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Associations Between Building Information Modelling (BIM) Data and Big Data Attributes

Faris Hyder Ali[a]*, Shamsulhadi Bandi[b]

[a,b]University of Technology Malaysia, UTM, Skudai, 81310, Malaysia

[a]Email: faris.ha@graduate.utm.my

[b]Email: shamsulhadi@utm.my

Abstract

There is a considerable effort to create and leverage digital data as the construction industry today relatively adopts innovative work processes. Among the innovative work processes getting traction these days, Building Information Modelling or BIM sits at the backbone of the industry's digital strategy with the capability to create a huge volume of digital data. Unveiling, the huge volume of digital data created by BIM processes could pave the way to leap the industry further. Big data is useful in this regard as a platform to derive potential insights from the accumulation of BIM digital data. Despite, a review carried out to understand the connection between BIM data and big data attributes suggests that the linkage between these domains is scantily mapped. Hence, a systematic mapping of these two domains is needed as a precursor for future research to establish the relationship between BIM data creation and big data progression. Using a systematic mapping approach, this paper aims to present an outcome from the analysis carried out to map both BIM data and big data attributes. The mapping analysis evidently suggests a noticeable connection among the two domains, mostly in operation and maintenance while the least is in the specification.

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

1. Introduction

While major industries begun to embrace technologies to improve revenue and productivity, construction industry appeared to be lagging in many aspects of technology adoption. Gartner Benchmark Analytics report stated of 19 industries surveyed in 2014, construction appeared sitting in the bottom where only 1% of revenue is being spend for overall technology adoption [1].

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* Corresponding author.

Alarmingly, as construction is only contributes minorly to national economy compared to other sectors [2], there is a need for the industry to be developed by adopting the many approaches offered by technologies [3]. Despite, some of the prominent technologies' intervention should not be left unnoticed. Fuelled by the concept behind the Industrial Revolution 4.0 and the initiatives led by construction stakeholders around the world, construction began to innovatively adopt technologies following the benefits it provides to the whole spectrum of construction practices [4]. These technologies, though some appeared to revamp the current practices are in fact needed to propel construction on par as any other industries. Even though the economic growth of construction can be expected to upsurge through technological realization, the sector is already well known for its contribution to the economic growth and socio-economic development in each country including Malaysia [5, 6]. As reported in Economic Census, there had been positive growth with 14.3% of annual growth rate in 2015 in comparison to 2010 in Malaysian construction economy though small in comparison to other sectors [7]. Since the construction is essential in terms of contribution towards the economy, it has been improved from time to time through various efforts such as the establishment of CIDB, the revision made to construction contracts, development of alternative procurement systems and so on [8-10]. Besides all those efforts, the industry still needs to be improved through the incorporation of technologies in its processes since the effort can help increase the productivity level where the potentiality was found about 5 decades ago [11-13]. Concurrently, technological adoption also will lead to the growth of the economy since it brings impact towards the national economy at the macro level while profit and market shares to companies and firms at the micro-level [14, 15]. Therefore, the digital technology can augment the construction to a better position. Currently, despite being among the least digitized industry, there are several technologies already being adopted such as augmented reality, building information modeling (BIM) software, cloud computing, Internet of Things and so on [16, 17]. Amidst several technologies in construction, BIM has a big impact towards the industry since it is being viewed as a backbone of new working method and digital strategy since the application is capable to connect and integrate with various kind of software which will lead to the creation of voluminous data [18]. Besides, without the integration, BIM alone is capable to produce huge amounts of data throughout the building lifecycle [19, 20]. Therefore, it inclines towards the outdatedness of BIM software itself where it will require another appropriate platform to ensure management and utilization of data [16, 21]. This is the situation that depicts the relevancy of the concept of big data in relation to BIM where the concept concerned with coping a large amount of data effectively [22]. Despite the relevancy of the concept, the relationship of BIM data to big data attributes is largely unknown. Thus, a systematic mapping of these two domains is required as a prerequisite for future research to be carried out. Hence, this paper aims to present an outcome of a systematic analysis carried out to map both BIM data and big data attributes. It outlines two objectives: (1) to explore a relevant piece of literature concerning the BIM data types and big data attributes, and (2) to identify a common connection between BIM data types and big data attributes. Therefore, this research has been carried out through an in-depth literature review.

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.

