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EMPLOYING DIGITAL TWINS IN ENGINEERING PROJECT MANAGEMENT WITH APPLICATIONS IN CONSTRUCTIONS

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Abstract: *The study focuses on bridging the knowledge gap between modern technologies and construction project management, aiming for a clear vision of digitizing construction project management through the effective use of big data on digital twin platforms. By employing a suite of specialized digital tools, the proposal is to establish a practical system for managing construction projects, enhancing modeling, and data processing, and reducing associated risks. The investigation underscores the importance of a robust database developed through mature information systems and building an efficient model on digital twin platforms. The conclusions highlight the need for solid foundations for digital twins, including mature information systems for monitoring changes based on intelligent computational models. Efficient management of big data within BIM contributes to resolving technical and administrative issues in construction projects.*

Keywords: *Digital Twins, Project Management, Big Data, Construction Projects Management, Industrial Engineering.*

1. INTRODUCTION

Considering the quick adoption of digital technology that entered all fields until it reached areas such as industrial engineering and management, the construction industry was soon to follow [1]. It should be noted that the construction industry contains many activities that make it a fertile environment for increased risks, in addition to relying on data, so it was necessary for researchers to think in a framework that includes the introduction of digital twins as management tools for costs, risks and quality, and not only for technical problem solving [2]. Studies indicate that the digital transformation of building construction can involve a large extent of work due to the considerable amounts of possible data from the projects. The advanced use of big data is considered one of the most important contributors to the gross domestic product of a national economy, so it is necessary that it can be exploited to enhance human labor contribution, increase economic and operational efficiency and enable global competitiveness [1]. Our previous work on the employment of digital twins in construction projects indicates that there is a high potential to integrate information technologies and data science in construction management using specialized platforms. [2]. Through the current paper, we substantiate a methodology for integrating digital technologies to manage big data in construction projects, by developing a specific digital model in a way that guarantees process performance improvement and increases efficiency and quality. Researchers define the digital twin as a virtual environment copy of a real artefact, that includes visualization, interactivity, data mining for abstract processing and decision making, as well as operational responsiveness [2], [3]. This article emphasizes the role of big data and artificial intelligence in employing advanced digital twins (DTs) in construction applications, by focusing on prominent recent scientific research, available on multidisciplinary electronic bibliographic databases, related to big data management and implementation methodologies for complex environments. In addition to reviewing the related literature, the paper focuses on identifying improvement tools through which

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the different levels of digital maturity can be developed. The article discusses the research potential of the two mentioned instruments by performing a critical analysis of the current challenges and opportunities.

2. AIM AND OBJECTIVES

The present study aims to mitigate the technical knowledge gap to obtain a digital system for managing big data and artificial intelligence in construction projects using digital twin platforms. The many uses and benefits of such a system justify the research efforts, as it can lead to better economic performance, enhanced social and environmental footprint and more satisfied stakeholders. The objectives of the research are as follows:

- To review previous studies discussing digital twins' employment in engineering projects, especially taking into account the particularities of the construction industry.
- To identify the tools used in digital twins in various industrial fields to achieve their main functions.
- To choose an adequate digital twin tool to prepare a model that simulates the digital management of data within construction projects, taking into account the exiting approach of BIM – Building Information Modeling.
- To choose a methodology for managing the huge data used in digital twin technology, either generated by the project site or by the artificial intelligence assistance systems.
- To obtain a comprehensive vision for managing big data and AI and for providing security and privacy elements to protect the data.

3. METHODOLOGY

To develop a digital model requires a set of specific tools within the realm of high-quality digital technology, such as computer and network engineering to connect all data sources, sensors and processing units, and cyber-security to protect data and information during use and decision implementation, in addition to structural engineering, construction materials engineering and so on [4]. The application of the specialized digital solutions includes the process of custom designing and modeling the construction project and construction site with the help of IT&C, sensors, and digital platforms, leading to the goal of (real-time) big data processing to integrate them into a single bi-directional digital system. [5]. The concept of digital twin is not only necessary nowadays but becomes a requirement to be able to handle a multitude of complex and competing requirements, including the modeling of incoming and outgoing data to replicate human project manager and project team decisions and interventions [6]. The following figure 1 shows a set of tools that can be used to develop digital twin solutions to achieve process optimization and high quality of deliveries [1]. These functionalities enable the most common functions that are expected to be performed within the construction industry and serve as the backbone of the following proposed measures to improve big data management.

