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Importance of Utilising Big Data Analytics in Enhancing Construction Data Management

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With the extensive volume of data accumulation, the need for a powerful, and effective data management tool became prominent. As a result, Big Data Analytics became a major choice of data management for different industries. However, the adoption of Big Data Analytics has been slow in the construction industry. Therefore, this research focused on identifying the importance of utilising Big Data Analytics in construction industry. A comprehensive literature synthesis was conducted to identify the requirement for an effective data management tool such as Big Data Analytics. In this context, different types of data, the advantages of properly managing data in construction context, along with an overview of the evolution of Big Data in the construction was reviewed. Thereafter, a qualitative research approach was adopted as the appropriate approach and semi-structured interviews with industry practitioners from Construction and Information Technology sectors were conducted. According to the findings, it was proved that Big Data Analytics has immense potential in enhancing the overall quality of the industry by acting as a data management tool. Accordingly, it is evident that the utilisation of Big Data Analytics in construction projects is crucial for effective data management and ultimately for the enrichment of the construction industry.

Keywords: *Big Data Analytics, Construction Industry, Data Management.*

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Introduction

The construction industry can be identified as a major contributor towards the economic growth of countries due to the role of the industry towards socio-economic development, specifically in developing economies (Lopes, 2012). Simultaneously, Oladinrin, Ogunsemi, and Aje (2012) stated that the performance of the construction industry is vital in the process of achieving the socio-economic development goals aimed at providing shelter and employment along with infrastructure development. Hence, Khan, Liew, and Ghazali (2014) emphasised that the positive performance of the construction industry is beneficial for an economy in numerous forms including wealth creation, increasing the quality of life, and creating employment. Since the construction industry performance depends majorly on the successful completion of individual projects, Khun-anod and Limsawasd (2019) stated that a thorough understanding of the factors that can affect the project performance is essential. In this context, Bandoh (2018) identified the inadequate understanding of resource requirements, ineffective collaboration, inefficiencies in risk identification and scheduling and design errors as major issues persisting in construction projects.

Based on the arguments made by Durdyev and Mbachu (2011), the construction industry is lagging behind most of the other industries in terms of performance due to planning, coordinating, and communicating complications relevant to data management. Since the construction industry heavily relies upon the historical data of projects, the lack of unified data management approaches has been hindering the performance of the industry (You, Fu, & Shi, 2018). Simultaneously, the diversity of data collected from the current construction projects is increasing due to the unique nature of construction projects from each other along with the involvement of different data storage formats (Storey & Song, 2017; Zhang, Luo, & He, 2015).

In order to address the above issues, traditional measures of data analysis must be made obsolete while new theories and methods must be incorporated to manage the growing demand for modern technologies with new perspectives (Wang, et al., 2018). Accordingly, Big Data analysis can be identified as an efficient measure to manage the unlimited amount of structured, unstructured, and semi-structured information within the construction industry (Kostyunina, 2018). This statement can be supported by the works of A. Konikov and Konikov (2017) where they emphasised that the three (03) V's concepts of Big Data; Volume, Velocity and Variety can be applied towards the construction data as well. However, further studies of numerous researchers have been focused on five (05) V's of Big Data with the addition of Veracity and Value (Han & Wang, 2017; Zhang, Luo, & He, 2015). Accordingly, the effective integration of 5V principles of Big Data has the potential of improving the overall performance of the construction industry that can transform economies (Manyika, et al., 2011). Further, Bilal M., et al. (2019) stated that the integration of Big Data analysis into construction projects can revitalise the total industry by providing opportunities to improve the construction project performance through data-driven insights. Hence, the aim of this paper is to identify the importance of the utilisation of Big Data Analytics in construction industry as a data management tool. The paper is structured as follows. Initially, it provides a comprehensive literature review on construction data types, and evolution of big data as a data management tool. This is followed by the methodology along with findings and conclusions.

