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The Future of Facility Management: A Case for Digital Twin

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ABSTRACT

In the field of building and construction, a digital twin model of all physical information substantially enhances decision making all through the individual stages in the life cycle of a facility starting from the preconstruction activities to deconstruction. In essence, digital twin can increase efficiency in building construction, management, and deconstruction. Based on this, the current study aims to understudy the benefits of application of digital twin to the built environment and building management systems. The study reviewed archived literature on digital twin, facility management, building management systems and the built environment. Findings from this study revealed the importance of digital twin in the built environment. Digital twin technology is a means to efficiently accomplish tasks in the building and construction industry. It can be used to mitigate cost and risks in the probable chance that something goes wrong. The predictive nature of digital twin is a massive game-changer for effective forecasting in building management; hence there is an imperative need to seek its advancement within the building industry.

Keywords: Digital twin, Digitalisation, Cyber-physical systems, Facility management, Building management

BACKGROUND

In very recent times, both the industry and academia have focussed more interest on digital twin as it was listed amongst the top 10 innovative scientific trends in 2017, 2018 and 2019 as inventoried by Gartner (Qi et al., 2018). With the recent trends in the uprising of cyber-physical systems and digital twin technology, it can be implied that the digital and physical worlds are gradually developing a solid inter-relationship and will definitely integrate as a whole in the nearest future, creating an alternate virtual universe (Qi et al., 2019). Following the entrance of the fourth industrial revolution, there is a specific need to optimise the built environment management system to meet the needs of the new age (Aziz, Nawawi, and Ariff, 2016). This research seeks to revolutionise management practices using digital twin to meet up with the 21st-century world. Ultimately, this study will develop a workable framework for optimising the management systems for built environment assets. This optimisation is necessitated by integrating IoT in built environment assets and

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the emergence of smart and intelligent buildings, infrastructures and cities. Managing the built environment components through digital twin technology will be the future of building and facility management.

STRUCTURE OF THE STUDY

This study was conducted using systematic reviews from relevant literature published on digital twin, facility management, building management systems and the built environment. The study reviewed extant archived literature from significant research databases. The database selected for the study includes the Web of Science and Scopus. The paper is structured as follows; Section 1 constructed a background to the study that developed to highlight the aim of the research. Section 2 discussed the structure which the study followed. Section 3 discussed the concept of facility management and innovation in the field. Section 4 extensively reviewed the concept of digital twin. Section 5 explored how built environment assets and building management systems can be improved through digital twin. Section 6 explored the implications of digital twin application to the built environment, discussing the lessons learnt, benefits and challenges of applying digital twin to facility management, building management and the entire built environment systems. Section 7 concluded the study, highlighting the responsibilities for best practices for a built environment based digital twin.

THE NEED FOR INNOVATIVE FACILITY MANAGEMENT

Making and executing decisions are very vital aspects of the management process of any investment in the building sector. Every management decision that must be made and subsequently executed all through the life cycle of an asset to upgrade its physicality, functionality, and performance must be made with proper care (Araszkiewicz, 2017). From the investment perspective, which is more concerned with return on investment, cost efficiency and profitability are significant factors that must be taken into consideration in the management process (Noor and Pitt, 2009). Investing in the building sector might be a little tricky as a lot of abstract attributes must be taken into consideration when estimating the returns. This escalates the need for a holistic outlook of the asset's lifecycle, which incorporates all management process involved with the asset right from conception, all through construction, maturity, usage, up-gradation till demolition (Potkány, 2015).

To ensure facilities reach their full financial and profitability potentials, a competent management process and system must be implemented. An efficient management system is informed by excellent and timely decision making. That usually involves the integration of all data emanating in the course of facility operation and the large pool of information accumulated from the various professionals and stakeholders who have been involved in the facility at one point within any phase of the facility life cycle (Noor and Pitt, 2009). Araszkiewicz (2017) noted that the tactical objectives of facility management could only be achieved through effective conveyance of information among building stakeholders and personnel.

