Role of Artificial Intelligence in Construction Project Management

Pavankumar Korke[1] , Gobinath R[2] , Manisha Shewale[3], Bhagyashree Khartode[4]*

[1]Research Scholar, Department of Civil Engineering, SR University, Warangal, India.
[2]Deparment of Civil Engineering, SR University, Warangal, India.
[3]Department of Civil Engineering, Dr. D Y Patil Institute of Technology, Pune and Research Scholar, SR University, Warangal, India.
[4] Department of Civil Engineering, Dr. D Y Patil Institute of Technology, Pune. India.

Abstract. The construction business currently contributes 13% of the world's Gross Domestic Product (GDP), and it is anticipated that by the year 2030, its value would have increased by 85%, reaching $15.5 billion globally. China, the United States of America, and India are the three countries that are most responsible for the demand in the building business. Keeping subcontractors, contractors, designers, clients, and other parties routinely supplied with vast amounts of information has been one of the most challenging difficulties in the construction industry. The application of Information Technology (IT) has significantly contributed to the integration of disparate pieces of information within the context of widely dispersed construction projects. The construction sector, including the full construction value chain, is presently going through a period of transformation. The amount of money that is being invested into Artificial Intelligence (AI) is rising at a rate that is almost impossible to keep up with. Because of this, there is the potential to enhance the productivity of human work by forty percent and double the annual rates of economic growth by the year 2035. This research presents a discussion of the numerous methodologies that have been researched by the researchers along with a review of the artificial intelligence that is used in the construction industry, specifically Construction Project Management. Additionally, this research offers a review of the artificial intelligence that is utilized in the construction business.

Keywords: Artificial Intelligence (AI), Construction Project Management (CPM), Data- driven management Information Technology (IT)

1. Introduction

The construction industry is a major contributor to the world economy; it accounts for 13% of the global gross domestic product (GDP), and it is expected to increase by 85% to $15.5 billion globally by the year 2030. The top three contributors to the construction industry's demand are China, the United States, and India. Together, these three countries account for 57% of the industry's total demand [1]. It is estimated that annual spending on global

* Manisha Shewale: manisha.surve1484@gmail.com

infrastructure will be $3.4 trillion between the years 2013 and 2030 [2]. This is around 4% of overall GDP. The industry is also regarded as a significant pillar of any nation's economy

and accounts for 3% of the total economic output in Nigeria [3], 4.3% in Germany, 6% in the United Kingdom (UK) [4], 4.1% and 6.8% the United States of America (USA) and China respectively [5,6], etc. Although it is economically significant industry, still one of the most visible problems is low labour productivity throughout the construction process. This, in turn, leads to the unnecessary waste of personnel, material resources, and financial resources. It is in everyone's best interest to practice good construction management in order to enhance product performance. This is since activities related to construction provide a significant economic contribution to our society. [7].Coordination on construction projects is difficult since everyone involved has their own set of goals for how they want to spend the money or other resources they get. This leads to a high level of check and control, which in turn generates the vast majority of the written documentation used to record transactions between the various parties. This is largely due to the lack of communication and cooperation among the involved parties. One of the toughest challenges in the construction industry is maintaining a steady flow of information to several stakeholders, including subcontractors, contractors, designers, clients, and others. In order to overcome this obstacle, information technology (IT) has been used to successfully promote the integration of fragmented information in the environment of distributed building projects. Throughout the many stages of a building's development, many PMISs include tools for teamwork and coordination. These tools allow team members to centrally organize, distribute, and exchange project-related papers and drawings while keeping the entire archive in a safe, easily accessible location. For transactions between public owners and contractors, which are mandated to be more open, transparent, and equally accessible to all qualified bidders, and where the formality and security of the data transaction is more important than those pertaining to private projects, they still do not adequately provide standard formats for the documents and information pertaining to a project [8]. Furthermore, completely integrated construction systems are relatively unusual. Users would be able to engage in true electronic cooperation with such a system since data could be transferred from one program to another. The concept of a virtual organization, or VO, was developed to facilitate electronic sharing of work and communication amongst geographically separated suppliers, partners, and collaborators. This is achieved by retrieving needed data from a centralized database on demand, accessing a shared application from anywhere, and responding to inquiries digitally [9]. To meet the goals of "Industry 4.0," which include much more automation, productivity, and dependability, the field of Construction Project Management is continually developing toward digitalization and intelligence. To get ready for the coming "fourth industrial revolution," this is being done. In other words, the entire construction value chain, which consists of the pre-construction, construction, and post-construction stages, as well as O&M, is undergoing a radical transformation. Artificial intelligence (AI) is the backbone to alter the way a construction project is carried out, and it is crucial to the goal of launching the actual digital strategies in Construction Project and Management (CPM). Artificial intelligence (AI) is a branch of computer science concerned with teaching machines to reason like humans and acquire new skills via experience. This allows the computers to handle ambiguous and difficult problems in a way that is deliberate, smart, and adaptable. Machine learning receives a disproportionate share of the increasing investment in artificial intelligence (AI), which overall is growing at a dizzying rate. This is done so that AI may first collect data from a wide range of sources that can be trusted to be accurate, and then use the knowledge gained from this data to make judgments that are both intelligent and flexible [10]. An Accenture report claims that AI is already permeating every area of modern life. By 2035, this has the ability to treble annual economic growth rates and improve human productivity by forty percent. Many companies are investing heavily in various forms of artificial intelligence to make sure the technology can deliver on the high expectations placed upon it. These advancements in technology help to define AI and open up new fields in which it can be used [11]. This study reviews the many artificial intelligence approaches studied and their applications in the construction industry, focusing on Construction Project Management.

