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A Review of An Intelligent Framework for improving projects in the construction industry Based on Building Information Modeling

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Abstract

Traditional methods in construction project management negatively impact project management, increasing costs, time frames, and reducing quality. However, advancements in artificial intelligence (AI) and Building Information Modeling (BIM) offer solutions to these issues, potentially replacing traditional methods. This study aims to explain the significance of AI and BIM in Egypt's construction industry and its impact on Engineering Project Management. It seeks to create a model encouraging companies and contractors to use AI technology more effectively, reflecting the Egyptian economy. The study also aims to increase awareness of the advancements in 6D models, including facility management, maintenance, and 7D models, which offer sustainability benefits. The study encourages companies to conduct more research and development, utilizing the large volume of data available in the Egyptian market, and creating models using AI and BIM technology to maximize the benefits of this technology.

Keywords: *Artificial intelligence (AI), Building information modeling (BIM), AI challenges, AI opportunities, Construction industry.*

1. Introduction

The use of AI and BIM programs in the construction industry has been growing, offering numerous benefits such as increased efficiency, safety, and quality outcomes [1]. AI and BIM can automate routine tasks, optimize processes, and identify patterns in past projects, reducing waste and time. They can also help identify potential safety hazards and suggest ways to mitigate them, reducing the risk of accidents and injuries. AI and BIM can also improve the accuracy and quality of construction projects by analyzing 3D models of building designs and monitoring progress in real-time. However, there are challenges associated with implementing AI and BIM in the construction sector [2]. Data quality and availability are crucial for the effectiveness of AI algorithms, while ethical considerations such as privacy, bias, and job displacement need to be addressed. Adoption and integration can be challenging, as project managers and team members may require training and support to effectively utilize AI and BIM tools. In conclusion, the use of AI and BIM in the construction industry can lead to improved safety, efficiency, and quality outcomes. However, challenges such as data quality, ethical considerations, and the need for training and support are essential for successful implementation. By addressing these challenges, researchers can contribute to the advancement of project management practices and provide valuable insights for project managers and organizations seeking to leverage AI and BIM to enhance project outcomes and efficiency [2].

This study aims to achieve several objectives related to the integration of AI and BIM technologies into construction project management practices in Egypt. The objectives include examining the impact of AI and BIM on the efficiency and productivity of construction project management processes, investigating potential cost savings and time reductions that can be achieved through their integration, assessing their effectiveness in

minimizing errors and improving the overall quality of construction project deliverables, identifying challenges and barriers in implementing AI and BIM in the construction sector in Egypt and proposing strategies for overcoming them, exploring their role in enhancing decision-making processes in construction project management and evaluating the perceptions and attitudes of engineering project managers towards their use and potential benefits and drawbacks. Furthermore, the study aims to develop a framework or guidelines for integrating AI and BIM into construction project management practices, considering industry-specific requirements and constraints, achieve the maximum possible benefit from their use in construction projects in Egypt, obtain an intelligent framework for any entity that wants to introduce AI and BIM technology into construction project management instead of traditional methods in Egypt and introduce new technologies such as 6D, 7D, and 8D models.

2. Literature Review

(Jesús Gil Ruiz1, Javier Martínez Torres2, Rubén González Crespo3, 2021) Discovered that Artificial intelligence (AI) is rapidly developing in fields like science, finance, and engineering. This work analyzes hybrid systems for project management, categorizing domains, and learning techniques. Researchers are increasingly using AI tools to improve project management, as they are more accurate than traditional methods. However, many models have limitations, and project managers should continue to evaluate results. A hybrid computing model is proposed to exploit AI's potential in project management fully. AI algorithms can be used for psychological and sentiment analysis to assess team performance and customer satisfaction. In 25 years, AI will likely manage entire projects with human oversight [3].

(Pan, Yue, and Limao Zhang, 2021) Declared that construction engineering and construction management (CEM) is rapidly adopting artificial intelligence (AI) as a research hotspot. This paper reviews 4,473 journal articles published between 1997 and 2020, focusing on six current research topics: knowledge representation and reasoning, information fusion, computer vision, natural language processing, intelligence optimization, and process mining. Future research directions include intelligent robots, cloud virtual and augmented reality (AIOT), digital twins, 4D printing, and blockchain to promote automation and intelligence in CEM. AI has the potential to revolutionize the construction industry by providing reliable, automated, self-modifying, time-saving, and cost-effective processes. AI plays a crucial role in extracting valuable insights from big data, fulfilling essential functions such as automation, risk reduction, increased efficiency, digitalization, and computer vision [4].