Literature Review

Different Types of Data in the Construction Industry

Building-related information and data accumulation have become a top priority in the modern era, where capturing and reusing accumulated information towards generating insights throughout the entire building life cycle have been pursued by many industry practitioners (Xu, Ma, & Ding, 2014). According to Zhang, Luo, and He (2015), basic project data can include data such as project briefing data, soil and geo-physical investigation reports, construction technique data, potential tenderer list, financial requirements of the project, cost estimates, material requirement statements and drawings. Accordingly, construction data are being stored in separate databases according to their structural forms (Konikov, Kulikova, & Stifeeva, 2018). These different databases can be categorised based on different formats

such as formatted report data stored in a company system, text data generating from different computers, tabular data, project cost-related data, picture, and video data along with 3D and 2D drawing files (Zhang, Luo, & He, 2015). According to Xu, Ma, and Ding (2014), different types of data in numerous formats require different data processing and data storage methods. As a result of this segregation, data has been categorised into three (03) main sub-sections namely, structured, unstructured, and semi-structured data which are all persistent within the construction context (Zhang, Luo, & He, 2015).

Current Data Management Techniques in the Construction Industry

With the increasing complexity of construction projects and industry-related technologies, data management has gained the attention of the industry practitioners in the present (Alsubaey, Asadi, & Makatsoris, 2015). This trend has been increasing in the construction sector since drawings and specifications with appropriate mediums have become a widely used data exchange technique by different stakeholders (Rajaratnam, Weerasinghe, Abeynayake, Perera, & Ochoa, 2021). In addition, Rezgui, Boddy, Wetherill, and Cooper (2011) stated that design data are generally shared among different parties using proprietary drawing formats such as DXF (Drawing/ Data Exchange Format) along with additions such as dimension layers and supporting documents. Accordingly, contract programme development, method statement and schedule preparation along with other planning deliverables are used as main information-sharing formats in the industry (Braimah, 2013). Moreover, management of data formats such as manual sorting, algorithm-based automatic processing, automatic text scanning and recognition can be identified as the main data management techniques utilised in the construction industry at present (Zhang, Luo, & He, 2015). However, despite having designated techniques in managing current datasets in the industry, traditional data management tools such as Relational Database Management Systems are not adequate in capturing, storing, distributing, and managing the extremely heavy load of data generated at present (Tanwar, Duggal, & Khatri, 2015). Further, Xu, Ma, and Ding (2014) emphasised that due to the lack of efficient data management platforms to match the increased rate of generation of data, most of the valuable data insights are not being properly utilised.

Applicability of Big Data as a Data Management Tool

The amount of data created within the world has been on the rise rapidly, where data set analysing has become one of the major concerns for most industries at present (Gaith, Khalim, & Ismail, 2012). According to Sagiroglu and Sinanc (2013), the amount of data created by humans was 5 exabytes until 2003, where the same amount can be created within 2 days at present. Therefore, many organisations are focusing on developing methods that can be used to extract and capture value from the abundant data volumes (George, Haas, & Pentland, 2014). Accordingly, the concept of big data was developed as a suitable option in deriving value from available datasets, where big data is defined as the amount of data that is beyond the ability of the existing data management tools to store, manage or process efficiently (Ozkose, Ari, & Gencer, 2015). As a supporting argument, Snijders, Matzat, and Reips (2012) identified big data as a term used to define large data sets which are highly complex up to the extent where they cannot be easily processed with the standard statistical software.

Big data is originated from numerous sources including internet click streams, online and mobile transactions, user-generated information, along with purposefully generated and collected information emitting from sensors or personal and business transactions (George, Haas, & Pentland, 2014). Big data generated from the above sources can provide invaluable insights to managers and other level users that can be directly used to improve the decision-making process radically (McAfee & Brynjolfsson, 2012). Thus, Schermann, et al. (2014) identified big data as a measure that provides the right information to the right user at right time within the parameters of the right volume and right quality. Similarly, Fan, Han, and Liu (2014) stated that high-dimensional data analysis such as big data serves two primary objectives namely, developing effective measures that can be used to predict the future through observations accurately and providing knowledge regarding relationships persisting between different features for scientific purposes. Moreover, the existing rate of data generation is expected to escalate rapidly with the technological advancements where it is anticipated that data will become available at a cheaper rate in

the future compared to the present (Fan, Han, & Liu, 2014). This trend is expected to increase or even accelerate in the future due to the unique principles of big data that are categorised as the 5V's of big data; Volume, Variety, Velocity, Veracity and Value (Wamba, Akter, Edwards, Chopin, & Gnanzou, 2014).

