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Connectivity of Building Information Modeling (BIM) Records to Big Data Features

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Abstract

The construction sector is now embracing new work procedures, which has led to a significant increase in the creation and use of digital data. Building Information Modelling (BIM) is one of the trendy new ways of working, and it's crucial to the construction industry's digital strategy because of the massive amounts of data it can generate. Revealing, the sector might take a giant leap forward because to the massive amount of digital data generated by BIM procedures. Here, big data serves as a foundation for potentially insightful conclusions to be derived from the accumulation of BIM digital data. However, there is a lack of a well-mapped relationship between BIM data and big data properties, according to an analysis that aimed to comprehend this connection. Therefore, in order to provide the groundwork for future studies that will discern the connection between building information modeling (BIM) data generation and big data advancement, a comprehensive mapping of these two domains is required. This study intends to provide an output from the research that mapped both BIM data and big data characteristics using a systematic mapping technique. It is clear from the mapping analysis that there is a discernible relationship between the two domains; the specification domain is the least connected.

Keywords: Digital data; Building Information Modelling; Big data.

1. Introduction

It would seem that the construction business was behind other sectors when it came to using technology to boost income and production. With only 1% of revenue going toward total technology adoption, the construction industry ranked dead last out of 19 analyzed in 2014 by Gartner Benchmark Analytics [1]. It is concerning that the construction industry does not contribute much to the national economy compared to other sectors [2]. Consequently, there is a need to improve the business by using the various technological techniques [3]. However, it would be remiss to ignore the impact of a few of the most notable technological developments. The idea of the Fourth Industrial Revolution and global efforts by construction stakeholders sparked a technological revolution in the industry, which has since adopted new methods and tools to improve every aspect of building [4]. Though some of these technologies seemed to reimagine established procedures, they are essential for bringing the construction industry up to speed with other sectors. The construction industry is already renowned for its contributions to economic growth and socio-economic development in every nation, including Malaysia [5, 6], and this is before even considering the potential for technology realization to boost construction's already impressive economic growth. Despite its relative insignificance, the Malaysian

construction industry had a positive growth rate of 14.3% in 2015 compared to 2010, according to the Economic Census [7]. Construction has been steadily enhanced over the years via a variety of initiatives, including the founding of CIDB, revisions to construction contracts, development of alternative procurement methods, and so on [8–10], all because of the vital role it plays in the economy. In spite of all that has been done, the sector is still lacking in terms of incorporating technology into its operations. This is despite the fact that these initiatives have the potential to raise productivity, which was first identified about 50 years ago [11–13]. Since technology adoption affects the national economy on a macro level and individual individuals and organizations on a micro level via increased profits and market share, it is clear that both contribute to economic development [14, 15]. This means that digital technology may improve the building a lot. Even though it is one of the least digitalized industries, the construction sector is now adopting a number of technologies, including cloud computing, augmented reality, building information modeling (BIM) software, the Internet of Things, and so on [16, 17]. Among the many technologies used in the construction industry, building information modeling (BIM) stands out as a game-changer. It is seen as the foundation of new methods of working and digital strategies, thanks to its ability to connect and integrate with different types of software, resulting in the creation of massive amounts of data [18]. On top of that, BIM may generate massive volumes of data during a building's lifetime even without integration [19, 20]. As a result, it seems that BIM software is becoming obsolete and that a new platform is needed to guarantee data management and use [16, 21]. This case illustrates how the idea of big data, which deals with efficiently handling massive amounts of data, is relevant to building information modeling (BIM) [22]. The notion is relevant, but little is understood about how BIM data relates to big data properties. So, before any further study can be conducted, a thorough mapping of these two domains is necessary. Therefore, the purpose of this study is to provide the results of an investigation into the mapping of BIM data with qualities from big data. The document lays out two goals: first, to find a relevant piece of literature on the different kinds of BIM data and big data features; and second, to find a common link between these two sets of data. Consequently, a comprehensive literature evaluation has been conducted as part of this study.