2. Concept of Construction Project Management

The current research provides an in-depth overview of the construction industry by reviewing the pertinent and most recent publications in order to summarize the actions and characteristics of CPM that are associated with it. It is important to highlight that, in order to make CPM a data-intensive area; significant amounts of diverse data are collected at each stage of the project. This is especially true since the emergence of building information modeling (BIM) and wireless sensor networks (WSN). Because of this, it is fair to execute a variety of AI approaches in order to take full advantage of such data in a variety of ways. These techniques can successfully confront the characteristics of CPM throughout the entirety of the project life cycle.

2.1 Activities involved in Construction Project Management (CPM)

The primary tasks involved in CPM can be broken down into three distinct stages, which are as follows:

2.1.1 Planning

The creation of in-depth plans for the development of the project about its resources, timetable, budget, dependencies, and other aspects is an absolute necessity prior to the commencement of the actual physical construction. The well-prepared plans need to be adjusted so that they fit within an acceptable time schedule and workflow. This will help reduce costs, shorten the amount of time the project takes, and eliminate irrational steps. For example, the building's schematic design can be sketched to provide a comprehensive description of the building's systems. Scheduling allows for the chronological distribution of various activities, after which dates, personnel, and resources can be assigned to each activity individually. The process of anticipating the amount of money and other resources that will be necessary to carry out a project within a certain scope is referred to as cost estimation. In a nutshell, the most important thing that needs to be done during the planning phase is the formulation of the project plan, which should rationally streamline the construction process. This plan can also serve as a reference to monitor the actual process and direct it to be completed on time and within the estimated budget.

2.1.2 Construction

This is the phase in which the actual physical construction is carried out, and as such, it is anticipated that the plan devised in the prior phase would be successful. The most important actors in the construction phase are the people who work on the construction itself and the project managers. They are the manual labor that construction workers use to perform on-site tasks, such as layout marking, excavation, foundation work, column casting, wall construction, lintel, roofing, plastering, fixing of doors and windows, electrical and plumbing works, tile laying, and painting, amongst other tasks. In order to operate modern machine tools, personnel with the necessary skills are required. When it comes to project managers, their responsibilities include monitoring the actual construction process in terms of the scope, budget, and time, and then comparing those observations to the planning that was originally outlined. In the event that an inconsistency is found, the action that corresponds to it can be carried out to bring the process back into conformity or to amend the plans so that they can do any changes. In addition, it is the manager's responsibility to recognize the potential for risk and the corresponding impact on the project's performance, schedule, or budget. These identified risks need to be assessed from both a qualitative and quantitative point of view for improved quality control. This will allow for the creation of timely answers that can be used to proactively address any possible problems.

2.1.3 Operation and Maintenance (O&M)

After the construction stage of the project is finished, it will move on to the Operations and Maintenance phase. [12] It is common knowledge that operations and maintenance consume the majority of the time during the life cycle, which results in a significant amount of cost that accounts for approximately sixty percent A created facility should be operated and maintained in such a way that it not only fulfils the anticipated functions over the course of its lifecycle but also ensures the users' safety and comfort. This is the purpose of O&M. In a more particular sense, operation refers to the provision of day-to-day services to operate and control the facility in a manner that is efficient, inexpensive, and dependable, whereas maintenance seeks to minimize the potential of system failure from two different perspectives.

One benefit of time-based preventive maintenance is that it helps identify prospective dangers and makes necessary adjustments to ongoing processes in advance of unanticipated occurrences. As a second point of interest, corrective maintenance that is performed after the occurrence of problems works toward the goal of repairing the broken parts and restoring them to their normal position as quickly as is practically possible. In addition, there has been a significant emphasis placed on environmental responsibility in O&M. The implementation of O&M must adhere to certain energy norms and standards in order to make the facility run reliably, safely, and more efficiently, and ultimately to increase the level of pleasure experienced by its users.

2.2 Typical Features of CPM

CPM can be thought of as a process that manages a series of interrelated tasks over the course of a predetermined amount of time while adhering to specific constraints. This is because the nature of a construction project is one that is one-of-a-kind, transient, and progressive in order to produce the desired outcome. The author did research on relevant publications, and he found that the most important qualities of CPM can be summarized using the following five points.

