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Review

Bibliometric analysis and review of Building Information Modelling literature published between 2005 and 2015

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ABSTRACT

The use of Building Information Modelling (BIM) has increased in recent years, mostly due to the potential of the methodology for improving construction project performance and efficiency. With a view to achieving a better understanding of the research work on this subject, this paper conducts a bibliometric analysis and a review of existing literature on BIM focusing on the last decade. The authors selected the articles published in journals with an impact factor higher then 1.0, as well as the top 100 most cited articles. The search resulted on 381 articles, which were then categorised in order to systematise the research conducted over the years. The authors have not only analysed the existing literature but also highlighted new emerging fields in BIM research, being possible to identify Collaborative Environments and Interoperability, Sustainable Construction, BIM Adoption & Standardisation, and BIM Programming as the categories with the most significant growth in the last years. It was also observed that the most researched topics were related with the development of BIM tools, the study of BIM adoption worldwide, the energy simulation using BIM-based information and, more recently, with the semantic interoperability and ontology. On the other hand, the study on BIM at the academic level is very small, as well as parametric modelling and quantity take-off.

Contents

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1. Introduction

The construction industry currently generates 9% of gross domestic product (GDP) and provides 20 million jobs in Europe [1], and is responsible for 40% of energy consumption and 38% of CO_2 emissions [2]. The building sector is probably the single largest contributor to resource depletion, greenhouse gas (GHG) emissions and energy consumption [3]. In response to this demanding reality, it has become important to improve the energy performance and resource efficiency of buildings, infrastructures and construction in general. To achieve this goal, the Architecture, Engineering, and Construction (AEC) sector will need to promote the use of collaborative-based and rich information methodologies, such as BIM.

The term "*Building Information Model*" first appeared in 1992, in "*Modelling multiple views on buildings*" article, published in Automation and Construction journal [4]. In this article, the authors proposed a new approach for modelling building information based on multiple aspects (e.g. spatial design, building structure, and energy). Since then, the research on BIM methodology has been growing significantly and new applications are being found. In the early phases of BIM research, most articles were published either in Architecture magazines [5–7] or in conferences, covering the novelty of BIM methodology/technology and how challenging it would be to adopt it.

Currently, BIM refers to the use of a shared digital representation of a built object to facilitate the design, construction, and operation processes and to form a reliable basis for decision making [8]. It is not only a method that foster closer cooperation between all the various technical teams involved in the different stages of a construction project's lifecycle [9], but also integrates the information inputs from all teams involved in a project. Recent research shows that the BIM methodology improves the flow of information between the parties involved in a project and encourages new design solutions. It also reduces the amount of time and money expended on a project, through highly accurate cost estimation, clash detection and other mechanisms [10,11]. Recognising these advantages, most contractors that started to use BIM in their projects do not intend to perform traditional methods again, as BIM increased their productivity and greatly decreased the requests for information and rework [10].

With the aim of providing the readers with sufficient knowledge of the current literature on BIM, we review herein the existing research in BIM. While there are a number of reviews of BIM literature already published [12–32], these either focus on specific aspects of BIM application instead of providing an overall picture of it or different selection criteria are used. So, this paper performs a bibliometric analysis of published research in the field of BIM and then a comprehensive review. It is chronologically organised, giving the readers a better understanding of the evolution of BIM over the last ten years. After the Introduction, the rest of the paper is structured as follows: Section 2 describes the research methodology in detail; Section 3 groups the papers into categories based on a bibliometric analysis; Section 4 discusses the contents of selected papers and identifies trends and research gaps revealed in the literature; and Section 5 presents the conclusions.

1.1. Originality of the review

Between 2006 and 2015 several literature reviews on BIM were published. In 2009, Eastman et al. [17] reviewed rule checking systems, as it was deemed as an emerging field in 2009, and argued that the advent of BIM tools and IFC would enable an automatic rule checking, as it was verified later. Two years later Jung and Joo [14] studied the literature in the fields of computer-integrated construction (CIC) and BIM, with the purpose of developing a BIM framework for real-world projects developed by companies. Love et al. [12] examined BIM literature in the area of design errors and also presented a systemic model for reducing design errors, concluding that little empirical research had been carried out in this field of study. Cerovsek [13] focused on the technological dimension of BIM literature and on BIM implementation in projects for new buildings, in contrast to Volk et al. [16], who focused on recent research on BIM for existing buildings. Zhou et al. [18] surveyed the state-of-the-art on construction safety and digital design, evidencing BIM as one of the studied fields, similar to the study of Skibniewski [31]. Despite the focus was not the BIM methodology, the authors analysed a few articles that used BIM tools for safety analysis during construction planning (4D BIM). Ding et al. [15] studied the existing BIM applications in the construction industry and proposed a BIM application framework to expand from 3D to nD as a result, similar to other studies [19,20]. A more systematic analysis of BIM literature was conducted by Yalcinkaya and Singh [27], which resulted in the compilation of published articles between 2004 and 2014. Despite the useful identification of BIM research areas, the respective discussion is more focused on the scope of a few studies within each research area than actually analysing the contents of the articles.

Other reviews focused on the different fields of BIM application, as structural design [21], infrastructure industry [29], as-built data collection and analysis [22,24,25,28,32], where technologies as photogrammetry and laser scanning were deeply studied, building performance simulation in early phases of the project [26], and sustainability [23,30].

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