2. Digital Data in BIM Environment

Digital environment is taking place and refining albeit slowly in construction in which leads towards the increment of digital data. There is a rise in digital data through every single digital activity [23]. Previously, text, images, audio and video are the only digital data generated in the industry [13]. Then, comes the usage of computer-aided design by the designer which replaces the previous practice of designing through drawing boards [24]. As of now, BIM is among the technologies that create humongous digital data [25]. BIM can be defined as “a process of collective creation and use of information about a building that forms the basis for all decisions throughout the life cycle of an object (planning, designing, issuing working documentation, construction, operation, demolition)” [26]. Meanwhile, BIM also defined as "a computer aided modelling technology to manage the information of a construction project focusing on production, communication and analysis of building information model" [27]. Therefore, it can be interpreted that generally, BIM involves the utilization of technology in producing virtual models containing data and information throughout the construction processes by the construction players for decision making. As BIM can be utilized right through design until the operation stage, various functions can be applied such as scheduling, quantification, energy-efficient designing, cost estimation and others [19, 28]. Based on those realizable multi functionalities, BIM

software generates numerous data that comprises of types, quantities, cost and brands of materials, dimensions data and other types of data [19, 20]. Besides, after the completion of construction, BIM also generates and provides a repository of data and construction-related information that can be utilized during the operation and maintenance stage which indicates the continuous creation of data throughout the lifecycle of buildings or infrastructure [19, 29]. Hence, it accentuates conspicuously that BIM is capable to generate huge amounts of data in diverse phases which will be useful in decision making by construction players [11, 30]. At present, BIM software like Tekla, Revit, FEM-Design and others, itself is capable to store, process and analyze the data accumulated in its tool [19, 31, 32]. For example, prescriptive and predictive analytics can be conducted on BIM data stored in its tool which provides cost prediction and measure the consumption of energy during the design stage and, this information will be useful during the construction stage [33]. Despite the capability of the analytics in BIM software, the generated BIM data are not being properly utilized though it can be used in a better way [34]. As it has been proven in the KPMG report that 70% of the surveyed construction players are not using data analytics [35]. Thus, it causes underutilization of data and loss of potentials that are achievable through the accumulated BIM data. Furthermore, it becomes much more complicated when there will be exponential growth in the amount of BIM data predominantly through the integration with another kind of relatable data [36, 37]. Moreover, scholars also are suggesting the integration with Linked Open Data (LOD) such as traffic, weather, density of population and many more [38]. These circumstances will direct towards the meteoric rise of data in which the conventional method cannot withstand in terms of processing systems and storage of data [16, 21]. Consequently, BIM data will necessitate platforms like big data technology which is competent to handle voluminous data in a suitable manner [22]. Though the concept of big data has been discussed since the 90s, it is only getting attention to the construction industry recently [16, 39, 40]. However, it is already being applied in various industries since the professionals in those sectors believe in the essentiality to implement this kind of technology in their field. It has been proven that big data analytics are being increasingly used by some sectors such as manufacturing, healthcare, banking, tourism and others [41-44]. Although all those industries are moving forward in adopting this new technology, the construction industry is still behind at the infancy stage despite its potential [45] as shown in Figure 1. The big data potential index for the construction industry was at a moderate level in 2008 [46] and it might have been increased from time to time.