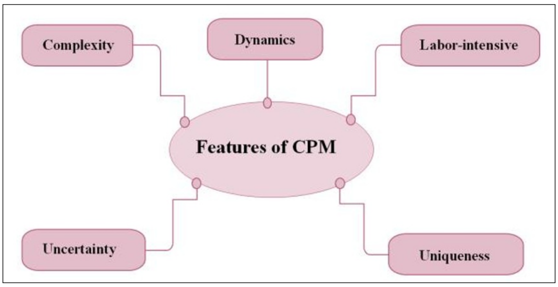

Fig.1. Features of CPM

2.2.1 Labour-intensive

In most cases, a large quantity of manual workforce will be engaged in a construction project. In order to implement, complete, and guarantee the quality of the project, this requires people who cancontribute significantly in terms of physicallabor.According to some estimates, the share of costs attributable to labour might take up more than 30 percent of the overall budget for the project, which suggests that labour-intensive work is an essential component in building. There has been a rapid increase in the demand for skilled and semi-skilled workers in the construction industry who possess extensive expertise and proficient skills. As a result, numerous efforts are required to provide professional training in order to improve the efficiency and productivity of construction projects. In the meantime, one trend that is taking place in order to relieve the burden of the costs associated with personnel is the replacement of unskilled workers by automatic machinery. It is hoped that the coordination of skilled labour forces with machinery will make it possible to move the project along in a manner that is less difficult, more productive, and less hazardous. In most cases, a large quantity of manual labour will be engaged in a construction project. This requires individuals who can contribute significant amounts of physical effort for the successful implementation, timely completion, and quality assurance of the project. According to some estimates, the share of costs attributable to labour might take up more than 30 percent of the overall budget for the project, which suggests that labour-intensive work is an essential component in building. There has been a rapid increase in the demand for skilled and semi-skilled workers in the construction industry who possess extensive expertise and proficient skills. As a result, numerous efforts are required to provide professional training in order to improve the efficiency and productivity of construction projects. In the meantime, one trend that is taking place in order to relieve the burden of the costs associated with personnel is the replacement of unskilled workers by automatic machinery. It is hoped that the coordination of skilled labour forces with machinery will make it possible to move the project along in a manner that is less difficult, more productive, and less hazardous.

2.2.2 Dynamics

Even though every step of a project, from its inception to its conclusion, has been meticulously mapped out, it is impossible for the project's actual execution to always adhere to the plan. Throughout the entirety of the lifecycle of the project, there will invariably be occasions calling for alterations or modifications to be made due to a variety of causes. For example, the project alternatives need to be redesigned because of a combination of human factors (such as unsatisfied customers, mistakes made by designers and engineers, and financial difficulties experienced by contractors) and unanticipated environmental conditions (such as an unwelcome delay, adverse weather, a complex geologic environment, and additional requirements for labour, equipment, and materials). In addition, if the scope of the project is altered in any way, whether it be expanded or contracted, the timeline and the budget should be modified to reflect these shifts in order to accommodate the new environment. Construction project managers need to be able to identify changes in a flexible manner and carry out effective controls if they want their projects to be successful.

2.2.3 Uniqueness

Construction projects are distinct from one another in terms of the client's requirements, the scale of the project, the conditions, the influences, and the limits. These differences contribute to an increase in the difficulty of managing the construction project. Because of this, it would be unreasonable to use the schedule, budget, design plan, and logistics from a completed project as a starting point for a new one. In addition, individuals who are involved in a project and perform a range of roles, including developers, engineers, vendors, subcontractors, executives, and additional service providers, are classed provisionally within the context of the project. It means that a distinct team works on each project, and that each team has its unique characteristics in terms of the participants' talents, proficiency, knowledge, interaction and collaborative abilities. Each task will be carried through with a different team. It is crucial to emphasize that a solution that allows for a high level of customization is regarded as a must in order to secure the reliability and efficiency of the project, which is very technological and unmistakably one of a kind. This is why it is essential to highlight that a solution that allows for a high level of customization is viewed as a must.

2.2.4 Complexity

The difficulty of a construction project can be caused by one of two factors: either the task itself or the participants in the project. For one thing, construction jobs are labour-intensive, varied, and linked, all of which increase the likelihood of encountering schedule conflicts or problems with overall performance. In order to ensure that the operation process goes off without a hitch, it is necessary to take a wide range of considerations into account, including security, the surrounding environment, the weather, the workers, the time limit, and others. In addition, although modern technology (such as BIM and IoT) and new materials are employed for more sustainable development, they are likely to contribute toward more complexity. This is because of the inherent nature of these technologies and materials. Another aspect of the project is that it will involve workers who come from a variety of different backgrounds, cognitive levels, and business interests. These workers will all play different roles in the project and will communicate and share information with each other to achieve the same objective. Because of the nature of this multi-disciplinary collaboration, the end outcome will invariably be complicated interactions between individuals and activities.

2.2.5 Uncertainty

Because uncertainties cannot be predicted before they take place, they are often seen as inevitable dangers that increase the likelihood that a project will fail. Notably, complicated building projects naturally come with a significant degree of intrinsic uncertainty, which is directly proportional to the myriad of components involved. For example, before building of the site, reasonable estimates of the schedule and costs need to be made in the face of significant uncertainty. The inaccurate estimation will make it more difficult to move the project forward. Concerning the architectural design, there are still a few questions that need to be answered, such as whether the design is auditable, whether or not customers are pleased with the design, and a few other related questions. During the construction process, there is a significant amount of unknown uncertainty brought on by the ground conditions, the soil-structure interaction, the weather conditions, the qualities of building materials, modifications to the design, the dependability of suppliers, and other factors. If these unknowns are identified and quantified at an early stage of the construction project, possible risks can be reduced, which will raise the likelihood of the construction project being successful.

