Building Information Modelling

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The evolution of the construction industry is associated with the continuous implementation of new technologies. Building Information Modelling (BIM) has revolutionised the collaboration and data sharing processes in the architecture, engineering, and construction (AEC) industry.

building information modelling (BIM) technologies bibliometric analysis

1. Introduction

The construction industry is changing its regular business methods, with information now being exchanged digitally rather than in paper form. However, the transformation is slow and currently facing many barriers. The evolution of the construction industry is associated with the continuous implementation of new technologies. BIM has added significant value in the development process of the construction industry. It is seen to be a primary asset of information exchange among various stakeholders in the AEC industry [1]. For instance, BIM has the potential to examine how a building is deteriorating over time, which can help in setting up an appropriate strategy for maintenance work [2]. However, it is still not fully employed in the late design stages [3][4]. Thus, there is a lack of comprehensive understanding of what BIM should look like in the future.

In any construction project, a significant volume of data, which can be vital, is left out without taking advantage of its unrevealed value. The construction sector needs to understand the importance of this overlooked information since mining and management of an enormous amount of data are critical for better decision-making in future construction projects. It becomes a matter of quality over quantity and how that is affecting the decision-making process; in particular, nongeometric information becomes more crucial than geometric information. Although BIM helps manage the information generated, it needs to be coupled with new technologies that can embrace digital construction by transforming the construction industry into a dynamic environment. However, there is still a lack of comprehensive understanding of the potential of the existing technologies and how they can be leveraged holistically towards future BIM.

Technology advancement and engagement in the construction industry has changed over the last decade. Technologies such as artificial intelligence (AI), cloud computing (CC), ontology, blockchain (BC), data analytics (DA), Internet of Things (IoT), laser scanning (LS), and machine learning (ML) have brought tremendous benefits to the construction environment. According to Digital Built Britain [5], which represents the next stage of the United Kingdom digital construction revolution, BIM has excellent potential to be combined with the IoT and DA, which can result in better infrastructure and improve the utilisation of the facilities. Moreover, the concept of a digital twin has

been around for several years, which is based on having a virtual model that simulates the existing situations of the real model [6]. This concept obtains real-time data using devices such as sensors that are enabled by technologies such as ML and AI. Bearing in mind that ML is a subset of AI. However, digital twin still requires a framework to follow. BIM, which is a combination of policies, processes, and technologies [7], can support digital twins by being represented as a digital data management platform that can form the starting point for digital twins. Therefore, despite concerns about how BIM can handle various semantic information, it shows that BIM and digital twins can complement each other. LS also plays a role in closing the gap between as-is BIM and as-built BIM, which helps with linking up late lifecycle stages to the design stage. Hence, previous technologies are an important topic and require further investigation. Furthermore, technologies such as ontology and CC have shown their potential to overcome semantic issues [8] and improve collaboration [9] within BIM, respectively. However, using the Internet as a platform for exchanging data among several team members can raise a major issue, which is security. Security has been identified as an important topic within BIM [10]. In recent years, BC has been introduced to the research community to overcome the security issues with BIM. However, most of the research that was conducted on this topic was either conceptual [11], a survey [12], or a literature review [13]. Hence, it is currently a hot research topic.

To achieve a cohesive environment that can bring together different stages in the building lifecycle, BIM entails the utilisation of new technologies. Merging technologies with BIM can result in a robust decision-making framework. However, most of these technologies are not fully embraced by the construction industry yet. The acknowledgement of these technologies has been slow due to the fact that the participants still lack knowledge of these technologies and are unsure whether these technologies will have a negative or positive impact on the project. There is still a lack of understanding on how these technologies are linked to BIM. Furthermore, [14] pointed out that the lack of knowledge about BIM capabilities is constraining the use of BIM, which further explains the need for conducting this research to deliver a comprehensive understanding of what BIM should look like in the future.