5V Characteristics of Big Data

A common misconception exists among business executives regarding whether 'big data' and 'standard data analytics' are the same concepts distinguished only by the term used to identify each concept (McAfee & Brynjolfsson, 2012). According to Sagiroglu and Sinanc (2013), these two terms have been creating confusion among different practitioners where the authors distinguish these terms according to the three key differences in big data: namely, Volume, Velocity and Variety. Apart from the traditional concept of 3V's of big data, most authors have identified new and emerging 'V's that can be used to define the modern characteristics of big data such as Veracity and Value (Han & Golparvar-Fard, 2016). Thus, big data can be further described as datasets that have high-volume, high-velocity, and high-variety along with high quality or veracity that can add value to the users in enhanced decision making, knowledge and insight discovery and optimisation of different processes (Ji, Li, Qiu, Awada, & Li, 2012).

Evolution of Large Datasets in the Construction Industry

The evolution of information technology has paved contemporary pathways for numerous industries to handle operations and as a result of this evolution, many industries made the transition from the conventional paper-based system to the digitally based information exchange (Gaith, Khalim, & Ismail, 2012). However, the construction industry has been identified as an industry with stagnant use of technological advancements compared to other industries (Goodrum, et al., 2011). According to Ratajczak, Riedl, and Matt (2019), the construction industry has been on an incline in both productivity and economic growth due to the involvement of IT. The main reason behind the productivity growth is the opportunities provided by the innovation in the industry that had a positive impact on the collaboration, communication, and information exchange within the industry (Gaith, Khalim, & Ismail, 2012). Similarly, big data analysis and developing valuable insights from massive datasets to discover latent trends have gained momentum in the construction industry as well (Bilal, et al., 2015). As a supporting argument to the aforementioned point, Colombus (2018) stated that there has been a growing curiosity to utilise big data analysis to improve the performance of the construction industry.

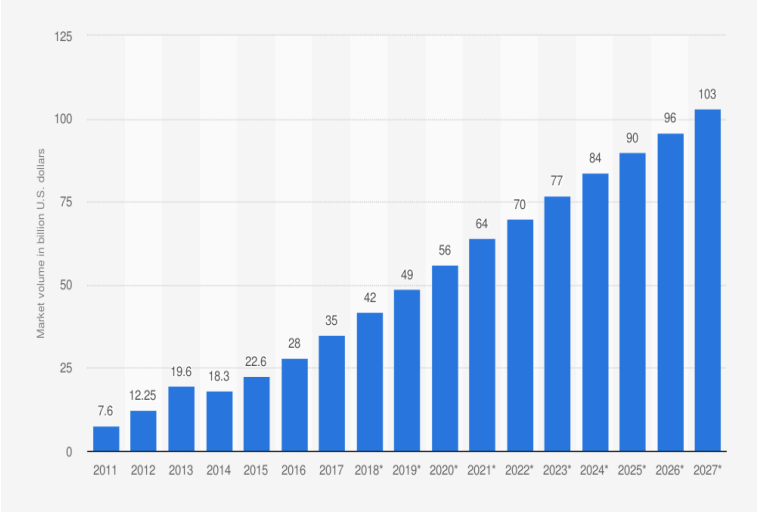

Figure 1: Change in the interest in big data by years from 2011-2027 (as projected)
Source: Colombus (2018)

According to Figure 1, the interest in the use of big data and the number of studies conducted regarding the tendency to utilise big data to improve the performance of numerous industries have increased over the years, hence, it is expected to increase in a steep curve in the future (Ozkose, Ari, & Gencer, 2015).

Methodology

This study aims to identify the importance of utilising big data analytics in the construction industry. Based on the exploratory nature of this study, A qualitative research approach was undertaken in achieving the aim of the research with data collection and analysis methods suitable for the qualitative approach. According to Almalki (2016), the qualitative approach is a measure used to identify the meanings that individuals or groups place on social or human problems. Initially, an extensive literature review was conducted to review the concept of Big Data and BDA related to the construction industry in the global context. Further, semi-structured interviews were conducted with construction practitioners and BDA Experts to evaluate the feasibility of applying BDA in the construction industry. According to Priola (2019), qualitative interviews allow the researcher to gain comprehensive information from the interviewees by assessing their opinions and experience through in-depth questioning. Since this research is focused on assessing the application of BDA in the construction industry, in-depth opinions and experiences of the respondents must be gathered. The profiles of the respondents are presented in Table 1.