3 Artificial Intelligence in Construction Project Management

The study and implementation of the laws that govern the actions of human intellect are at the heart of the field of artificial intelligence (AI). After fifty years of progress, it has become a topic that transcends borders and has far-reaching implications. This technology is currently being applied in a broad range of situations, some of which include systems of

experts, knowledge-based systems, smart systems with databases, and smart robot systems, to mention a few of these applications. Expert system has been labeled "the information handling and decision-making technology of the twenty-first century," and it is the domain of artificial intelligence that is the oldest and most wide in scope. In the field of civil engineering, many issues, particularly in engineering design, construction management, and programme decision-making, were influenced by many uncertainties that could be solved not only by the need for mathematics, physics, and mechanics calculations, but also depend on the experience of practitioners. This was especially true for engineering design, construction management, and programme decision-making. For instance, when it comes to the design of engineering projects, the administration of construction projects, and the decision-making process for programming, many problems were influenced by various uncertainties. This information and experience are not only illogically insufficient but also imprecise, and they cannot be handled using normal methods due to their lack of precision.
Nevertheless, artificial intelligence possesses its own set of advantages. It can solve difficult issues to the levels of expertise of professionals by imitating the expertise of experts. Overall, the field of civil engineering is ripe with potential application areas for artificial intelligence's wide range of capabilities.

It is thought that AI methods will become the next digital frontier if AI abilities continue to grow. These ways will be able to efficiently translate massive amounts of data into valuable information, which will lead to a high degree of automation and intelligence in both industry and commerce. The adoption of AI approaches is currently lagging behind the process in the construction industry, despite the fact that a significant amount of engineering data is increasing at an unprecedented high rate in the construction project. As a result of this, there is a significant amount of interest in applying a variety of AI methodologies in the CPM domain in order to capitalize on the advantageous opportunity presented by digital evolution for increased productivity and profitability.

3.1 Benefits of Artificial Intelligence in Construction Project Management

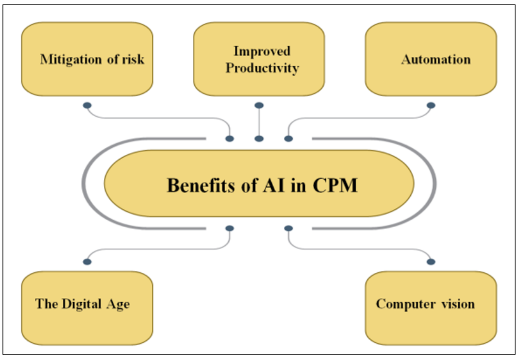

Fig. 2. Benefits of AI in CPM

3.1.1 The Digital Age

It is essential to note that Building Information Modeling (BIM) has been the primary impetus behind the digitalization of the construction industry. In recent years, BIM has advanced far further than 3D modeling in terms of its ability to supply a pool of information for the whole lifecycle of a project [13]. BIM has the potential to function as an AI-capable digital backbone, which can further accelerate the digitization of information used in intelligent CEM. For BIM, it provides a platform for not only gathering vast volumes of data about all parts of the project, but also for sharing, exchanging, and analysing data in real-time to enable in-time communication and cooperation among a range of parties. This is accomplished using a building information model (BIM). The usage of BIM is the means by which this can be accomplished. They do this as part of the artificial intelligence (AI) methodology, with the goal of automating and improving the building process. The data comes from the building information modeling (BIM) system. The integration of BIM and AI has the potential to transform paper-based jobs into online administrative tasks. For one thing, it is able to provide information that is both the most efficient and the most effective in terms of keeping the ongoing project continuously up to date. This capability is one of its distinguishing characteristics. An additional advantage is that it may make use of the data that is contained in the BIM in order to perform real-time analysis. This makes it possible for quick responses to be taken in order to simplify the process, shorten the amount of time it takes to operate, cut expenses, lower risk, and optimize personnel arrangement, among other things.

3.1.2 Automation

The management of projects can become more technically automated and objective thanks to artificial intelligence. Conventional methods of construction management often rely on manual observation and operation, which is fraught with the potential for erroneous judgments and errors that are more complex. It has been shown that solutions based on AI can help overcome the many restrictions that relate to this type of construction management. For example, machine learning algorithms are use in order to intelligently learn from the vast amount of data that has been acquired for the purpose of uncovering previously unknown information. In order to facilitate automatic data analysis and decision making, these algorithms are also included into software that is used for project management. The insights that are obtained from such advanced analytics enable managers to gain a better understanding of the construction project, to formalize the tacit knowledge that has been gathered from previous project experiences, and to promptly recognize difficulties with the project in a data-driven manner [14]. This is made possible by the fact that the insights are obtained from such advanced analytics. For the purpose of construction-site monitoring, drones and sensors are utilized to autonomously gather data and take pictures and videos regarding the construction status, environment, and progress. This is done with the intention to offer a broader overview of the construction location throughout every phase of the project without the involvement of human intervention. This is done in order to achieve the goal of providing a more comprehensive picture of the site. Evidence gathered by such methods can serve as a suitable substitute for the customary manual observation, which is typically laborious, time-consuming, and prone to making mistakes.