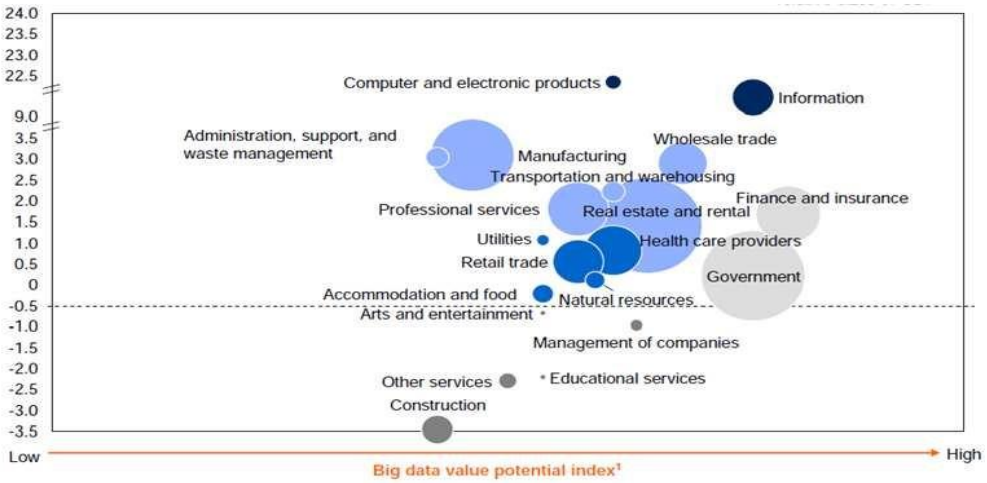


Figure 1: Potential of Various Industries in Capturing Value from Big Data [46]

Since there is a potentiality, the adoption of big data technology will be useful to solve the underutilization issue by deriving value from the accumulated construction data. In the context of BIM software, the derivation of value from the data creation in BIM will become possible where the valuable information will be produced and can lead to the creation of new business models and services [47]. Furthermore, big data analytics also will add value to BIM by forming data-driven BIM where various benefits will be achievable through this adoption [48]. Some of the possible benefits are an increase in productivity, reduction in cost, earlier completion of project, management of risk and so on [48, 49]. Meanwhile, the benefits have been already proven in other sectors as shown in the following Table 1.

Table 1: Benefits of Big Data Attained in Various Sectors [46]

No	Sectors	Benefits
1	US Healthcare	- $300 billion value per year - 0.7% productivity growth per year
2	US Retail	- 60% increase in net margin - 0.5-1.0% productivity growth per year
3	Europe Public Administration	- €250 billion value per year - 0.5% productivity growth per year
4	Manufacturing	- 50% reduction in product development - 7% reduction in working capital

As the adoption of the big data will provide solutions and add value to the formation of a large amount of BIM data, it can be considered that the technology will bring a positive impact on the construction industry in the future especially for BIM. Hence, the propensity and profitability exhibit how essential the need to establish the associations between BIM and big data in which will be identified through this research.

3. Systematic Mapping Analysis Process

The research has been done through an in-depth review of various secondary sources available. Thousands of different sources about BIM and big data in construction have been explored and rigorously reviewed via online databases, e-journals and e-books. The systematic mapping analysis was carried out by connecting two different things, types of BIM data which are material data, design data, dimension data, cost data, specification data, schedule data and operation and maintenance data while another one is 6 V's of big data that are volume, velocity, variety, veracity, value and visualization. Though the domain of the big data concept is 3Vs, the study used 6 Vs to make the research much reliable and acceptable since many more characteristics were being fulfilled through the associations with BIM data types. In order to carry out the mapping analysis, several methods utilized in reviewing process were scanning, 2nd level reading comprehension which is interpretive comprehension and extraction of relevant data [50, 51]. During the process, only 43 of the sources have

indicated the relationship between BIM data types and big data attributes where there were direct and indirect indication. Then, to synthesize the outcome from the review, a table of associations between BIM data types and big data attributes has been developed. Therefore, the research methodology applied illustrates a systematic approached used to realize the research aim as previously contemplated. The Figure 2 illustrates the process of in-depth review.

