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AN OVERVIEW OF THE INFLUENCE AND APPLICATIONS OF MODERN INFORMATION TECHNOLOGIES IN CONSTRUCTION MANAGEMENT

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Abstract: The construction sector relies heavily on data, and the successful completion of its projects depends on adequate access to and automated management of the data. Therefore, it is crucial to manage information resources effectively in the building's field since it affects people's productivity, the completion of projects on time, and the cost-effective completion of projects. Although each step of the lifecycle has its data and is maintained separately, most data are typically shared throughout the project's phases to aid decision-making. In the past few years, information technology played a significant role in contemporary culture. As a result, many initiatives have been embarked on to pay extreme attention to creating efficient tools to handle a broad spectrum of responsibilities throughout the construction phase. Regardless, there are still multiple challenges to overcome before information technology concepts can be efficient within the project management framework for construction. In order to identify obstacles and prevent their use to highlight their effects on project stakeholders, this paper reviews the literature on information technology applications in the construction sector. It focuses on how these applications can improve visualization, data exchange, and productivity while increasing safety and sustainability.

Keywords: Information technology; construction management; automation in construction; internet of things; advanced technology in construction management.

1. Introduction

Information technology (IT) improvements have revolutionized the management of infrastructure and environmental systems, enabling better monitoring and control. Information technology in systems management allows for data collection and aids decision-making regarding embedded and dispersed parts (Clough et al, 2000). In the construction industry, the manufacturing process's intricacy, variety, and quirkiness significantly impact output and production levels (Wu et al, 2012). However, using information and communication technologies (ICTs) presents new opportunities for collaboration, coordination, and data exchange among various parties involved in a building project (Forcada, 2005). The potential application of IT in the construction industry is vast, and its impact on production efficiency, cost optimization, and manpower management has been significant.

Several use cases exist that demonstrate the positive impact of IT on construction projects. For example, by using building information modelling (BIM), design and construction teams can share project information and collaborate more effectively, resulting in higher-quality outcomes, lower costs, and faster project delivery (Eastman et al, 2011). Similarly, using drones in construction sites can help with site inspections, surveying, and progress monitoring, reducing the need for manual inspections and improving safety (Wu et al, 2021). In addition, integrating the internet of things (IoT) and artificial intelligence (AI) in construction projects offers significant potential benefits. The IoT enables the connection and communication of various devices and systems on construction sites, providing real-time data and analytics for improved decision-making (Li et al, 2020). Conversely, AI offers the potential to optimize construction processes, reduce costs, and improve efficiency by automating tasks and improving decision-making (Pena-Mora et al, 2015).

Therefore, this paper aims to review and contrast previous research on the application of IT in the construction industry, with a particular focus on the impact of recently developed technologies such as BIM, drones, IoT, and AI. This study's methodology adopts a systematic papers review based on Google Scholar's database with sources from over 25 journals. Within the review context, about 100 related academic papers were selected and then shortlisted based on their closeness to the topic. Thereafter, the shortlisted studies were grouped into topics' similarities, and then each group was discussed in a separate section.

2. Current Information Technologies for the Construction Sector

Over the last few decades, the construction industry has witnessed an increase in the use of information technologies to streamline various aspects of construction projects. Growing demand for enhanced productivity, increased efficiency, and cost reduction have driven this shift from traditional paper-based methods to more sophisticated IT solutions. With the integration of supply chains and advancements in mobile computing, the construction industry has become more dependent on information technology applications to manage construction projects. Computer-aided design and drafting (CADD) and BIM are among the most significant advances in information technology. These tools have enabled architects and engineers to create 3D models of buildings, which can be easily edited and shared with other stakeholders. This has improved the efficiency of design processes and reduced the risk of errors in construction projects.