3.1.3 Improved productivity

Methods from the field of artificial intelligence can also be used to substantial effect in the area of optimization problems. The purpose of these challenges is to ensure that the construction project is carried out in an efficient and effective manner. For example, artificial intelligence has made it possible for new methods to be developed, such as process mining, which offers helpful insights into the intricate building process [15]. Process mining enables several useful activities, including the monitoring of essential workflows, the forecasting of deviations, the identification of hidden bottlenecks, and the extraction of patterns of collaborative behaviour. The implementation of such recently gained information is necessary for the successful completion of the project and has the potential to direct the optimization of the construction execution process.
It is predicted that unnecessary steps, reworks, and arguments, along with potential delays and poor cooperation, will be avoided. Additionally, it is hoped that these things will be

avoided. The result of this is that strategic decisions may be made for the early-stage troubleshooting of problems, which drives the increase of operational efficiency. In addition to this, it is effective in avoiding adjustments that are more time-consuming and costly in the stage that comes after this one. There is a wide variety of different sorts of optimization algorithms, and each one of these algorithms is a powerful tool that can be utilized to construct more convincing architectural designs that strike the optimal balance between time, money, and quality [16]. Additionally, AI-powered robots have been directly adopted on construction sites in order to take over repetitive and routine construction duties such as bricklaying, welding, tiling, and others. This is done in order to free up human workers to focus on more complex tasks. This is being done in order to lessen the amount of manual labour that is necessary for the completion of these jobs. They can operate continuously without taking a break at an almost identical pace and level of quality, demonstrating that the suitable deployment of intelligent machinery will ensure efficiency, productivity, and even profitability.

3.1.4 Mitigation of risk

Even when there is a large level of unpredictability in the environment, artificial intelligence is able to monitor, analyze, examine, and anticipate possible hazards in terms of safety, quality, efficiency, and cost across teams and work areas. This capability has gained widespread acceptance for the purpose of risk detection, assessment, and prioritization [17]. To learn data collected from the construction site, a variety of artificial intelligence methods, such as probabilistic models, fuzzy theory, machine learning, neural networks, and others, have been applied with the goal to capture interdependencies of causes and accidents, measure the probability of failure occurrence, and evaluate the severity of the risk from both the qualitative and quantitative points of view. This was done in order to improve safety on the construction site. They are able to effectively overcome the limits of traditional risk analysis, such as the ambiguity and "vulnerability" that occurs from professional experience and subjective judgement. They are able to do this by using a combination of statistical modeling and simulation techniques. As a result of this, AI-based risk analysis has the potential to deliver helpful and predictive insights on significant issues. These insights can aid project managers in fast prioritizing potential risks and deciding proactive actions as opposed to reactive ones for the purpose of risk reduction. Streamlining operations on the job site, modifying employee arrangement, and ensuring that projects are completed on time and without exceeding their budget are some examples of proactive risk reduction efforts. To put it another way, artificial intelligence presents exciting potential for the achievement of early troubleshooting, which can contribute to the prevention of unfavourable failure and accidents in the intricate workflow. Additionally, robots can take over tasks that could be hazardous, hence reducing the amount of people that need to be involved in hazardous areas.

3.1.5 Computer vision

In the process of determining the condition of civil infrastructure, the laborious and unreliable visual examination has been steadily replaced by the automated and reliable computer vision techniques. This has been accomplished using newer technology. Deep learning strategies have taken centre stage in the most recent iterations of advancements made in computer vision technology. These techniques make use of end-to-end learning in order to automatically interpret, evaluate, and comprehend the data that is included within images and videos. Computer vision is primarily used to perform visual tasks for two main purposes known as inspection and monitoring, which have the potential to promote the understanding of complex construction tasks or structural conditions in a manner that is

comprehensive, swift, and reliable [18]. That is number of people who need to be employed in dangerous situations. Computer vision is primarily used to perform visual tasks for two main purposes known as inspection and monitoring. Computer vision is primarily used to conduct visual tasks for these two primary purposes in order to achieve intelligent management in the construction project. Inspection applications perform tasks such as automated damage detection, structural component recognition, identification of hazardous behaviour, and condition identification.
Monitoring applications are a non-contact method for obtaining a quantitative comprehension of the infrastructure's status. This knowledge can be utilized, for instance, to estimate strain, displacement, and the length and breadth of fractures. In conclusion, vision-based approaches in CEM are relatively inexpensive, basic, productive, and accurate. These methods can reliably convert image data into actionable information for the evaluation of structural health and assurance of construction safety.

4 Data-Driven Management in Various Phases of Construction

In most cases, the construction project is broken down into a number of discrete stages, which often comprise the following: planning, initiating, building, and finishing [19]."In particular, the lifecycle of a construction project consists of a range of stages including planning, design, procurement, construction, operation, and maintenance [20].