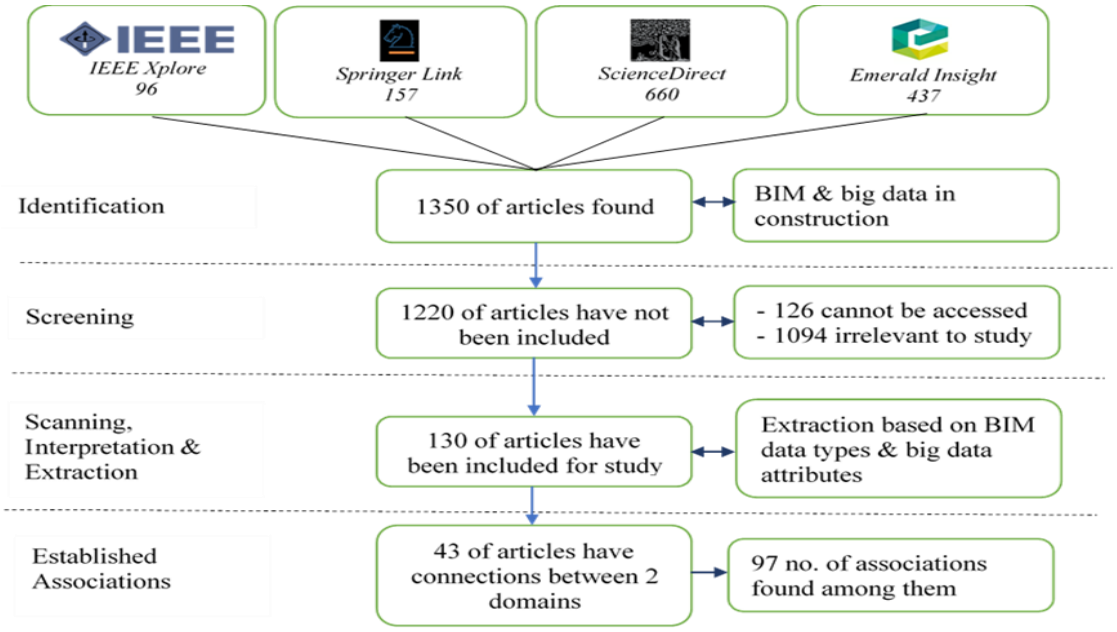


Figure 2: Process of In-depth Review

4. Systematic Mapping Analysis Outcomes

Based on Table 2, the mapping analysis delineates the significant connection between BIM data types and big data attributes. Firstly, the most associated BIM data is operation and maintenance data where it is being linked with 6 out of 6 V's of big data characteristics. This is happening might because of the operation and maintenance stage is the lengthiest period throughout the lifecycle of building or infrastructure which allows the generation of data from various sources in a continuous manner [29]. In contrast, the least relatable is specification data that only can relate to veracity. It is might due to the construction specifications require the construction workers to follow accurately and precisely the scopes and methods that have been outlined [88]. Despite the least is only can be linked with a single attribute, it depicts that all the identified types of BIM data have connections with big data attributes. In the perspectives of big data, veracity is the only attribute that is being emphasized in each of the BIM data since the accuracy of data is important for smoothness in construction. As it has been mentioned that clearly defined data and information needed in the BIM platform for the improvement of the project in the earlier stage and lessen the conflicts during the construction stage [16, 21]. On the other hand, the least associated big data attribute is velocity where it is only related to operation and maintenance data. It can be because of the generation of sensor data during the operation phase through automation systems and others [89]. The outcomes from the systematic mapping hypothetically reflect the connotations among the two domains based on the analysis of the relevant literature. This will be a useful basis for future research that seeks to determine the associations between BIM and big data in the real-world practice.

Table 2: Mapping of BIM Data Types to Big Data Attributes

Attributes of Big Data / BIM Data Types	Volume	Velocity	Variety	Veracity	Value	Visualization
Material	[52]		[31]	[24, 28, 53, 54]		[55]
Design	[16, 56]		[57]	[21, 58]	[16, 28, 57]	[24, 32, 57, 58]
Dimension				[53, 58]		[24, 58]
Cost			[31, 59]	[24, 28, 32, 54]		
Specification				[60, 61]		
Schedule				[62, 63]	[24]	[55, 63, 64]
Operation & Maintenance	[16, 36, 52, 65-76]	[36, 52, 66, 68, 69, 73, 77-80]	[31, 65, 67, 69, 71-73, 78, 81-85]	[21, 65, 72, 81, 84, 85]	[36, 66, 67, 71, 72, 82, 84, 86]	[65, 70, 72, 77, 81, 82, 84, 87]

5. Conclusion

The study findings are restricted by the number of papers that can be accessed via the UTM database. Despite the dearth of literature on the topic, researchers have used systematic mapping analysis to determine the commonalities between various kinds of BIM data and the properties of big data. It showed that all the different kinds of BIM data have some kind of relationship to the big data characteristics, but that only the data related to operations and maintenance meet all six requirements of big data. At the same time, out of all the stated BIM data types, only truth has relationships.

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