

A COMPREHENSIVE LITERATURE REVIEW OF RESEARCH TRENDS OF APPLYING AI TO CONSTRUCTION PROJECT MANAGEMENT

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ABSTRACT

Artificial Intelligence (AI) is universally reaching every industry thus far, it is coming to the fore in construction industry by redesigning project world and altering the role of project managers.

It provides the ability for computers to simulate human-like thinking and is comprised of machine learning, Internet of things (IoT), automation, natural language processing and robotics.

In construction industry, AI is affecting project planning, time and cost management, optimization of resources as well as post-construction activities.

Along with assessing teamwork patterns and making recommendations, it also has an impact on the workforce and how individuals handle projects.

Despite a broad range of research papers written about this theme there are still not so much of practical applications conducted in practice. Therefore, the aim of this study is to provide an overview of using AI in Project Management and to show how it is affecting construction industry along with exhibiting future trends. This article will also show positive and negative sides of AI in Project Management and how does it manage competencies. It will propose possible utilitarian solutions including a critical review over the research topic.

The outcomes of this study contribute to the body of knowledge on AI in project management through a comprehensive investigation of literature and provide guidelines for further research on the phenomenon of AI in project management.

KEYWORDS

Artificial Intelligence, Project management, Problem-solving, Robotics, Machine learning, Construction.

1. INTRODUCTION

Henceforth the human history on managing projects there had been challenges on keeping the projects on time, budget and people on task.

Despite being one of the oldest and biggest sectors in the world—employing 7% of the workforce and spending more than \$10 trillion on products and services connected to building—the construction sector is also one of the least digitalized. (McKinsey Global Institute, 2017., [mgi-reinventing-construction-in-brief.pdf](#) ([mckinsey.com](#)))

Construction is an immanently high-risk industry with abundance of risks and fragments such as quality, costs, time configuration etc. that have an effect on a project's success. It is also an industry with countless opportunities for bad coordination, miscommunication, and disconnected processes. (D. Hartsuiker, K. Stowe et al., 2018.)

Data discontinuity, inconsistency, and inaccuracy provide one of the largest obstacles to successful project management. (B. Keskin, 2016.)

Technology has been applied in the building industry for decades to improve productivity and make construction projects safer.

The need for making decisions based on data is at the exponential growth, AI's ability to integrate, gather, analyze and visualize relevant information in real-time is one of the most valuable assets in construction projects. (D. Hartsuiker, K. Stowe et al., 2018.)

P. Taylor highlighted in his studies that by 2030, AI would be able to reliably and effectively complete 80% of project management tasks, including data collecting, reporting, and predictive analysis, among others. (P. Taylor, 2021.)

The review extracted the recent studies than examine the way that AI and machine learning can improve construction project management effectiveness

AI also has a promising approach to solving problems in project management such as big volumes of data and process complexity. (W. Eber, 2020.)

Brynjolfsson and McAfee are considering AI one of the most important general-purpose technologies of modern era. Machine learning is clearing up the time for project managers to work on creativity and focus on more important things by performing tasks on its own. (Brynjolfsson and McAfee, 2017.)

According to a PWC article, AI should be used more frequently in projects in the form of virtual assistants and robots that can do tasks on their own.

Construction firms have started utilizing AI in a variety of ways over the past several years to improve efficiency and innovation. In the building industry, AI is already demonstrating

its worth, from optimizing labor schedules to increasing worker safety to maintaining a close watch on building projects.

Finding methods to simplify the process and increase efficiency in a field recognized for its many moving parts is a primary goal. This research will give insight into how AI will alter how project assignments are delivered and managed in the future.

According to *Buildots* article, businesses that adopted digital construction tools, reported a 5% reduction in construction costs, a 5% improvement in completion speeds, a 25% increase in labour productivity and a 25% reduction in overall labour costs. That's substantial savings in cost and time for any size construction project. (Buildots, Artificial intelligence in construction, July, 2022.)

The study's main objective is to identify difficult circumstances and gaps, as well as tools that can help project managers and other professionals involved in projects by utilizing artificial intelligence.