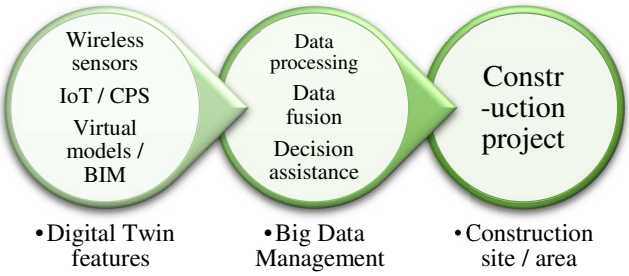

Fig. 1. Digital Twins tools for construction project management

4. THE DIGITAL TWINS CONCEPT

Figure 2 indicates the flow of big data using the digital twin approach, with both a physical system and the virtual system component. This includes organized and unorganized data flowing from various sources that cover the stages of the project such as design, planning, implementation and assessment. It is processed, analyzed, and transformed into understandable information through visualization, simulation, decision support and documentation generation. The 3 main components become visible below:

- **Artificial intelligence:** automatic control is carried out according to the project, such as control, oversight, problem analysis, and resource provision.
- **Digital Twin:** it is a complex intermediary between both systems using various functions existing or new to the digital ecosystem: analytics, learning, etc.
- **Project management:** plays the role of monitoring the behavior of the system, addressing problems that require human intervention.

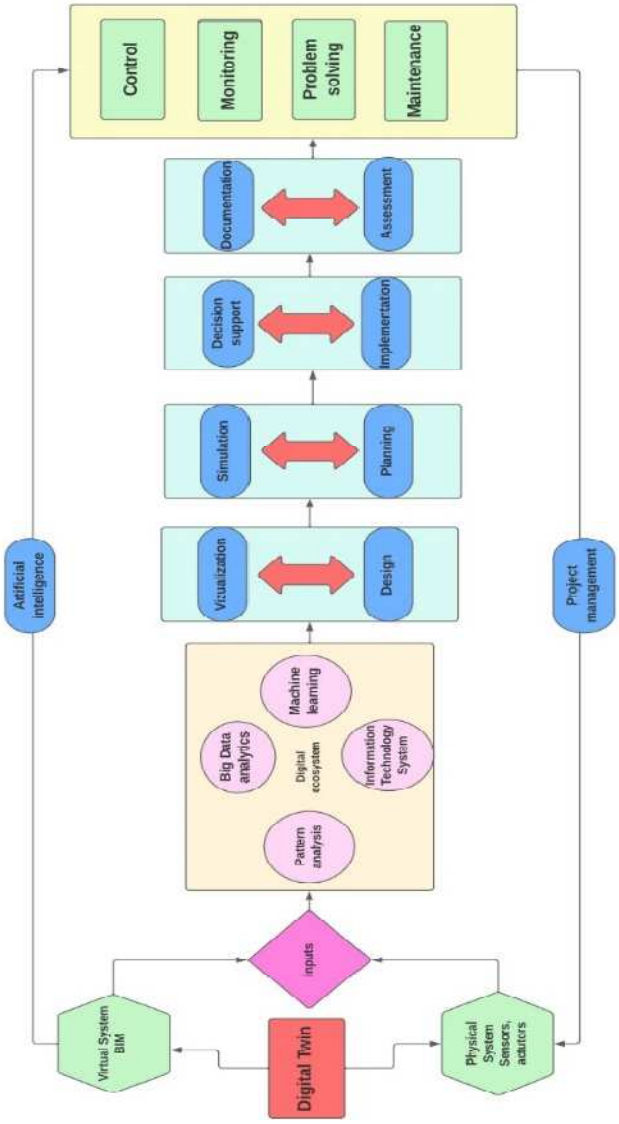

Fig. 2. Data flow and functions of a digital twin for construction projects
(Figure based on [7] and [8], adapted for use in the construction industry)

Figure 2 shows that the effective collection of data from the real environment is done by means of sensors and actuators, while from the virtual environment is done by means of simulations or BIM.

The three distinct levels of intervention start from these sources and carry out automated, human-based or mixed interventions, while the digital twin keeps the synchronicity between the construction site and its computer representation. Using machine learning models, statistical methods and probability analysis upon big data and emerging patterns, running on dedicated hardware IT systems, the digital twin can be conceptualized as a meta-function of the construction project digital ecosystem.

Some studies [7] indicate that many big data processing tools can be used, such as Hadoop, Storm, S4, Spark, etc., which perform parallel processing in multiple computational ways, while others recommend the use of cyber-physical systems and Internet of Everything [8], which delocalize an important part of the data processing, freeing the AI system of this burden.

As shown in figure 2, the flow of data helps create a machine learning-enabled digital twin, which is used in continuous development and improvement processes.

The virtual model is designed as one of the forms of artificial intelligence that reviews the data generated by the real physical twin.

The data from both the virtual and real physical twins is reviewed into an artificial intelligence system to achieve the goals of the industrial project, which includes many goals such as design, planning, organization, etc.

In addition to using the results to help in decision-making, the improvement and development process then takes place in both the real or the virtual physical system.

The figure shows the process of benefiting from big data analytics within the effective exploitation strategy for integrating relevant and timely data using the digital twin in the industrial environment.