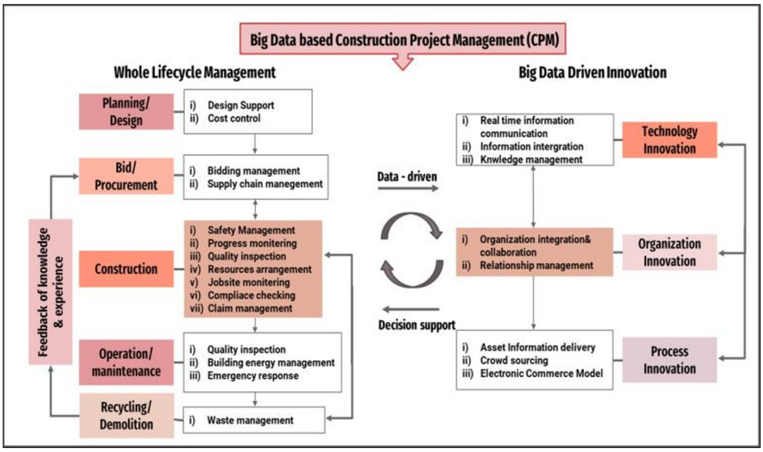

Fig. 3. Comprehensive Scenario of Data-driven CPM

With the use of a Big Data-based technology inference approach and a semantic reasoning rule, it is possible to automate the search for work items that need to be done during the schematic design phase. In addition, the application of data mining strategies in engineering design has the potential to help make difficult information more readily available to engineers. Fig 3 shows the comprehensive scenario of data- driven Construction project management (CPM). According to the findings of the study, which were predicted by the research, the following are some concepts that employ developing IT to handle CPM problems:

4.1 Phase of Bidding and Acquisition

Although big data-related technologies have the potential to be employed in bid and procurement processes, they are not currently being utilized for this function. Discussion of DSS-based decision support systems for evaluating and assessing bids [21]. The employment of virtual reality (VR), Web 2.0, and cloud computing were utilized to guarantee that the buyer's demands and procurement strategy were met. Estimating the time and cost variance in the bidding process has also been done with the use of other methods that make use of machine learning (such as Support Vector Machines, decision trees, genetic algorithms, and artificial neural networks; [22]. Technology that can process large amounts of data could improve the performance of construction supply chain management. As a result of the continued growth of the mobile internet, an increasing number of individuals can benefit from the knowledge they wish to share at this very moment. [23]. Several independent investigations were conducted in response to the issue of monitoring building materials. A material monitoring system that is based on RFID may be able to assist in the collection and transfer of data involved in the use and storage of materials, all while improving the overall efficiency with which materials are used [24]. In addition, research has been conducted on construction sites with the use of wirelessly connected sensors [25]. Validation practices, such as RFID-based quality management, unified architecture component and parts construction, and logistics management or vertical transportation, were suggested to implement collection, storage, and retrieval of valid data from equipment and materials throughout the entirety of the lifecycle of a construction project, [26]

4.2 Phase of Construction

Implementation of projects, rather than analysis of large amounts of data, is the primary focus of the construction phase. Occupational health and safety management [27] is currently regarded as one of the most pressing challenges facing businesses today. An association rule-based data mining method could be used to study the relationships between construction accidents and safety accidents [28]. These strategies are employed in association rule-based data mining methods. For the purpose of ensuring that the crane operations are carried out in a secure manner, it may be necessary to make use of more complex integrated technologies. Some examples of such technologies include mobile devices with Internet connectivity, wireless sensor networks, and real-time data transfer. Workers are verifying that their safety gear is in working order by using RFID gateways and tags. Systems must rely on RF location and tracking technology (such as a Zig Bee network or WSN) or computer vision techniques to actively manage workplace accidents or to maintain real-time situational awareness on complex construction sites. This is necessary for systems to actively manage workplace accidents (such as CNN-based algorithms). These are the foundational elements that make up integrated safety and accident prevention approaches [29].

The analysis of data constitutes the second primary strategy that will be utilized throughout the construction phase. Using an algorithm that is based on machine learning to process a massive amount of quality inspection data from building components or structures enables the computer to use this data to learn and grow more proficient over time [30]. They have made their way into a wide variety of other fields as a result of the extensive use of ANN-based performance prediction models in the construction industry [31]. These models are especially helpful for identifying architectural faults, which enables engineers to better determine when and how problems should be fixed. The scheduling of work is one of the primary considerations when it comes to performance management in the construction sector [32]. A scanned point cloud model has the potential to create an as-built building information model when used in conjunction with image-based reconstruction. It is feasible to determine whether construction is proceeding according to schedule by utilizing an integrated BIM-based AR system. [33] Mismanagement of resources, particularly human resources, materials, and equipment, can frequently be blamed for delays and cost overruns in building projects [34]. Therefore, application of KDD approaches to unearth significant insights from an enormous amount of data pertaining to labor resources, with the goal of assisting organizations in better organizing their resources. [35]. On the other hand, knowledge-based simulation was utilized throughout the entirety of the constructing process in order to increase the dependability of queuing systems. Particularly difficult is the construction of operational infrastructure for megaprojects. A knowledge-based simulation modeling, which was developed by Akhavian and Behzadan [36], has been utilized in order to show the process of construction fleet operations. In the past, various novel approaches to the tracking of on-site building operations have been proposed. Big data visualization is frequently utilized in conjunction with BIM, and it is also possible to make use of time-lapse films or video feeds [37].