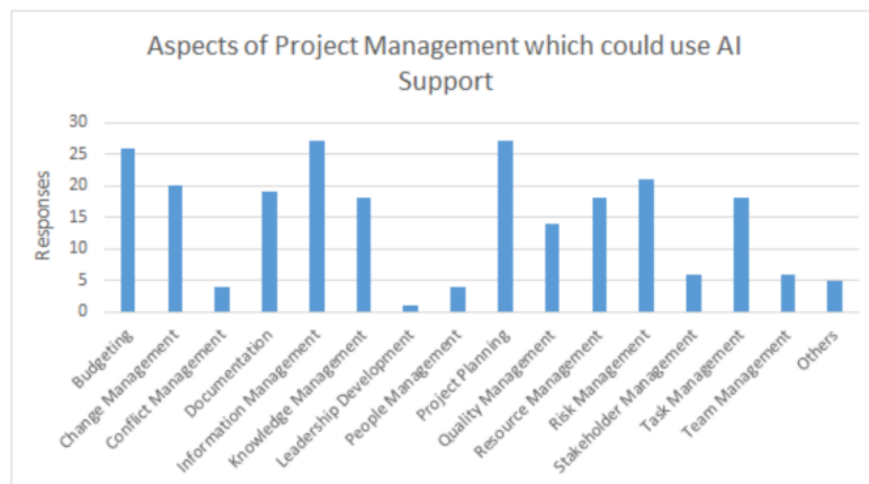


Figure 1. Project management areas that can benefit from AI help (source: BUTT, 2018 as cited in Elrajoubi, 2019)

The figure 1. represents areas where AI support can be used for project management and as shown in the picture, budgeting, information management, project planning have the most beneficial support. The main goal of this research paper is to show current and future AI tools and software's, the way AI can support and affect project management in construction, building industry and project development.

The paper studies segments of project in which AI is of use or can be integrated in the future. The review has identified research papers, reports, reviews on this topic and project-focused literature and journals mostly in recent years.

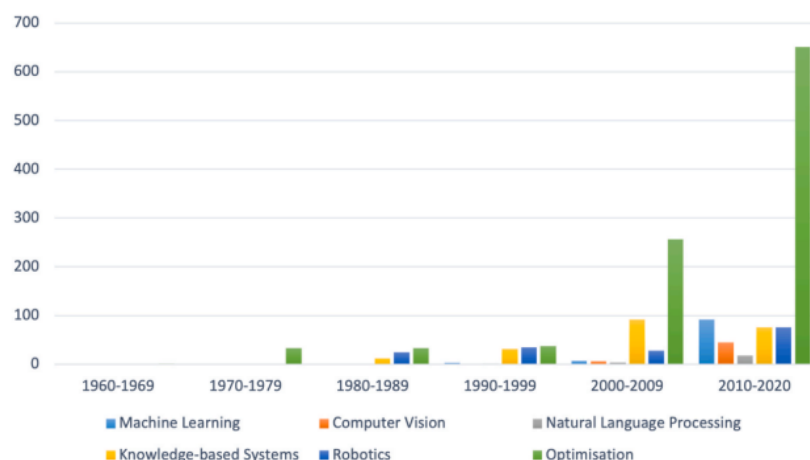


Figure 2. Frequency of Papers in AI from 1960–2019 (source: Abioye et al.)

In figure 2. S.O. Abioye et al. showed in their paper graphic visual which represents frequency of papers from 1960. to 2020., where the trend for increasing number of publications regarding AI in construction is visible in the recent years.

2. METHODOLOGY

This study provides readers with analyses, reports and case studies of possible integration of AI into project segments. The paper will analyze parts of project flow in which AI is integrated or can make improvements. It will be sectioned by project parts such as scheduling, execution and monitoring and controlling. Furthermore, the article will provide AI tools and methods that are being used as a part of companies of modern era or a future possibility. Case studies used in this research are articles published mostly in the years between 2014.-2022). This review focused on articles and research papers recently published in the *International Journal of Project Management*, *PM World Journal* and *Project Management Journal*. This research is designed to provide perspective and application of AI in construction project management, it will show the formation of AI that is being used in suggested project segment and the tools that are being researched or used by construction companies and the way AI can be implemented.

3. INTEGRATION OF AI INTO PROJECT PROCESS FLOW

In this paper AI is being researched through project phases including scheduling, execution, monitoring and controlling as well as AI-powered tools and their influence in project management furthermore the difference that they make.

3.1 Scheduling

To effectively manage projects, project scheduling is crucial. It sets the project's scope and the goals necessary to carry it out. A project plan outlines the project's execution, monitoring, control, and closure procedures. Every project requirement, such as prices, risks, resources, and deadlines, must be incorporated into the plan.