Over the years, facility management has been characterised by drastic development to include digitalisation and information technology tools that aid information processing and management. Incorporating information technology into the new age facility management has created an avenue to provide more efficient solutions on operational buildings (Qi et al., 2018). This fusion has eased the process of estimating cause and effect models, interpreting the information from models, mapping out adequate forecasts and drawing probable conclusions, thereby facilitating a more efficient management system (Aziz, Nawawi, and Ariff, 2016). The building industry has been graced with a number of transformations in the last couple of decades. These transformations can be attributed to the infusion of digitalisation into all practices within facility life cycle management (Støre-Valen, 2019).

THE CONCEPT OF DIGITAL TWIN

Digitalisation as a paradigm has drastically improved over the years. This improvement can be attributed to advancements in Information communication technology in recent years, especially new generation technologies including artificial intelligence (AI), three dimensional (3D) systems, cloud computing, simulation, and Internet of thing (IoT). As a result of the newfound interlinkages between the virtual world and the physical, digitalisation has become the basis of numerous innovations of the new world (Botkina et al., 2018). The world today has become engrossed with digitalisation. This has given rise to the concept of a digital twin, which outlines the virtual models of systems. In the 21st century today, this concept is revolutionising the world (Tao and Qi, 2019).

The concept of digital twin is one that ensures virtual models rely on data in terms of boundary conditions, behaviours, parameters, and dynamics collected from the physical entity that allows for real-time illustrative replication of the models (Tao and Qi, 2019). Rosen et al., (2015) noted that the concept behind digital twin is not new, however, it emanates from combinations of existing technologies including, 3D modelling, simulation, and prototyping. Numerous fields are beginning to intellectualise the application of digital twin to specific areas. Generally, it is used to pre-empt complications and optimise system efficiency (Tao, Zhang and Nee, 2019). Digital twin is based on the concept of cyber-physical systems, which is an intricate interrelationship between the real world and the cyber world. Cyber-physical systems are aimed at attaining a superior world through the inter-fitting of physical space and cyberspace (Shelden, 2018).

The concept of digital twin gives meaning to the possibility of an alternate universe and a science fiction future. The pioneering use of the concept of Digital twin can be tracked back to the early 21st century when NASA used it to create a virtual replica of spacecrafts in order to run diagnostics and troubleshoot solutions to problem that might be encountered in the actual flight. The application of digital twin to various industries have been tested and numerous organisations have gotten around to designing and creating digital twin for their physical assets. For instance, digital twin has used in the manufacturing industry to enhance service delivery, supply chain management, and business development (Alonso et al., 2019).

IMPROVING BUILDING MANAGEMENT SYSTEMS THROUGH DIGITAL TWIN

In the recent clamouring for digital twin usage, the built environment has not been left out. Construction engineers, architects, and other building stakeholders have shown major interests in the adoption of digital twin in the building sector to enhance service quality and users' satisfaction throughout buildings and infrastructure life cycle (BSI Group, 2019). The application of digital twin to the built environment field requires that the physical architecture of the real asset be digitally duplicated into a virtual form with all pertinent information (Ito, 2019). By nature, the built environment is a very complex and unpredictable system which makes it more challenging to be digitised than other controlled systems such as a production assembly. However, recent trends and development in digitalisation and cyber-physical systems have made digital built environment a possibility, and as such create immense opportunities for transformation and innovation within the built environment field. This innovative transformation has made digital twinning possible (BSI Group, 2019). Digital twin entails replicating a complex virtual building model on the cyberspace, which can then be used to generate an almost accurate simulation of intricate real-life situations and occurrences (Ito, 2019).

A digital twin for facilities does not only cover the design and construction of built environment facilities but also incorporates all post-construction and operational phases. The digital twin system is designed with the capacity of collecting, computing, and interpreting all data vital throughout the lifecycle of a facility. This is done to ensure an informed and timely decision making in order to enhance operational efficiency (Alonso, 2019). In the same vein, Ito (2019) noted that the technology allows for the acquisition of data from the physical world through a complex network of sensors installed as part of the building. Building data obtainable includes environmental information, energy consumption, water flow, indoor environmental quality, structural conditions, underground conditions, leaks, electricity and stability, as well as lighting, heating, acoustic and cooling systems, to mention a few. Data obtained through physical interconnected sensory systems will be used to perform analytical simulation for the virtual building in the digital space (Støre-Valen, 2019).