Additionally, these tools have provided better visualization capabilities, enabling stakeholders to assess designs and make more informed decisions. Moreover, computer-aided facilities management (CAFM) software has facilitated the efficient management of buildings, including maintaining facilities, equipment, and building systems. CAFM software allows building managers to track assets, schedule preventive maintenance, and manage work orders in real time, reducing downtime and enhancing building performance. There are tools for project management, document management, and communication in the business and information management category. These IT solutions help construction companies manage their projects and collaborate with team members across different locations. With these tools, project managers can easily track project progress, schedule tasks, and manage resources, resulting in increased efficiency and productivity.

IT solutions have been developed in the building engineering applications category to address specific engineering issues such as structural analysis, building acoustics, and energy efficiency. These applications enable engineers to simulate various scenarios, optimize building systems and reduce energy consumption, resulting in significant cost savings. Finally, in the computer-aided cost estimation category, there are various tools for estimating project costs accurately. These tools have improved the accuracy of cost estimates, leading to more realistic project budgets and better cost control.

In summary, the current information technologies for the construction sector provide solutions for various construction challenges such as design, data management, project management, and cost estimation. As the construction industry becomes more reliant on these IT solutions, it is expected to become more efficient, productive, and cost-effective.

3. Mobile Computing and Wireless Technology

Mobile computing and wireless technology have revolutionized the construction industry by enabling easy access to information and real-time data analysis. Using portable devices, such as smartphones and tablets, has become an essential part of project management, especially on-site construction management. Mobile computing allows decision-makers to monitor and regulate job sites remotely while providing them access to centralized databases in real time. Additionally, wireless technology facilitates the transfer of data and information between devices, reducing the time required for information exchange.

Recent studies have focused on using mobile computing and wireless technology in the construction industry. For instance, Nielsen and Koseoglu (2007) analysed the use of wireless communication in underground projects, while Molony (2008) examined the significance of ICT in Tanzania's informal construction industry. Suman et al (2009) investigated the factors that affect the adoption of mobile ICT to raise productivity in the building sector within the context of business engineering management. Moreover, Bowden et al (2006) demonstrated the use of wireless technology and portable computers in construction projects, including the operation of global positioning systems and geographic information systems in waste reduction.

Mobile computing has enabled construction workers to easily access relevant information and real-time data analysis. For instance, workers can use mobile devices to receive instructions and submit progress reports, reducing the time required for communication and enhancing productivity. The use of mobile computing and wireless technology has also facilitated remote collaboration among team members and enhanced decision-making processes. Additionally, mobile devices can be used to access BIM and other design documents, improving coordination between the design and construction teams. Furthermore, wireless technology has enabled various sensors and devices that monitor and control different aspects of the construction project, such as temperature, humidity, and structural stability. The sensors can be connected to the IoT to allow real-time data analysis and remote control of the construction project.

In conclusion, mobile computing and wireless technology in the construction industry has significantly improved on-site construction information management. Mobile devices have enabled workers to access relevant information easily and submit real-time progress reports. Wireless technology has facilitated the transfer of data and the use of various sensors and devices to monitor and control different aspects of construction projects. The use of mobile computing and wireless technology is expected to increase as construction companies seek to enhance productivity, reduce costs and improve the quality of construction projects.