Martnez and Fernández-Rodríguez demonstrated that, by using certain AI algorithms, AI may go beyond being useful in identifying important success aspects of a project and even go as far as to forecast its success rate from the initial stages. As a result, it will be easier to decide whether to move on with a project or what adjustments need to be made. Although they underlined the fact that these machine learning applications are highly promising, they should become more widespread by the year 2030 and beyond. (Martinez, D. M. and Fernandez-Rodriguez, J. C. (2015), PM World Journal, April 2019)

Categories of AI	Application	Impact
Machine learning	Scheduling	Analysis of a large amount of data based on historical figures and human input. Makes it possible to evaluate millions of scheduling options that take humans exponentially longer to accomplish
Pattern recognition	Health, Safety and Environment	Predict/early detection of dangerous situations by using machine learning algorithms in combination with pattern recognition
Pattern recognition	Storing space	A digital map that continuously shows the site and where it is possible to store materials or machines. Will increase the predictability and efficiency on site
Pattern recognition	Detection of unregistered people	Using pattern recognition to detect people and find those who are not registered at the construction site. Will increase the safety and possibility of larceny and criminal damage
Automation	Robots executing dangerous work	For example, work in the height, such as fire protection of steel beams. Will improve the safety of humans
Automation	Self-driving construction machinery	The use of robots and self-driving construction machinery will change work flow
Automation	Quality assure work	Robots that drives around the construction site scanning the site situation and compare it with the BIM. This technology may save hundreds of hours spent of quality assuring work, both considering the main- and subcontractors

Figure 3. 11 categories of AI support in construction (source: Martinez, D. M. and Fernandez-Rodriguez, 2015)

According to Dam et al. (2018), AI will change many elements of (software) project management practice, from automating fundamental administrative duties to providing analytics-driven risk projections and quantification, easing project planning, and providing practical advice. Popular techniques like Agile will undoubtedly see significant changes in terms of how they are applied.

According to a survey of 56 project managers from various sectors done by BUTT in 2018 and mentioned in Elrajoubi in 2019, planning is the area of project management that receives the most AI help. (BUTT, 2018 as cited in Elrajoubi, 2019). Machine learning algorithms may be used to automatically create mind maps from the WBS and further extract the tasks from the WBS and their relationships. (PM World Journal, April 2019)

In 2015., Martinez and Fernández-Rodríguez explored two models based on neural networks and support vector machines. They have created two alternative models for each indication due to the distinctions between the cost and scheduling indicators. Support Vector Machine (SVM) for pricing (accuracy of 92%) and Adaptive Boosting for scheduling (rate of 80%). They concluded that the studied models contain flaws and limits, indicating that project

managers should still rely on their experience and contrast the outcomes of using artificial intelligence with those obtained using conventional tools before making a choice. This will allow them to make any necessary adjustments

In his book “Applying Artificial Intelligence to Project Management”, Paul Boudreau (2019) outlined a step-by-step strategy for enhancing project processes using AI technologies that may be specifically adapted to building projects for effective planning. (Applying Artificial Intelligence to Project Management, P. Boudreau, 2019.)

Machine learning-based project management (MLPM), which implies that AI will have an influence on the decision, is the best type of AI in project management. A large amount of prior case data, which may be considered a type of "experience" for AI, is required to examine a project. When project managers enter the data of the current project, AI may evaluate the project's progress, determine whether the cost exceeds the norm, determine the likelihood that the project will be behind schedule, and even identify potential issues before they arise. In contrast to humans, AI is adept at seeing gradual trends in a stream of data, and the more data it has, the more accurate the conclusions of its analysis. Based on the study findings, AI provides the project managers with a suitable option, but humans still make the ultimate choice. Companies will pay more attention to the design team as a result of "data cleansing," which is examined by people, because it increases efficiency and creativity. Although MLPM will deliver enormous advantages and its costs will be offset, the expense of building it now, is too expensive. (PM World Journal April 2019.)

Engineers and researchers accompanied with APM, and the University of Sussex conducted research in a form of surveys and interviews among project professionals on application of dynamic conditions. They attracted 1015 responses on series of aspects like; interpersonal skills, importance of training and certification, knowledge management contracts, agility, sustainability, diversity within project teams and technology and data.

This paper focused on reports from technology and data segment and collected results. Interviewees stated that technology and data are mature fields as in the use of standardized tools while also being major opportunities for reinvigoration of project management by exploring the field of data science and AI.

