construction offers several advantages, including reduced construction time, minimized on-site disruption, improved quality control, and enhanced sustainability through material efficiency and waste reduction.

* 한양대학교 대학원 스마트시티공학과
** 서울예술대학교 교수, 건축학석사
*** 한양대학교 건축학부 건축공학과 교수, 공학박사
(Corresponding author: Department of Architecture, Professor, Hanyang University, yhahn@hanyang.ac.kr)

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However, the unique characteristics of modular construction, such as the standardized modular units and assembly process, require tailored facility management strategies to address specific challenges and maximize operational performance. This is where the integration of Building Information Modeling (BIM), Internet of Things (IoT), and Geographic Information System (GIS) becomes crucial. By integrating BIM, IoT, and GIS, facility managers gain access to a centralized platform that facilitates data-driven decision-making, proactive maintenance planning, resource allocation optimization, energy efficiency improvements, and enhanced occupant comfort.

The purpose of this paper is to explore the implementation of a BIM-IoT-GIS integrated digital twin specifically tailored for facility management in modular construction projects. It is expected to contribute to advancing the field of facility management in modular construction and promotes the adoption of integrated digital solutions to achieve more resilient, intelligent, and sustainable built environments.

2. Key concept summary

BIM is a sophisticated digital modeling approach that revolutionizes the construction industry by creating detailed 3D models of buildings and infrastructure projects [1]. These models contain rich information about the physical and functional characteristics of components, materials, systems, and processes involved in construction. BIM enables

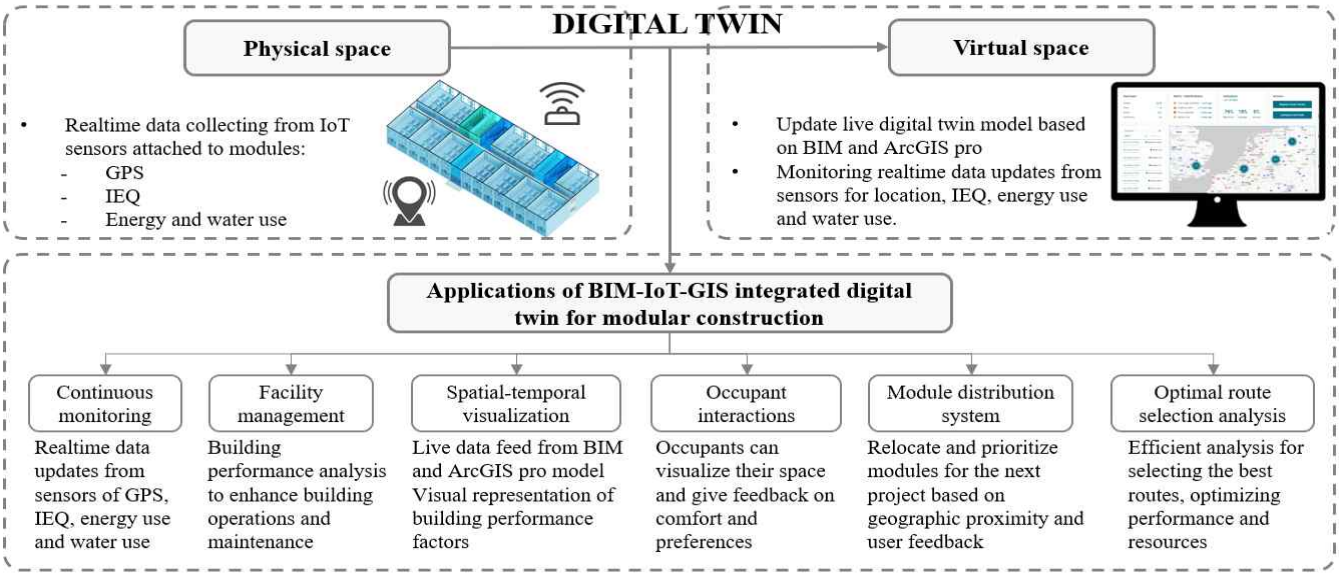

그림 1. Key concept of the study

stakeholders such as architects, engineers, contractors, and facility managers to collaborate effectively, visualize designs, detect clashes, analyze performance, and make informed decisions throughout the project lifecycle. It facilitates data sharing, version control, and information management, leading to improved project outcomes, reduced errors, enhanced coordination, and better communication among project teams.

IoT technology refers to a network of interconnected devices embedded with sensors, actuators, and software that enables them to collect, exchange, and analyze data in real-time [3]. IoT technology empowers construction and facility management teams to make data-driven decisions, improve asset performance, reduce downtime, and enhance overall project efficiency and sustainability.

GIS play a pivotal role in construction and facility management by providing a spatial context and enabling geographic data analysis [3]. GIS technology allows users to capture, store, manage, analyze, and visualize spatial data related to construction sites, infrastructure assets, environmental features, and geographical boundaries. GIS tools and maps enable stakeholders to make informed decisions based on location-based information, conduct spatial analysis, identify patterns, assess risks, and communicate spatial data effectively across project teams and stakeholders.

Digital Twin technology is a virtual representation or simulation of physical assets, processes, or systems that combines BIM, IoT, and other data sources to create a dynamic, real-time digital model [4]. Digital twins enable monitoring, analysis, simulation, optimization, and predictive modeling for improved decision-making, performance evaluation, and operational efficiency. In construction and facility management, digital twins offer a holistic view of assets, enable remote monitoring, support predictive maintenance, facilitate performance analysis, and enhance asset lifecycle management. They provide a platform for data integration, collaboration, visualization, and advanced analytics, driving innovation, sustainability, and resilience in built environments. The figure 1 illustrates the key concept of the study.

3. Conclusion

In conclusion, the implementation of a BIM-IoT-GIS integrated digital twin in modular construction for facility management represents a significant advancement in optimizing the performance, sustainability, and efficiency of built environments. The synergistic integration of BIM, IoT, and GIS enables a holistic approach to facility management, encompassing design, construction, operation, and maintenance phases. Through this integrated digital twin framework, stakeholders gain access to real-time data on environmental conditions, energy usage, equipment performance, occupancy levels, and maintenance needs within modular buildings. Embracing these advancements will drive innovation, resilience, and sustainability in the construction and facility management sectors, ultimately creating smarter, more efficient, and user-centric built environments for the future.

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