4.3 Phases of Operation and Maintenance

The main concerns of conversation are quality control audits and the management of energy use. Inspection of the product's quality is one of the fundamental control aims in the construction and maintenance industries. It is possible that engineers will utilize a machine learning-based algorithm to help them make decisions that will preserve the building structures. To give an illustration, Cheng et al. demonstrated that multilevel association rule mining using a genetic algorithm is an effective method for analysing design defects. [38] The collection of real-time data on apartment development project faults is possible using a system that is coupled with a PDA and wireless web. Natural disasters can be detrimental to the construction industry. Robotic platforms have been found to be an effective method for using image-based automatic 3D crack identification to find defects in post-disaster structures [39]. Monitoring a building's consumption of energy has developed into a widespread practice in recent years. Because the size of the real-time building energy monitoring data is always growing, [40] it is necessary to have tools for analysing large amounts of data.

4.4 Phase of Recycling and Demolition

Because of the rapid rate at which urbanization is occurring, most of the environmental problems that are caused by debris from buildings are of a serious nature. Keeping this fact in mind, there has been a recent uptick in the number of proactive initiatives aimed at eliminating wasteful building practices at the conceptual level [41]. The analytical framework for construction waste that Bilal and his colleagues developed provides the opportunity for design exploration and optimization, both of which have the potential to cut down on construction waste. Earth information system (EIS) was established to make excess resources and building site recyclables available to the general population, [42] even though reducing trash and preserving the environment were the primary goals.

5 Conclusion

AI is a breakthrough technology that can bring about enormous changes in both our jobs and our lives. Despite this, the application of AI in CPM, which is characterized by its uniqueness, labour-intensiveness, dynamic complexity, and uncertainty, is still in its infancy. In the not-too-distant future, it is projected that the construction industry will place a larger emphasis on artificial intelligence (AI), as well as invest more money in AI. A variety of artificial intelligence technologies will be utilized in order to train appropriate models in order to successfully manage the rapid development of data generation in CPM. It is projected that artificial intelligence would be able to deliver on promises about prediction, optimization, and decision making, which will enable the traditional construction industry to catch up with the rapid speed of automation and digitization. The most important findings, as uncovered by this exhaustive investigation, are as follows:

i. Most academics will be focusing their efforts on the construction phase, which is the stage in which fewer digital tools and methods will be discovered.

ii. The use of BIM and ML approaches occurs most frequently in CPM since research in this area focuses heavily on data analytics and visualization.
iii. Even though approximately half of the research is devoted to two distinct areas, construction performance management and construction supply chain management and resource optimization, less than half of the entire volume of research that has been published is focused on these two issues.

References

1. Robinson, T. G. Global, construction market to grow $ 8 trillion by 2030 : driven by China, US and India. Global Construction, 44. (2015)
2. Jonathan Woetzel, Jan Mischke, Nicklas Garemo, Martin Hjerpe, Robert Palte, *Bridging infrastructure gaps : Has the world made progress?* McKinsey Global Institute, (October), p. 10. (2017).
3. Egwim, C. N., et al. *Extraction of underlying factors causing construction projects delay in Nigeria*. Journal of Engineering, Design and Technology, European Commission. European construction sector observatory. (p. 27). June (2021)
4. Wang, T. (2018). China: Construction industry's contribution share to GDP 2018–2021
5. Wang, T. (2019). *Value added of U.S. construction as a percentage of GDP 2018*. Statista (18 April 2020)
6. Yue Pan and LimaoZhang, *A critical study and an examination of future trends about the roles that artificial intelligence will play in construction engineering and management* Automation in Construction (122 103517) (2021)
7. K.J. Kim, K.H. Chin, S.H. Han, S.K. Woo, M.Y. Cho, *Contractor integrated technology information service in construction*, Canadian Journal of Civil Engineering 29 (4) 589–601. (2002).
8. Camstar System Inc., *The Virtual Factory – Managing DistributedManufacturing in a Connected Economy*, (2001)
9. M. Purdy, P. Daugherty, *Why artificial intelligence is the future of growth*, in: Remarks at AI Now: The Social and Economic Implications of Artificial Intelligence Technologies in the Near Term, pp. 1–72.(2016)
10. M. Chui, *Artificial intelligence: the new digital frontier*, McKinsey Company Global Inst. 47 (2017)
11. R. Ghanbari, M. Jalili, X. Yu, *Correlation of cascade failures and centrality measures in complex networks*, Futur. Gener. Comput. Syst. 83 390–400, (2018)
12. Z.-Z. Hu, P.-L. Tian, S.-W. Li, J.-P. Zhang, *BIM-based integrated delivery technologies for intelligent MEP management in the operation and maintenance phase*, Adv. Eng. Softw. 1151–16, (2018)
13. Y. Hu, D. Castro-Lacouture, Clash relevance prediction based on machine learning, J. Comput. Civ. Eng. 33 (2) (2019)
14. W. Van der Aalst, *Data science in action, in: Process Mining*, Springer, Heidelberg, (2016)
15. R.F. Aziz, S.M. Hafez, Y.R. Abuel-Magd, Smart optimization for mega construction projects using artificial intelligence, Alex. Eng. J. 53 (3) 591–606, (2014)
16. F. Afzal, S. Yunfei, M. Nazir, S.M. Bhatti, *A review of artificial intelligence based risk assessment methods for capturing complexity-risk interdependencies*, Int. J.Manag. Proj. Bus. (2019).