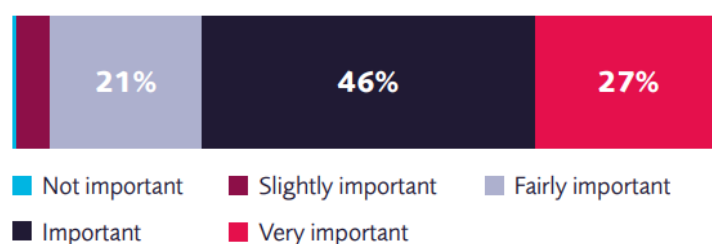


Figure 4. The perceived importance of technology and data (source: D. Nicholls et al., *Dynamic conditions for project success, 2021*)

According to survey respondents, figure 4. depicts how people view the value of data and technology. 73% of interviewees (project professionals) believe that technology and data are “important” or “very important” and 21% believe it is “fairly important”. Furthermore, authors reported survey respondents on different subcomponents of technology and data.

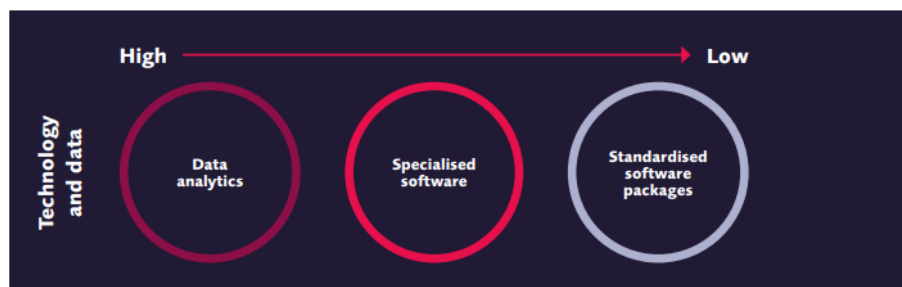


Figure 5. Importance of sub-components of technology and data (source: D. Nicholls et al., *Dynamic conditions for project success, 2021*)

The relevance of the technology and data sub-components that survey respondents selected as being relevant is shown in figure 5., along with the choice of the project growth area and data analytics as the most significant area.

As a consequence of construction being low margin, high risk and demanding industry, Rene Morkos developed *Alice*, AI software that offers the opportunity for companies to enhance project efficiency from pre-construction to project delivery. *Alice* focuses on managing the most efficient use of project resources, labor, equipment and materials. Alice is providing the reduction of risks during the planning phase and managing the changes during the project flow as well as making data-driven decisions. Alice offers general contractors the opportunity to have competitive advantage in bidding which maximize their odds of winning profitable business. (Kyle Wiggers, TechCrunch, 2022)

BuildStream helps larger-scale construction projects enhance asset utilization and save money by integrating telematics data and records into a single central platform using AI and IoT. Every area of equipment management, including construction, maintenance, labor, and procurement scheduling, has been digitalized. By analyzing timesheets and costs in one location and monitoring workflow spend in real-time, it is reducing errors. (Vetted QA/QC professionals for your engineering projects | BuildStream)

Kintech and Vattenfall reported in their case study the improvement that BuildStream made by its integration in their projects. They stated that maintaining the project schedule, ensuring quality standards and communication between the parties are crucial for the success of a project which is why they engaged with BuildStream. The platform supported the on-time delivery of the project, 80% more efficient communication compared to the traditional coordination approach, transparency of the inspection status, it provided centralized and clear schedule of activities. (Kintech and Vattenfall, 2021., Learn how Kintech and Vattenfall improved their inspection coordination efficiency by 80% with BuildStream)

3.2 Execution

Q. Wang showed that the most important part of AI is performance improvement, with the power of discovering problems that human can't foresee, AI can make significant improvement and help the company to be competitive by bringing value to stakeholders. Two forms of AI in project management are stated in this research that can be implemented in execution part of the project. The first is autonomous project management (APM), which exemplifies a high degree of AI and gives AI the chance to proactively gather the data it needs to assess and manage a project. Once it has made a decision and taken suitable action, it will add value to satisfy important stakeholders. Integration and automation (IA), which has to do with controlling quality, comes in second. At this point, AI can obtain the data it requires for project analysis and management. AI will make a choice and take appropriate action to produce value for important stakeholders. Both technologies have not yet been implemented but the article suggests not to ignore it. (Q. Wang, PM World Journal, April 2019.)