5. RESULT

To establish a digital twin system to manage the construction project, there are three basic

elements that must be available and operational, as mentioned by [9]:

- **Building Information Model (BIM).** It contains information and data of the construction project, the building itself, as well as the instruments for creating and operating the entity.
- **Analyses of Big Data:** Data is processed and analyzed according to statistical data and machine learning models associated with artificial intelligence, to evaluate and predict the technical or managerial situation, through the process of continuous measurement, comparison and updating.
- **Knowledge database:** It includes sources of relevant information collected from experts and similar previous projects, whereby it is utilized to obtain integrated information and data that allow organizing project management to deliver upon its key indicators.

Thus, we can create a database and an information systems infrastructure within the BIM [10] based on a model for storing and processing big data, to solve project problems with the help of digital twins. In Figure 3 the concept of big data management for the digital twin in construction projects is illustrated based on the work from [1].

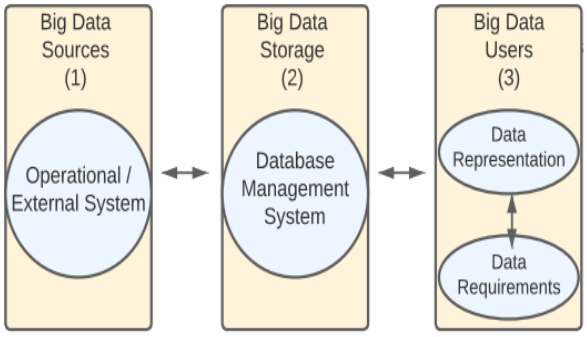

Fig. 3. Big Data in Digital Twins for Construction Management (Source: [1])

The application of this model from [1] in the studied case includes three main focus areas, which can be detailed as follows:

- **Big Data sources:** which includes data sources collected from external outlets and sensors, available on the construction site or machinery, or coming from various suppliers of construction materials.
- **Big data storage:** it is the information and data knowledgebase where they are stored, and where specific tasks such as protection, backup, redundancy check and obsolete data deletion are performed for the entire system; this is to be undertaken by the construction project management team through dedicated IT infrastructure functions.
- **Big data users:** where the data is reviewed and converted into information to display and understand, preferably in an automated fashion, thus controlling activities based on the higher-level results of the reviews, facilitating the work of construction engineers and related functions, to enable their delivery of the expected results.

The digital twin system is characterized by providing space for the process of development and improvement through:

- Providing an open environment for information and data to be exchanged and analyzed through various engineering applications.
- Knowledge of construction project data and information and decision-making through reliable reports.
- Ensuring storage operations for long periods of time, as it can constitute preservation of the project history and derive benefits from it in the future.
- Automatically synchronize storage data with the running digital system data.
- The possibility of converting project data into information that is understood, while the progress of implementation is known at all times with increased accuracy.

Previous studies and our own work on the edification of the digital twin based on scientific foundations for successful management of construction projects, point to the need to rely on robust information systems that allow monitoring and follow-up of changes based on smart computational models.

In addition, to achieve fine control through the process of comparison and prediction of results, advanced modeling and data mining is required, which allow for improvements that increase quality and mitigate potential risks.

6. CONCLUSION

We can infer that the custom digital platform proposed should integrate software and ideas from engineers, developers, and managers to form an advanced technological vision to drive construction project implementation in line with requirements, even in the case of complex support functions that enhance the functionality of a building, such as transportation services [11].

The system should include cooperation from all project parties to establish an information rich environment for the twin to operate.

Through this approach, the application of big data in BIM will solve many technical and administrative problems facing the construction project through the process of analysis and processing on a large scale and in a complex environment, where big data provides a multitude of parameters that have been modified in accordance with the understanding of BIM models of available and expected outcomes.

The basic elements of BIM constitute a storage medium for data such as schedule, cost, modeling, performance, etc., where the data is matched within the system that represents the life cycle of the project with its stages.

The digital twin assists the management process in a way that ensures the success of achieving the set goals by providing reports and information that help in making rational decisions.

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Utilizarea gemenilor digitali în gestionarea proiectelor inginerești cu aplicații în construcții

Rezumat: Studiul se concentrează pe reducerea decalajului de cunoștințe între tehnologiile moderne și gestionarea proiectelor de construcții, adoptând o viziune clară asupra digitalizării managementului proiectelor de construcții prin utilizarea eficientă a datelor mari pe platforme de gemeni digitali. Prin utilizarea unei suite de instrumente digitale specializate, se propune stabilirea unui sistem practic pentru gestionarea proiectelor de construcții, îmbunătățind modelarea, prelucrarea datelor și reducând riscurile asociate. Investigația subliniază importanța unei baze de date solide, dezvoltată prin sisteme mature de informații, și construirea unui model eficient pe platforme de gemeni digitali. Concluziile indică necesitatea fundamentelor solide pentru gemenii digitali, incluzând sisteme mature de informații pentru monitorizarea schimbărilor bazate pe modele computaționale inteligente. Gestionarea eficientă a datelor mari în cadrul BIM contribuie la rezolvarea problemelor tehnice și administrative în proiectele de construcții.

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