Industries in the modern world are predominantly dependent on a highly complex operational process to run effectively and efficiently. This makes management and maintenance various components of different economic industries a herculean task. One of the vital necessities of providing proactive management and maintenance is the ability to adequately gather data on the health status of physical components within the system. Digital twin offers an avenue through which the physical condition of elements within a system can be ascertained, hence it industry application is most suitable for predictive maintenance (Aivaliotis, 2019). The concept of digital twinning has been applied successfully in other fields. In the field of building and construction, a virtual model of all physical information substantially enhances decision making all through the individual stages in the life cycle of a facility starting from the preconstruction activities to deconstruction. In essence, digital twin can be used to increase efficiency in building construction, management as well as deconstruction (Alonso, 2019). Looking to the future, digital twin will transcend built environment modelling beyond individual buildings to incorporate the whole society to comprise of urban metropolises, including people, buildings, facilities, transportation routes, electrical grids, and other urban infrastructure systems which will expedite the adoption and development of cyber-physical systems (Ito, 2019).

IMPLICATIONS OF DIGITAL TWINS IN THE BUILT ENVIRONMENT

The application of digital twin in the built environment will, by a great margin, revolutionise the industry. Using digital twin, physical assets and facilities can be better designed, planned, constructed, managed and maintained. Organisations involved with any part of construction and operation of built environment assets can utilise digital twin technology to efficiently accomplish their tasks. It can be used to mitigate cost and risks in the probable chance that something goes wrong. Plans and theories on buildings and infrastructure can be subjected to rigorous tests in the virtual environment before they are applied in the physical world. This is done to detect and filter out any kind of anomalies in the new plan that can affect the construction or operation of the facility. Once a problem is detected in the virtual environment, efforts can be taken to rectify and re-test them for success before direct application to the physical world. This will help to navigate through foreseen problems which save time, cost and risk that would have been incurred if the plans were to be directly implemented in the physical world without initial realistic tests. Digital twin can be used to answer an important question, 'what outcome is to be expected if we carry out this task?'.

The benefits of digital twin become insanely crucial when it is utilised for prediction purposes. Forecasting the future in the built environment has always been difficult because of its complex nature. However, with the advent of digital twin, predicting future events about built environment facilities will make it easier. Being able to visualise plans and theories through digital twin before implementation during construction and operation of buildings has advanced the predictability of built environment components. In totality, digital twin has the potential to enhance decision making about the kind and size of facility needed as well as when exactly it will be needed. It will also improve decision making in maintenance, safety and for risk mitigation. All these benefits of digital twin will drastically improve efficiency in construction, management, and maintenance of facilities, rippling into improved services and user satisfaction.

A major challenge faced in adopting digital twin for the built environment is associated with the fact that a digital twin is extremely complex to create.

Besides, the intricacies of the built environment and all its components increase the difficulty of creating a workable digital twin for the built environment. Also, the plethora of data associated with this kind of digital twin and the vast array of professional that it will be designed for further aggravates the complexity. The system must be designed to interpret enormous data and be easily understandable by different built environment professionals and other stakeholders that will utilise it.

CONCLUSION

The study aimed to understudy the application of digital twin to the built environment and building management systems. The study reviewed archived literature on digital twin, facility management, building management systems and the built environment. Digital twin technology is a means to efficiently accomplish tasks in the building and construction industry. It can be used to mitigate cost and risks in the probable chance that something goes wrong. The predictive nature of digital twin is a massive game-changer for effective forecasting in building management. Hence there is an imperative need to seek its advancement within the building industry.

The established management system in the built environment is reactive in nature – it attends to the situations as they occur, increasing maintenance cost and downtime. There is a need for the management system to be proactive – it should predict and find ways to mitigate problems before occurrence. The fourth industrial revolution came with diverse upgrades in most industry, and it is, therefore, vital to explore how the built environment management system will respond to this change. The use of digital twin to efficiently transform different industries, including the built environment, will only succeed if all stakeholders contributing to service and product quality are willing and able to work together and interchange ideas. Also, the digital twin system must be designed so that underlaying technologies and data must be interconnected to ensure a useable and suitable system.

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