3.2.1 Predictive analytics

By creating future insights based on historical data and analytics techniques like statistical modeling and machine learning, predictive analytics is used to create predictions about future events. Businesses can accurately predict trends and behaviors using historical and present data.

The time and materials required to finish a project may be more precisely estimated by project managers. Predictive forecasting seeks to deliberately spot and mitigate hazards before they overwhelm the project. Gaining an overview of project risks and filling in identified gaps, prioritizing necessary actions to improve projects, realizing early project value, preventing financial losses by improving project oversight, and removing superfluous project characteristics to increase project efficacy are all advantages of predictive analytic (*Applications of AI in Project Management* – Saviom)

D. Hartsuiker explored that AI is enhancing the effectiveness of projects by giving project managers the access into plentitude of information that can help with identifying patterns and early diagnosis of project risks so they can be reduced. (D. Hartsuiker, K. Stowe et al., 2018.)

U. Sampson presented in a research that potential and research interest for using technologies such as BIM, augmented and virtual reality, mobile technology, Internet of Things and more has increased in the last few years regarding construction project management and control. It has been demonstrated that IoT, predictive analytics, cybersecurity, and blockchain are still in their early life as real-world building applications. (Uchenna Sampson Igwe et al 2020)

3.2.2 Project data analytics

Research paper, conducted by *Association for Project Management* stated the use of project data analytics in the current times across organizations. They reported the use of descriptive and predictive data analytics within and across organizations by investigating existing knowledge of researchers at Manchester, Southampton, Sheffield, and Warwick. According to their research, descriptive data analytics is accepted in practice, within the organizations and in the form of “benchmarking” across organizations. Within the organizations is being used in a limited way.



Figure 6. Project data analytics

Figure 6. represents Project data analytics: the state of the art and science, report by Association for Project Management.

They came to the conclusion that AI is a great support role for the team in eliminating repetitive activities and initial data-generating, but that this can only be accomplished with greater grasp of project data analytics and similar concepts. Right now, overall management of project delivery is nonexistent, but it is far more possible for specific project segments. (*Project data analytics: the state of the art and science, report by Association for Project Management*)

A.Robertson et al. performed research on project data in a form of a guide, they presented how data analytics can enhance projects and how can individuals and organizations make a better use of it. The guide is designed for project professionals, senior leaders of project-based organizations, program managers, business intelligence directors and everyone with the intention of improving project performance and delivery. They asserted that general AI

is still not implemented but narrow AI is enhancing project delivery, they mentioned forms of AI innovations that are being used in current times such as blockchain technology applications in a form of smart contracts, use of augmented reality for design development, drones for quality control on construction sites, Internet of Things, digital twins, BIM etc.

The early adopters of data analytics are innovations like Digital Twins, BIM and project control tools and that integration of data analytics in such capital programs helped with usage of data analytics in transformation programs as a help for deeper understanding of stakeholder requirements. (A. Robertson, A. Murray, G. Parkes, M. Paver, *Getting started in project data*, 2020/21)

3.2.3 Digital twins

In their research, V. Kumar Reja and K. Varghese examined the use of digital twins in building project management. Through the automation and acceleration of conventional design and execution as well as the project's finances, physical environment, digital twins provide a high-fidelity digital counterpart of a physical asset that may be used to support construction projects. This study predicts that digital twins will be a frequent tool for project management and planning construction operations and that they may be a stronger tool for making precise and on-time judgments. The digital twin has other strategic advantages, such as lower and more predictable building costs, quicker approval periods, and higher user and customer satisfaction. They claimed that cutting-edge building and process-based BIM technologies are combined with real-time, people-focused data sets to create digital twin technology. (V.K. Reja and K. Varghese, *Digital Twin Applications for Construction Project Management*, 2022)

3.2.4 Autodesk Tandem

A cloud-based digital twin technology platform called Autodesk Tandem makes it possible for projects to be digital and converts rich data into commercial insight. AEC firms may construct and deliver a digital twin to building owners and operators by utilizing BIM data throughout the process. The conveniently available, contextual, and informative data they get enables ready-to-go operations. Organizations and data are connected with Autodesk Tandem through an end-to-end digital process that covers capital planning, architecture, engineering, construction, and asset management. This aligns the owner's needs with the project team's duties. (Autodesk Tandem)