(Order, Alphabetical, and Adel BELHARET, 2020) Exploring in this report the impact of artificial intelligence (AI) on project management and its potential future reshaping. they suggest five directions for further research: identifying emerging businesses as consultants for major corporations, examining Tesla and GAFAM's AI usage, polling MoTIS alums, interviewing selected alumni, and examining PM associations' readiness for change. The field of AI and project management is rapidly developing, with major consultancies like Gartner, Accenture, and PWC taking it seriously. Understanding AI's impact on PM operations is crucial for effective coaching and change management [5].

(Ong, Stephen, and Shahadat Uddin, 2020) Exploring in this article the evolving role of data science and artificial intelligence in the project management industry, highlighting potential applications and future uses. they revealed that complex technology applications streamline industry-standard practices, and AI in project management aims to improve operations through sophisticated methods like resource management, estimation, risk management, KPIs, prediction, and experimentation. As technology advances, data science and AI will become integrated, enhancing communication and development [6].

(Makaula, Siphosenkosi, Megashnee Munsamy, and Arnesh-Telukdarie, 2021) Presenting in this paper a framework for AI in construction management, based on a literature review. highlighting the various AI

technologies and their applications throughout a project's life cycle. AI can aid in advanced project execution, material procurement, modularization, planning, design, and simulation. Although it may lead to job losses, it can also generate new jobs in the emerging technology value chain. The paper emphasizes the importance of AI in the construction sector, particularly in Africa, a developing country that requires technological advancements [7].

(Salehi, Hadi, and Rigoberto Burgueño, 2018) Declaring in this article that AI, particularly machine learning, pattern recognition, and deep learning, is a valuable tool in structural engineering for addressing complex issues and reducing experiment time. These algorithms are essential for non-destructive structural and material evaluation, damage detection, optimization, and earthquake engineering. They can also enhance SHM frameworks, computational mechanics, and optimization fields. However, their limitations and potential for further study are still being explored [8].

(Prifti, Valma, 2022) Examining in this study the shortcomings of project management and the potential of artificial intelligence (AI) as a tool for improvement. Identifying the main issues faced by project managers and highlighting the benefits and drawbacks of AI adoption. The study suggests that AI can enhance productivity, emotional intelligence, and creativity in project management. However, the implementation of AI in project management comes with risks. Despite the importance of project managers, AI has the potential to boost efficiency. While AI systems can optimize project management components, further research is needed to address challenging issues and develop effective solutions [9].

(Manzoor, Bilal, et al, 2021) Discovered in this study that Artificial intelligence (AI) is increasingly being utilized in civil engineering for its benefits in data collection, environmental impact analysis, and productivity. This study conducted a systematic literature review of 105 AI research publications, analyzing 3478 academic publications. The US has the most significant influence on AI characteristics such as interconnection, functionality, unpredictability, and individuality. The review highlights the importance of AI in civil engineering, particularly in rich countries, and its potential to improve construction projects. AI can expedite learning, simplify complex reasoning processes, and boost productivity, reduce production costs, and reduce pollution, all of which have improved living conditions. However, the review acknowledges limitations, such as a focus on journal publications and an incomplete representation of existing AI literature. Further research is needed to fully understand the potential of AI in sustainable development [10].

(Abioye, Sofiat O., et al 2021) Presented that the construction industry faces numerous challenges, including cost and time overruns, health and safety issues, productivity, and labor shortages. The industry is one of the least computerized in the world, making it challenging to address these issues. Artificial Intelligence (AI) is transforming industries like manufacturing, retail, and telecommunications, enhancing profitability, efficiency, safety, and security. However, AI-related issues still exist in the construction sector. This research aims to understand AI applications, investigate methodologies, and identify opportunities and challenges for AI applications in the construction sector. The study examines AI applications in activity monitoring, risk management, and resource and waste optimization. The research divides AI subfields into emerging, ripe, and mature, with computer vision, robotics, and natural language processing falling under emerging technologies. Deep learning, a less powerful AI technology, has been slow to gain traction. The study also highlights potential research topics for AI in construction, such as Building Information Modeling (BIM), Internet of Things (IoT), quantum computing, augmented reality, and cybersecurity [11].