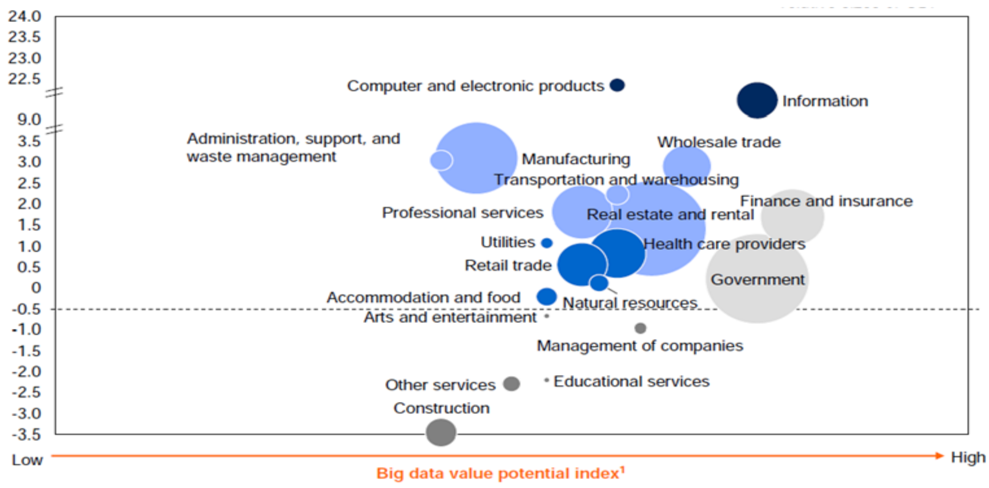

Figure 1: Potential of Various Industries in Capturing Value from Big Data [46]

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.

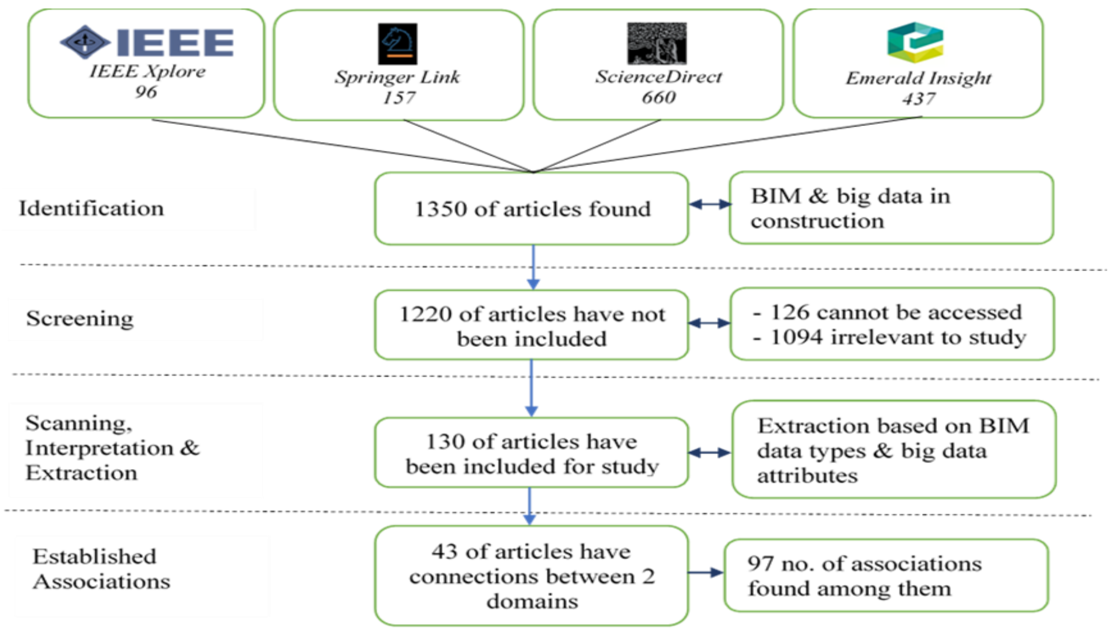

Figure 2: Process of In-depth Review

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 outcomes of the research are constrained by limited articles available and accessible through UTM database only. Despite limited literature available concerning BIM and big data, the research still has managed to identify the common connection between types of BIM data and big data attributes which are realized through systematic mapping analysis in available research. It depicted that all BIM data types have their connection with big data attributes though only operation and maintenance data that fulfil all 6 V's of big data. Meanwhile, veracity is the only attributes that has associations with all defined BIM data types.

6. Recommendation

Although the associations are only established in a theoretical manner, this will be an initial step to overcome the oblivious state of their relationship. Therefore, this identified connection is imperative since it can be the basis to carry out future research particularly on the effect of BIM data creation on big data progression. This will lead to the recognition of the relationship between them and whether the BIM is leading towards big data or otherwise in reality.

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