4. Building Information Modelling (BIM)

Building information modelling (BIM) has transformed the way construction professionals design and manage building projects. The BIM system is a data-rich, digital model that enables designers, engineers, contractors, and other stakeholders to collaborate and share information throughout the building's life cycle (Wang et al., 2013). BIM offers numerous advantages in the construction industry, including improved communication, waste reduction, and lower costs (Chien & Barthorpe, 2009; Matarneh et al., 2019). BIM provides a virtual representation of the building, allowing construction teams to evaluate potential issues and optimize the building design before construction begins (MacLeamy, 2004). Moreover, BIM can improve efficiency, better project outcomes, and reduce costs for construction companies. BIM technology enables better communication between project teams, providing a central repository of data accessible to all involved parties (Khalfan et al., 2015). This facilitates effective collaboration between different disciplines, such as architecture, engineering, and construction, and ensures that everyone is working with the same up-to-date information (Dave & Koskela, 2009). BIM's 3D visualization also makes it easier for non-technical stakeholders to understand the project, reducing the likelihood of misunderstandings and miscommunication (Sher et al., 2009). One of the critical advantages of BIM is waste reduction, which is a significant issue in the construction industry. BIM reduces the likelihood of costly errors and miscommunication between parties, often leading to rework and waste (Goedert & Meadati, 2008). By enabling real-time collaboration, BIM helps identify and resolve potential issues early in the design process, reducing the likelihood of costly errors later on. This, in turn, reduces waste and improves project outcomes (Dossick & Neff, 2010). BIM also offers significant benefits in terms of cost reduction. According to research conducted by the National Institute of Standards and Technology, BIM can reduce construction costs by up to 4%. BIM helps reduce construction time, labour, and material costs by streamlining the design process and enabling real-time collaboration. Furthermore, BIM can help reduce change orders and minimize the number of construction errors and omissions, which can add high costs to a project. By reducing these costs, BIM can help construction companies increase their profitability while delivering high-quality projects to their clients (Kang & Lee, 2018). In addition to the benefits mentioned above, BIM can also improve the quality of the final product. By providing a virtual representation of the building, BIM enables construction teams to identify potential issues and optimize the building design to ensure that the final product meets the desired quality standards. Furthermore, BIM enables construction teams to test and evaluate different materials, components, and systems, helping to ensure that the building is constructed to the highest quality (Chen & Lu, 2017).

5. Virtual Reality (VR)

According to Chassiakos (2007), virtual reality (VR) technology refers to a computer-simulated environment that may include haptic, auditory, and visual channels for human-machine communication. Generally, Chien and Barthorpe (2009) acknowledged it as a system that permitted interesting real-time viewing of 3D content as a communication podium. A novel assessment model was introduced in Sweden by Dehlin & Olofsson (2008), which is used by a multidisciplinary working team while evaluating, planning, implementing, and utilizing ICT investment virtual reality in construction project management. In order to improve the design and individual construction interactions in Australia, Sher et al (2009) looked into the use of ICT (3D Virtual world). Christiansson et al (2011) proposed a virtual innovation in a construction project using ICT to design a method that includes building end-users in a collaborative process with design engineers and gathers end-user requirements on the ultimate use of structures. Eight expansion points with great potential for improved efficiency and quality using cutting-edge ICT, particularly virtual reality, were identified by various construction ICT developers (Ekholm and Molnar, 2009). Chaisuparasmikul (2006) proposed a system for virtual simulation and modeling for the cooperation, integration, and exchange of data, as well as for other objectives, including operational energy modelling and estimation, the inspection of building code, registration, and compliance. A virtual reality study revealed the advantages of using VR in architectural design, promotional materials, and training, as well as the fact that it accounted for 76% of the most effective tools in improving the effectiveness of marketing communications (Chien & Barthorpe, 2002).

6. Artificial Intelligence (AI)

A vast area of computer science called artificial intelligence is devoted to building intelligent machines that can perform tasks that traditionally require human intelligence. In terms of concept, AI is a mathematical strategy that imitates the human brain to comprehend the underlying function of data and create closed-form models that map between the input and output functions. As a result, it has a wide range of possible applications in the construction industry, such as arranging the placement of plumbing and electrical systems in contemporary buildings. This methodology has been used in recent years to create several models that can predict concrete behaviour (Habib and Yildirim, 2021), structural response (Luo & Paal, 2022), and project expense (Juszczyk, 2017).

Nowadays, a variety of businesses are utilizing AI to design safety systems for work sites, including tracking the real-time interactions between employees, equipment, and items on the job site, as well as alerting managers to potential safety concerns, productivity issues, and execution failures (Chou & Pham, 2013; Luo & Paal, 2022). In general, the use of AI in construction management has the potential to transform the industry by providing valuable insights that can help construction managers optimize project planning and scheduling, improve safety, ensure quality control, and manage risks (Anumba et al., 2004; Zhou et al., 2016). By analysing data from various sources, such as sensors and cameras, AI can identify patterns that indicate potential equipment problems and predict maintenance needs, reducing downtime and increasing efficiency (Charlesraj, 2014; Habib & Yildirim, 2021). AI can also analyse historical data to identify scheduling conflicts, optimize labour allocation, and predict how changes to one part of the project will impact other areas (Jan et al., 2013; Juszczyk, 2017). Safety is a critical concern in the construction industry, and AI can help to improve safety on construction sites by analysing data from sensors and cameras to identify potential hazards and alert workers to potential safety risks