2. Background

2.1. The Benefits and Limitations of BIM in the AEC Industry

BIM can be characterised as a depot for various information and knowledge, which can be essential for project success and valuable throughout a project's lifecycle [1][15][16], especially because various stakeholders require different information to be exchanged in a project [17]. However, BIM is mostly used in the design and preconstruction stage, and less used in further stages of the building lifecycle [3][4]. The complexity of an asset necessitates adopting new technologies or tools to help manage all this information within BIM and take a further step to realise the full potential of BIM [18].

BIM has brought several advantages to the AEC industry. For instance, it can help with enhancing collaboration on a project by bringing stakeholders closer together and supplying them with visualisation functionalities [14]. Consequently, it helps with synchronising the design and construction plans and detecting design errors [16]. If utilised in an appropriate manner, it can influence numerous aspects such as cost estimation, schedules,

compliance checking, design analysis, and environmental and thermal performance [1][15][19]. However, there are still several challenges facing BIM in the AEC industry. For instance, interoperability and integration have been acknowledged as important issues in BIM due to the existence of heterogeneous tools and systems [14][20]. Being unable to exchange data seamlessly limits collaboration in the AEC industry, which affects BIM adoption. Moreover, the cost of BIM software tools is one of the factors limiting the application of BIM [14]. Sun et al. [14] also pointed out other factors such as BIM model ownership, model accessibility, data management issues, and data isolation, not to mention the security issues within BIM [10]. There is a necessity to overcome the limitations within BIM since the usage of BIM has become mandatory in some countries. The blend of new technologies in the construction field can help resolve several limitations that restrict BIM adoption in the AEC industry. However, this can take several years to accomplish. There is still a lack of comprehensive understanding on how these technologies are linked to BIM and how they can be leveraged holistically towards future BIM innovations. The possibility of more than one technology working collectively with BIM is close to realisation, but remains a crucial topic for investigation.

2.2. Bibliometric Analysis of BIM Research

Exploring field knowledge is an excellent approach to discover gaps and point out the most vital research areas. To evaluate the advancements and research areas in the construction industry, Oraee et al. [21] recommended bibliometric analysis for targeting specific areas of the construction industry. Bibliometric analysis is a document analysis method that is applied to determine the topics related to a field based on the profiles, relationships, and clusters in the research [22].

Many bibliometric analyses on BIM literature have been published in the last three years, which shows that there is great interest in the research field in expanding on BIM. Starting in 2017, Li et al. [23] provided a logical and precise review of BIM knowledge and proposed a BIM knowledge map founded on a knowledge base, domains, and evolution. They endorsed future periodic studies utilising such analysis to improve the BIM knowledge map. Moreover, He et al. [24] conducted a systematic and quantitative review covering only the managerial areas of BIM. The findings of He et al. [24] led to proposing an integrated conceptual framework to structure the future direction of these areas. In addition, Oraee et al. [25] carried out a bibliometric analysis to assess the existing literature on collaboration in BIM-based construction networks. Consequently, this led to the suggestion of a collaboration pentagon as a comprehensive analysis tool for studies on BIM collaboration. Furthermore, Oraee et al. [26] presented another bibliometric analysis of the body of knowledge issued in the proceedings of the Construction Research Congress. However, this was a wide-ranging study and not specifically about BIM. Nevertheless, Oraee et al. [26] indicated the prominence of BIM and its abilities to enhance and boost construction processes.

Moreover, Zhao [27] carried out a bibliometric analysis on BIM research wherein he acknowledged that BIM study has predominantly concentrated on categories of engineering, civil engineering, architecture, and construction and building technology along with current emerging categories such as management and sustainability. Furthermore, Zhao [27] identified the hot topics of BIM research, e.g., CC, LS, and Ontology. On the other hand, Santos et al. [28] showed a systematic analysis of all research on BIM and a review of the leading publications. They emphasised the innovative expanding in BIM research field, and found that topics related to BIM tools, BIM adoption, energy

simulation, interoperability, and ontology are the standout subjects in BIM research. Finally, Hosseini et al. [29] followed a quantifiable method to investigate the body of BIM knowledge, whereby 45 distinct themes that are closely associated with BIM were recognised.

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