Table 1: Profile of the respondents

Respondent	Discipline	Industry Experience	Exposure to Construction Sector	Exposure to Big Data Analytics
R1	Director – Consultancy Firm (Ch. Quantity Surveyor)	30 years	Yes	Yes
R2	Director – Consultancy Firm (Ch. Engineer)	25 years	Yes	Yes
R3	Lecturer – Leading University (Computer Science Engineer)	20 years	Partially	Yes
R4	IT Consultant – Consultancy Firm	12 years	Yes	Yes
R5	Technical Manager – Engineering Software Development Organisation	07 years	Yes	Yes
R6	Data and Business Analyst	07 years	Partially	Yes
R7	Quantity Surveyor	07 years	Yes	Yes
R8	Lecturer – Architectural Software School	06 years	Yes	Yes
R9	Civil Engineer	06 years	Yes	Partially
R10	Machine Learning Engineer/ Machine Learning Researcher	02 years	Partially	Yes
R11	Data Analyst	02 years	Partially	Yes
R12	Cybersecurity Specialist	02 years	Partially	Yes

In order to properly address the use of big data analytics in the Sri Lankan construction context and the global context, experts from Sri Lanka as well as from foreign countries, were interviewed. Ultimately the collected data was analysed through manual content analysis method since it can provide meaningful insights to the research area.

Findings of the Study

Applicability of Utilising Big Data Analytics in the Construction Industry

Big Data Analytics can be utilised for large volumes of datasets with high velocity and a variety that has the capacity to be valuable to the end users by providing high quality insights. Hence, when assessing the applicability of Big Data Analytics in any industry, it is important to assess whether the industry contains datasets with the above characteristics while having structured, unstructured, and semi-structured data types. Accordingly, all the respondents were asked to identify the different types of data in the construction industry. In this context, all the respondents identified the different data recording and storing methods used for different types of activities within different stages of a construction project as identified in Table 2.

Table 2: Different types of data recording and storing used in the construction industry

Date Records	Data Recording and Storing Methods
Drawing files	AutoCAD 2D+3D, Revit Architecture, CostX, Image files, Handwritten records
Soil investigation reports	Microsoft Word, Microsoft Excel, Image files, Handwritten records
Cost estimates	Microsoft Word, Microsoft Excel, Image files, Handwritten records, AutoCAD 2D+3D, Revit Architecture, CostX, Navisworks, Bluebeam, Planswift, CATO, Candy, CubiCost
Bills of Quantities	Revit Architecture, CostX, Navisworks, Microsoft Word, Microsoft Excel, Image files, Handwritten records, Bluebeam, Plaswift, CATO, Candy, CubiCost
Specifications	AutoCAD 2D+3D, Revit Architecture, Microsoft Word, Microsoft Excel, Image files, Handwritten records
Project programmes	AutoCAD 2D+3D, Revit Architecture, Navisworks, Microsoft Word, Microsoft Excel, Microsoft Project, Handwritten records, Audio and Video formats, Synchro Pro
Method statements	AutoCAD 2D+3D, Revit Architecture, Microsoft Word, Image files, Handwritten records
Invoices and payment records	Microsoft Word, Microsoft Excel, Image files, Handwritten records, Quickbook
Geological Data	GIS Software
Project Management Data	Primavera
Drawing files	AutoCAD 2D+3D, Revit Architecture, CostX, Image files, Handwritten records
Soil investigation reports	Microsoft Word, Microsoft Excel, Image files, Handwritten records
Cost estimates	Microsoft Word, Microsoft Excel, Image files, Handwritten records, AutoCAD 2D+3D, Revit Architecture, CostX, Navisworks, Bluebeam, Planswift, CATO, Candy, CubiCost
Bills of Quantities	Revit Architecture, CostX, Navisworks, Microsoft Word, Microsoft Excel, Image files, Handwritten records, Bluebeam, Plaswift, CATO, Candy, CubiCost
Specifications	AutoCAD 2D+3D, Revit Architecture, Microsoft Word, Microsoft Excel, Image files, Handwritten records
Project programmes	AutoCAD 2D+3D, Revit Architecture, Navisworks, Microsoft Word, Microsoft Excel, Microsoft Project, Handwritten records, Audio and Video formats, Synchro Pro

Source: Findings of the Study

According to Table 2, it is evident that the activities in a construction project utilises different software and other methods to record and store data. Therefore, a large accumulation of data will be there from each construction project. In this sense, it is essential to have a proper data management approach such as Big Data Analytics. According to R4, with the adoption of digitalisation, a large amount of data, especially unstructured data have been generated. However, most of the data generated are wasted and unused due to a lack of proper data analysis tools. At present, there is basic analysis software used by many professionals. However, according to R4, *"only structured data can be easily analysed using relational database analysis software used in the present".* Unstructured data generated from different sources in large volumes and velocities are overwhelming the existing data analysis software. Therefore, R2 identified Big Data Analytics as the solution to the large volumes of data for many industries.