17. J. Seo, S. Han, S. Lee, H. Kim, *Computer vision techniques for construction safety and health monitoring*, Adv. Eng. Inform. 29 (2) 239–251 (2015).
18. D. D. Gransberg and M. A. Ellicott, *Life cycle project management.* AACE International Transactions, American Association of Cost Engineers. (1997).
19. S.-K. Lee, K.-R. Kim, and J.-H. Yu. *BIM and ontology-based approach for building cost estimation,* Automation in Construction, vol. 41, pp. 96–105. (2014).
20. T. Cheng, Y. Wang, and Y. Sun. *Development and application of tender evaluation decision-making and risk early warning system for water projects based on KDD*, Advances in Engineering Software, vol. 48, pp. 58–69. (2012).
21. E. O. Ibem and S. Laryea. *Survey of digital technologies in procurement of construction projects,* Automation in Construction, vol. 46, no. 46, pp. 11–21. (2016).
22. M. J. Skibniewski and W.-S. Jang, *Simulation of accuracy performance for wireless sensor-based construction asset tracking*, Computer-Aided Civil and Infrastructure Engineering, vol. 24, no. 5, pp. 335–345. (2010).
23. W. Lu, G. Q. Huang, and H. Li. *Scenarios for applying RFID technology in construction project management*, Automation in Construction, vol. 20, no. 2, pp. 101–106. (2011).
24. E. J. Jaselskis and T. El-Misalami. *Implementing radio frequency identification in the construction process*, Journal of Construction Engineering and Management, vol. 129, no. 6, pp. 680–688. (2003).
25. Z. Ren, C. J. Anumba, and J. Tah. *RFID-facilitated construction materials management (RFID-CMM)—a case study of water-supply project*, Advanced Engineering Informatics, vol. 25, no. 2, pp. 198–207. (2011).
26. C.-W. Liao and Y.-H. Perng. *Data mining for occupational injuries in the Taiwan construction industry*, Safety Science, vol. 46, no. 7, pp. 1091–1102. (2008).
27. C.-W. Cheng, C.-C. Lin, and S.-S. Leu. *Use of association rules to explore cause-effect relationships in occupational accidents in the Taiwan construction industry*, Safety Science, vol. 48, no. 4, pp. 436–444. (2010).
28. M. Amiri, A. Ardeshir, M. H. Fazel Zarandi, and E. Soltanaghaei. *Pattern extraction for high-risk accidents in the construction industry: a data-mining approach*, International Journal of Injury Control and Safety Promotion, vol. 23, no. 3, pp. 264–276. (2016).
29. [30] W. Fang, L. Ding, H. Luo, and P. E. D. Love. *Falls from heights: a computervision-based approach for safety harness detection*, Automation in Construction, vol. 91, pp.53–61. (2018).
30. D. Zhong, H. Lv, J. Han, and Q. Wei. *A practical application combining wireless sensor networks and internet of things: safety management system for tower crane groups*, Sensors, vol. 14, no. 8, pp. 13794–13814. (2014).
31. X. Luo, F. Leite, M. Asce, and W. J. O. ’Brien. *Location-aware sensor data error impact on autonomous crane safety monitoring*, Journal of Computing in Civil Engineering,vol. 29, no. 4. (2014).
32. F. Tang, T. Ma, J. Zhang, Y. Guan, and L. Chen. *Integrating three-dimensional road design and pavement structure analysis based on BIM*, Automation in Construction, vol. 113, Article ID 103152. (2020).
33. A. Hammad, S. AbouRizk, and Y. Mohamed. *Application of KDD techniques to extract useful knowledge from labor resources data in industrial construction projects*, Journal of Management in Engineering, vol. 30, no. 6. (2014).

34. R. Akhavian and A. H. Behzadan. *Evaluation of queuing systems forknowledge-based simulation of construction processes,* Automation in Construction, vol. 47, 37–49. (2014).
35. R. Akhavian and A. H. Behzadan. *Knowledge-based simulation modeling of construction fleet operations using multimodal-process data mining*, Journal of Construction Engineering and Management, vol. 139, no. 11. (2013).
36. K. Liu and M. Golparvar-Fard. (2014). *Crowdsourcing construction activity analysis fromjobsite video streams*, Journal of Construction Engineering & Management, vol. 141, no. 11,Article ID 04015035. (2014).
37. Y. Cheng, W.-d. Yu, and Q. Li, *GA-based multi-level association rule mining approach for defect analysis in the construction industry*, Automation in Construction, vol.51, pp. 78–91. (2015).
38. Y. S. Kim, S. W. Oh, Y. K. Cho, and J. W. Seo, *A PDA and wireless web-integrated system for quality inspection and defect management of apartment housing projects,* Automation in Construction, vol. 17, no. 2, pp. 163–179. (2008).
39. M. M. Torok, M. Golparvar-Fard, and K. B. Kochersberger. *Image-based automated 3D crack detection for post-disaster building assessment,* Journal of Computing in Civil Engineering, vol. 28, no. 5. (2013).
40. H. Moon, H.-k. Lee, Y.-s. Lee, and J.-J. Kim. *Earth information system (EIS) for there use of resources between construction sites,* Journal of Asian Architecture and Building Engineering, vol. 6, no. 2, pp. 267–274. (2007).
41. M. Bilal, L. O. Oyedele, J. Qadir, *Big data in the construction industry: a review of present status, opportunities, and future trends*, Advanced Engineering Informatics, vol. 30, no. 3, pp. 500–521. (2016).