The construction industry's Quality Assurance platform Astralink incorporates Augmented Reality (AR) technology to close the gap between 3D digital blueprints (BIM models) and practical field activities. It uses trademark Computer Vision and Deep Learning procedures for connection to BIM models and prevents occurring real-time construction errors. Usage of Astralink enables building companies to significantly decrease costs, speed up project completion, and improve site security. The platform is used by some of the world largest construction companies across US, UK, Germany, and Thailand. (Astralink) Co-founder and

CEO, Niran Shrestha teamed up with CTO, Tim Axness and created *Kwant.ai*, industrial human-machine intelligence platform using AI-powered predictive analytics. It was created for analyzation of multiple projects and project schedules using the AI. The results conducted by research on a construction management company showed that *Kwant.ai* helped to increase productivity across all projects on average 11%. The company saved on average 7 hours per person per week and saved over \$150K per year. (Malbro case study, 2022.)

Procore Technologies is construction management software platform which incorporated AI in their firm with the intention to increase the usage of data in construction. Their founder, Tooe Courtemanche said that with AI-powered upgrade to their platform, Users of Procore can reduce risk while enhancing decision-making in real-time during the building process. AI implementation has enhanced the organization and accessibility of project information. They stated that this kind of improvement is a game changer in the manner of finding information throught the different elements of project management tools. Customers reported that Submittal Builder has allowed them to cut 5-7 days of effort from each assignment. (Procore Delivers Artificial Intelligence to Unlock Insights from Construction Data).

3.2.5 Time management

David Morczinek and Adam Kersnowski in 2017. co-founded AirWorks, AI-powered autonomous drafting software. They developed a platform for built world that allows firms to quickly produce CAD drawing from aerial images which speeds up the process by weeks and even months. The software uses computer vision and machine learning algorithms to autonomously categorize data and produce CAD outputs. It serves for civil engineers, construction managers, real estate developers etc. This type of AI integration allows engineers to eliminate monotonous work and focus more on creative project processes. (AirWorks | Autonomous drafting software for AEC firms

Versatile developed *CraneView* an AI-powered platform that provides a reliable solution for automated construction data collection to empower digital transformation journey. The platform itself provides a comprehensive evaluation of the project's advancement while greatly boosting onsite security. The platform helps project managers to make quicker, more informed decisions, speeding up project completion and increasing project income. It was reported that CraneView improved production rates by 50%, look-ahead scheduling errors by 45-52%, reduced cycle times by 25-50%, reduced overtime from 36hr/month to zero. (Homepage - Versatile)

The construction company Austin Commercial used CraneView in their process, and reported it helped them identify trends and provided them with special real-time insights on the activities that enhanced planning efficiency. They were able to streamline the entire hoisting process and increase project execution thanks to the CraneView system. (Austin Commercial on Delivering Results with Artificial Intelligence in Construction - Versatile)

3.3 Monitoring and Controlling

According to Martínez, Fernández-Rodríguez (2015) knowing the status of project and how it is managed and controlled is team's main duty. They integrated AI algorithms into prediction for project success and they based it on scope, budget, time, and quality.

For project control forecasting with earned value management, Wauters and Vanhoucke conducted research on a k-Nearest Neighbor (KNN) based extension. A training set with more comparable observations can be made smaller by using the KNN algorithm as a predictor and component. In order to anticipate the actual length of a project, an Artificial Intelligence (AI) algorithm uses the smaller training set. The investigations show that when the training set is identical to or different from the test set, the Nearest Neighbor methodology offers the best stability results and is able to enhance the AI methods. (Wauters & Vanhoucke, 2015.)

K.M. Aljebory and M.QaisIssam focused on carrying the project with the usage of AI algorithms. In the area of project controlling, they used Primavera database and BIM. The developed systems are using the core factors from: defining construction methods and the tasks schedule, sequencing of project activities, estimating resource requirement of each task, estimating each task's duration and schedule development to develop realistic plan. Primavera may be used for standalone projects but is primarily intended for project-based organizations. It is intended for project scheduling, management, and cost estimation. (K.M. Aljebory and M. QaisIssam - *Developing AI Based Scheme for Project Planning by Expert Merging Revit and Primavera Software*, 2019.)

Buildots AI. Are bringing together up-to-date analysis of live-build images compared with a detailed BIM model in one place which offers more productivity and cost-efficiency in construction management. Buildots AI is connecting the work on-site, using frequent data feeds from hardhat-mounted 360-degree cameras that captures and analyses images with the BIM. This comparison allows AI to automatically identify completed work, which is presented on one central platform connecting project managers straight to reality and keeping them updated.