In addition, R10 identified big data as a sub-area of ML that extracts valuable information from large datasets that are difficult to be processed using conventional data processing methods. As mentioned by the respondents, Big Data Analytics is an invaluable addition to the data management aspect of different industries. The construction industry is not an exception and therefore, the use of Big Data Analytics in construction is also highly essential. According to R6, the construction industry produces large volumes of data at present with the use of BIM in 3D or even 5D. Moreover, R5 specified that in the pre-construction as well as in the post-construction phase, construction professionals must deal with large volumes of data. However, the construction industry has not adopted the use of big data properly. According to R5, during his time at a contracting organisation, the traditional and handwritten methods were mainly used for data recording purposes, especially in bar schedule and other material record keeping. As a result of this, there were many problems associated with the data analysis since they had to manually sort and find required data for new projects. Therefore, R5 mentioned that digitalised methods of data recording allow improved storage, organisation, categorisation, and analysis of data which can be used for different purposes later. However, most of the respondents agreed that the use of Big Data Analytics is limited in construction, especially in Sri Lanka. Even in the global context, the full use of Big Data Analytics has not been achieved by many industries.

Importance of Big Data

According to R2, if Big Data Analytics is properly integrated, it can provide numerous advantages to different industries. R2 further emphasised that many industries have been utilising Big Data Analytics for some period mainly for marketing purposes. According to R2, *"Companies such as Facebook, Google, Apple and Amazon use Big Data Analytics daily to improve their businesses".* In addition to the analysing advantages of Big Data Analytics, R4 highlighted that storing unstructured data can also be difficult due to the various storage requirements. Since Big Data Analytics software and platform provide adequate storage spaces and other requirements, transitioning towards Big Data Analytics is highly beneficial for many industries. In addition, R10 further stated that Big Data Analytics is useful when extracting graph features from large graphs that consist of millions on nodes such as social media networks. Accordingly, most companies use Big Data Analytics to generate valuable insights from data collected in social media.

Most of the respondents highlighted the example scenarios that can be improved by using Big Data Analytics. In this context, R5 specified that the use of Big Data Analytics will be beneficial in ensuring collaboration among construction professionals. This is possible due to the increased use of BIM in construction projects. As an example, R5 stated, *"if a designer completes his design in a Revit model and shared it with other construction professionals, all the other team members will be able to work on a common platform".* This will avoid numerous disputes and delays in the total process. According to R4, *"some actual expenditure will exceed the original budget and as a result, some construction companies may go bankrupt".* This happens due to a lack of planning and not having a way to know possible price increases and other negative outcomes beforehand. With the use of Big Data Analytics, this aspect becomes possible, and the construction companies will be able to avoid high costs and time overruns. In addition, R4 stated that cost estimates, quantity estimates and all the other prior estimating activities will be possible with the use of Big Data Analytics. Based on these estimates, construction

professionals can decide how to manage certain resources. Therefore, the overall quality of the construction will increase, and the industry will improve in terms of time, cost, and quality of the outputs.

Conclusions

Due to the complex nature of construction projects, there can be large volumes of data accumulation in a high velocity which can be converted into valuable insights with the integration of a proper tool. However, the construction industry has not adopted a proper data management tool that can utilise the large data accumulation to enhance the overall productivity of the industry. When assessing the Sri Lankan context, the industry is lagging behind from other countries in terms of technological revolution. Therefore, as a solution to address the large data accumulation and data wastage due to not being managed properly, Big Data Analytics can be identified. As this study pointed out, construction projects involve different types of software and different data recording and storing formats which can result in a large collection of data throughout the project lifecycle. In addition, from the suggestions made by the industry experts on the use of Big Data Analytics in the construction sector, it is evident that utilising a proper data management tool such as Big Data Analytics can improve the decision making and numerous other aspects of construction projects which can enhance the overall productivity of the industry leading to nation-wide socio-economic developments, especially in developing countries such as Sri Lanka.

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