(Chou & Pham, 2013; Luo & Paal, 2022). AI can also detect quality issues and provide real-time feedback to workers to fix issues quickly, analyse data, and create predictive models to manage risks (Habib & Yildirim, 2021; Juszczyk, 2017). While AI is still in the early stages of adoption in the construction industry, its potential benefits make it an area worth exploring for any construction manager looking to increase efficiency, safety, and productivity (Dave & Koskela, 2009; Elghaish et al., 2020).

7. Blockchain Technology

Blockchain is a digitally distributed ledger that was first publicly introduced as the technology behind Bitcoins roughly ten years ago (Chaisuparasmikul, 2006). The lack of accountability in building projects seems to have been an issue for years, and with profit margins so slim, businesses started searching for ways to minimize costs and avoid taking responsibility for the mistakes that may arise (Bowden et al., 2006). It seems likely that blockchain will have a profound impact on the construction industry by providing solutions for payment and management processes, supply chain management, and other concerns (Khalfan et al., 2015). Another potential blockchain application that combines conventional contracts with blockchain technology is a smart contract (Chien & Barthorpe, 2009). Unlike traditional technology that stores the data in a centralized database, blockchain is a decentralized database and is widely accessible throughout the system, which reduces the need for document duplication (Adwan & Al-Soufi, 2016). The contracts are included in the blockchain and can be reachable by a quick search (Dave & Koskela, 2009). Since a blockchain system is sequential, it holds contractors accountable by mandating that a project adheres to predetermined requirements, or the contract will be violated (Anumba et al., 2004). As a result, blockchain technology has the potential to transform the construction industry by providing a decentralized, secure, and transparent way of storing and sharing data (Zhou et al., 2016). It can automate contractual agreements through smart contracts, improve supply chain management by providing real-time visibility and verifying the authenticity of materials, and enhance quality control by providing a tamper-proof record of the materials used in a project (Elghaish et al., 2020). Additionally, it can improve BIM by providing a secure way to share data and maintain a tamper-proof record of project documentation (Charlesraj, 2014; Wang et al., 2013). Blockchain can help reduce disputes, increase transparency, and improve collaboration and communication among project stakeholders (Dave & Koskela, 2009; Kamara et al., 2002). While blockchain technology is still in its early stages of adoption in the construction industry, its potential benefits make it an area worth exploring for any construction manager looking to increase efficiency, safety, and productivity (Goedert & Meadati, 2008).

8. Geospatial Technology

The application of computerized models to depict buildings has solidified the practice of construction digitalization, but genuine digital construction goes far beyond simple representation (Elghaish et al, 2020). In order to increase production and efficiency in the construction process, geospatial data about a specific location on the earth's surface is crucial (Habib et al, 2020). Furthermore, modern geospatial technology permits real-time stakeholder communication in a single project management environment. Users can build complex models on the website using building information modelling tools, which allows them to see the overall scenario more clearly. Before the first shovel pushes the ground, numerous activities, including planning, design, computation, and bidding, must be supported by information that is as intelligent and helpful as feasible. On the contrary, Geographic information systems (GIS) handle and examine data related to a location on Earth (Habib and Matouk, 2020). The AECO/FM (architecture, engineering, construction, operation, and facility management) industry uses BIM and GIS extensively since it is information-intensive and has numerous stakeholders with a range of skills (Zhou et al, 2016).

9. Other Emerging Technologies in the Construction Industry

Indeed, "construction technology" encompasses a broad range of technologies utilized in the construction sector. Emerging technologies, such as BIM, artificial intelligence (AI), and 3D printing, can assist in automating construction projects. **Table 1** gives an overview of the major technologies used in the construction sector.