Saurabh Ladha is one of the founders and CEO of Doxel, a real-time project control platform that in 2021 won the "best solution" award from "Artificial Intelligence Breakthrough", a renowned market intelligence firm that honors the best businesses, technologies, and goods in the worldwide Artificial Intelligence (AI) market.

Doxel empowers teams with a comprehensive view of their project and its data. It uses breakthrough computer vision technology that contextualizes the project's progress, and it is empowered with timely, accurate insights. That enables project executives to make cost-saving, well-informed decisions for their project every time. The *Doxel* platform's core differentiator is its ability to provide objective data in real-time that is contextualized for strategic goals. Every square inch of a site is scanned by Doxel's autonomous devices every day using LIDAR and HD cameras. The AI system at Doxel processes the visual input and computes the amount of appropriately placed material as well as the efficiency of the

installation. Doxel integrates with already-existing digital assets including BIM, schedule, and budget to provide decision-makers with timely alerts on potential schedule delays, cost overruns, and quality concerns. This gives owners and general contractors more leverage to influence outcomes and more predictably complete projects. (Doxel | AI Powered Project Controls). The software was applied in Pennsylvania Chemicals Project which involved four engineering and procurement contractors and up to 7000 people every day on construction site. *Doxel* was able to infiltrate the project mid-construction and supplemented the existing methods of reporting while establishing and maintaining an accurate performance baseline.

A construction intelligence tool called INDUS.AI provides real-time visibility and actionable insights into all operations, productivity, performance, and hazards at a building site for real estate investors, owners, developers, and general contractors.. It makes construction projects easier to manage, safer and more transparent. The INDUS.AI platform can monitor transport and calculate equipment productivity. Additionally, it offers in-the-moment project controls so that timetables may be adjusted, and overcharges can be tallied. The platform may be used by the clients to improve resource allocation, decrease delays, or boost billing accuracy. It can track over 100 million square feet of building sites every day, using its AI engine to spot abnormalities and advancement. In 2021. Procore acquired Indus.AI into their platform.

3.4 AI Tools and functions

When analyzing AI tools and functions within project management, the following table will synthesize the latest discoveries of AI tools and functions and their role in the project. (Table 1.)

Table 1. AI tools and methods and their function in a project development (source: PWC and research paper *INTELLIGENT PROJECT MANAGEMENT TOOLS INTELLIGENT TOOLS FOR PROJECT MANAGEMENT*, P. Chust, H. Barberá, A. G. Perez, October 2020)

	AI TOOL/METHODS	DESCRIPTION	FUNCTION IN PROJECT
1.	Chatbot assistant	Automation of repetitive and monotonous tasks	Supporting project managers and communication
2.	Smart Critical Path Method System (SCPMS)	Supporting the balance between time, cost and quality for mega construction projects	
3.	Machine learning-based PM	supports PM processes and goes along with PM tools	-execution -monitoring and controlling
4.	Natural language processing (NLP)	Extracting and understanding human language	Predicting risks in the bidding process
5.	ARTIFICIAL NEURAL NETWORK (ANN)	Simulates human brain and processes information	Prediction of cost overruns

6.	Case-based reasoning (CBR)	Solving new problems by retrieving stored cases	Risk management
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Project managers will benefit from the growth of virtual assistants by being able to stay current with industry trends and increase project value by bringing in specialists.

Project assistant bot Stratejos helps project teams by providing daily duties, establishing new tasks, or asking employees to complete open issues.

A virtual assistant called PMOtto provides recommendations on a task's time, cost, and resources using machine learning.

Hoffmann et al. investigate Cloverleaf, an AI-based platform that enhances understanding into how project team members perform, emphasizes focus on skill development and positions individuals in project teams, and aids in putting together the ideal project team. (Hofmann et al.,2020.)

R. Fayek et al. used Smart Critical Path Method System (SCPMS) to research the progress of advancement in optimization and furthermore balancing time, cost, and quality for mega construction projects. They designed the model that will reduce construction time and cost while enhancing its quality. The model contained four main tasks: storing project data and activity, providing calculations, and facilitating the input of project data.

They stated that the models put out should be valuable to individuals who make decisions, particularly those who are involved in new kinds of contracts that demand high-quality performance in large-scale building projects. (Remon Fayek Aziz ,Sherif Mohamed Hafez, Yasser RagabAbuel-Magd,2014.)

M. A. Elseifi, and O. Elbagalati, researched and reported application of ANN in highway project. An artificial neural network (ANN) is a type of computer program that mimics how the human brain functions to process data. It may be applied to project management to forecast cost overruns depending on a variety of factors, including project size, contract type, and more. In accordance with the functional requirements, it also aids in automating the scheduling of project activities. ANNs are utilized in civil engineering for categorization, system modeling, prediction, and optimization. (Applications of AI in Project Management (saviom.com)). ANN was applicated in highway construction in Louisiana, USA by replicating past cost trends and estimating the future ones. (Mostafa A. Elseifi, Ph.D., P.E. Omar Elbagalati, 2017.)

4. CONCLUSION

In this study we have found most studies that show application of AI in construction industry and segments of a construction project that are being implemented in the current times as well as future opportunities for development of AI in building industry. We have found

softwares which are powered by AI that are being used in project segments like planning, scheduling, monitoring etc. This article will be able to aid project managers as well as engineers and everyone included in project management to explore possible opportunities for integration of AI in their companies, projects, and further research. This article shows detailed composition of latest studies, real-life application, articles, softwares, tools where AI is making a difference and how can AI change project development and speed up the process of project delivery.

In the phase of scheduling, AI is making the difference regarding the reduction and prediction of risks as well as predicting the time of the project delivery through AI platforms like Alice and Buildstream. Digital twins are offering the visualization of plan where possible obstacles can be solved before times. In the execution phase of the project AI is helping stakeholders and clients to keep up with the project activities and its changes in real time. In this phase, AI is reducing the repetitive tasks and by that aiding project managers and everyone involved in dealing with more complex problems. Platforms like Astralink and AirWorks are making a great difference in segment of time and cost management which reduces the unnecessary cost. In the phase of monitoring and controlling AI's best usage is in its algorithms integrated in softwares like Buildots.AI and Doxel where the project can be live streamed and changes can more precisely be controlled and deal with. AI tools and functions in the form of robots as virtual assistants or functions like SCPMS and ANN are significant support for project managers and engineers involved in projects to ensure more problem solvation and reduction of unnecessary tasks while freeing their time to focus on creativity within technical environment.

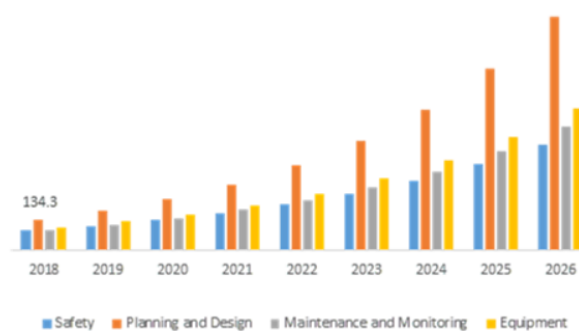


Figure 7. AI In construction market by application

Figure 7. represents AI In construction market by application. According to this picture, AI will produce a great deal of profit especially in the segment of planning and design. Research dive analysis stated that planning and design generated \$134.3 million in 2018 and is projected to grow at a CAGR (Compound Annual Growth Rate) of 28.9% during the foreseen period. Source forecasts AI in construction industry by the year 2026. (ARTIFICIAL INTELLIGENCE IN CONSTRUCTION MARKET REPORT, 2020.,AI in

Construction Market Analysis, Growth, COVID-19 Impact, and Review 2019–2026 (researchdive.com)

Most studies propose AI tools, machine algorithms etc. as useful and positive implement into project management and construction projects. Mentioned researchers that adopted AI tools and machine learning algorithms into their studies or projects are highlighting the advancement, speed, and accuracy that AI brings when it comes to projects. Negative sides of AI right now is that it works with inaccurate data conducted by human mistake and although the increased interest in recent years over the researched topic it has yet to be developed in practice. According to most case studies used in this article there is more positive the negative sides of AI development. Most are afraid of AI because of the fear of replacing human jobs, but despite the fact that some jobs, mainly the repetitive administrative tasks of project will be replaced, much more will be opened, because AI can never make decisions when it comes to choosing the right option at the end. In that aspect project manager can't be replaced by AI, instead it can help and free up the time for project managers to focus on more creative ways for problem solving, people on the team and client needs. AI has great potential to enhance the construction project process and delivery and make it more accurate, effective, and fast-moving.

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