Table 1. Types of emerging technologies in the construction industry

Type	Brief Description
LiDAR	LiDAR technology uses a laser light signal sent to a receiver typically positioned in another place on the site to measure the distances between two spots. It aids in scanning the location and creating a real-time 3D model for the engineer. Safety management is just one of many possible uses for this technology.
Smart Hardhats	Throughout recent decades, global efforts have been visible to design intelligent devices such as watches and phones. Shimbun Company developed a new cutting-edge technology for labour safety management. It is an improvement over the conventional hardhats used by workers since it differs in a way it offers a variety of capabilities by tracking the worker's location, body temperature, and mobility with an integrated trigger for an emergency call if something wrong happens.
Smart Infrastructure Systems	An intelligent infrastructure system is a collection of devices and software typically used to keep track of the resilience and performance of the system that supports the structure to avert any potential catastrophic breakdown. In order to warn the structural team of threats or unexpected events like earthquakes or blasts, this technology has been developed for years and has begun to be used in critical facilities around the world.
3D Printers	3D printing technology is now a rapidly evolving field of study because of its ability to lower risks and expenses while expediting the construction process. Due to its advantages over conventional systems, this technology has previously been used in several locations worldwide, including the United States and Mexico, and will eventually be utilized in other countries.
Robotic Systems	The growth of robotic system development is undoubtedly a result of the technology's bright prospects for automation and scalability in the future. At the moment, robotic automation has a significant potential to increase efficiency and flexibility across the construction industries, including the production of modular homes, robotic welding, the management of materials on building sites, and the use of robotics to produce 3D-printed homes. Thus, if it is handled wisely in the construction sector, this technology has a promising future.

10. Advantages and Disadvantages of New Information Technologies to the Construction Industry

The advantages and disadvantages of the new IT in the construction industry are in **Table 2**.

Table 2. Advantages and disadvantages of the new IT in the construction industry

Advantages	Disadvantages
Improved project planning: information technologies such as building information modelling software can provide accurate and detailed project plans, allowing for better coordination between construction teams and improved project scheduling.	High initial costs: implementing new information technologies can require significant upfront investments in software, hardware, and training, which can be a barrier for smaller construction companies.
Enhanced collaboration: cloud-based collaboration tools, such as virtual workspaces, project management software, and mobile apps, can allow for easier communication and collaboration among project stakeholders, even if they are located in different locations.	Resistance to change: some construction workers may be resistant to learning new technologies or find them difficult to use, leading to resistance and reduced productivity.
Increased efficiency: automation technologies such as robots, drones, and 3d printers can streamline construction processes and reduce the time and resources required to complete a project.	Cybersecurity risks: as construction companies increasingly rely on digital data and connected devices, there is an increased risk of cyber-attacks, which can compromise sensitive information and disrupt project timelines.
Enhanced safety: technologies such as virtual and augmented reality can allow workers to train in simulated environments, reducing the risk of accidents on construction sites.	Limited applicability: not all technologies may be relevant or applicable to all construction projects, which may limit their overall effectiveness and return on investment.
Improved sustainability: information technologies such as sensors and smart building systems can improve buildings' energy efficiency and overall sustainability.	Dependence on technology: over-reliance on technology can lead to a lack of human oversight and decision-making, which can lead to errors or oversights that can impact project outcomes.

11. Conclusion

In conclusion, this paper has examined and summarized recent information technologies and their possible applications in the construction sector. Within this context, topics such as building information modelling, artificial intelligence, augmented reality, mobile computing, and blockchain were addressed while highlighting their usage in many facets of the construction industry. In fact, two of the most crucial technologies now used in the construction industry are building information modelling and artificial intelligence. Nevertheless, one of the prospective ones is the use of robotic systems to automate the production of prefabricated or 3D-printed dwellings. More initiatives in this direction are required to draw attention to critical role-playing concerns, including the method for conducting quality control and quality assurance in such projects, the supply-chain management, and the safety management of the labour working at advanced technology sites.

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