(Shaqour, E. N, 2022) Declared in this study that the construction industry in Egypt faces challenges in project management due to poor management, resulting in time, money, and materials loss. Building Information Modeling (BIM) technology can help address these issues by enhancing the application of project management knowledge areas and providing benefits. This study investigates the current state of project management knowledge in the Egyptian construction sector, focusing on the impact of BIM technology on these areas. The

research was conducted among experts using BIM software in project management, and a sample of 106. The study found that implementing BIM tools could improve the project management process, covering all areas of management unevenly. Benefits include centralized data management, improved cost control, construction schedule maintenance, descriptive information, and dealing with stakeholders from various backgrounds. The study also highlighted the need for improvement in communication management, particularly risk management. BIM tools can significantly increase risk management by up to 13% and communication management by up to 17%. The study concludes that the construction industry should adopt technological applications in all project phases to improve its performance [12].

(Amin, K. F., and Fonbeyin Henry Abanda, 2019) Exploring in this study the use of the Royal Institute of British Architects (RIBA) Plan of Work and Building Information Modelling (BIM) guidance materials in Egypt's construction sector. It found that incorporating the RIBA PoW would be beneficial if existing construction operations were better documented and related to BIM ideas. A BIM-RIBA PoW was created by identifying primary BIM objectives and activities at each project lifecycle. However, reaching professionals with significant experience in facilities management has proven challenging [13].

(Hasan, Amjed Naeem, and Sawsan M. Rasheed, 2019) Discovered that The Architecture, Engineering, and Construction (AEC) industry in Iraq faces challenges such as poor quality, communication, cost overruns, and project delays. Building Information Modeling (BIM) can automate these operations, but its implementation is slow. The study aims to understand the benefits, obstacles, and incentives of 5D BIM in the Iraqi construction sector. The results show that the awareness rate of Iraqi engineers about BIM is low, with 67.5% of respondents aware of it. The main benefits of BIM include collaboration, digital representation, visualization, effective QTO tool, and reduced change order. Challenges include culture resistance, belief that recent software and traditional approaches are sufficient for 5D BIM tools, and the lack of qualified staff. The study provides a baseline for measuring changes in the use of 5D BIM for cost estimates, which could help overcome these barriers to 3D and 5D BIM interoperability. The findings serve as a springboard for further research into boosting BIM implementation in the Iraqi building industry [14].

(Mohamed, Amira Elshazly, 2019) Illustrated that the Egyptian construction industry is grappling with environmental challenges, energy use, and water scarcity. To tackle these issues, experts in Architecture, Engineering, and Construction (AEC) are promoting sustainable green construction practices. Building Information Modeling (BIM) is a new technology that can improve project quality, lower costs, and promote passive design. This research examines the influence of BIM deployment on sustainable construction practices and evaluates current trends in the AEC industry. It discusses sustainable design and constructability in the construction industry, the successful use of BIM in the pre-construction phase, and the role of government and other stakeholders in adopting BIM for sustainable construction. Interviews with BIM users and specialists were conducted to investigate the BIM implementation situation in Egyptian consulting businesses. The study recommends successful BIM adoption in Egypt and recommends collaboration among industry stakeholders to develop a roadmap for BIM adoption. However, obstacles such as top management opposition, technology costs, poor execution, and lack of training hinder successful implementation [15].

(Nabil, Yasmin, Ahmed H. Ibrahim, and Suad Hosny, 2023) Aiming in this study to demonstrate the significance of Building Information Modeling (BIM) in controlling Reduced Reinforced Concrete Material Waste (RRCMW) in building projects. Two questionnaire surveys were conducted to assess the progress of BIM usage in Egypt over the last seven years. The results showed that 94% of consultants practice BIM in 3D, while 72% of contractors agree to practice it in 3D. 86% and 78% of consultants use BIM in 4D and 5D, respectively, while only 43% and 40% of contractors agree with practicing BIM 4D and 5D models. Despite BIM's limited implementation in Egypt, 61% and 58% of respondents considered it significant in 6D and 7D, respectively. The study concluded that while BIM has shown significant improvement in Egypt over the past

seven years, its use remains limited and ineffective. Engineers must be knowledgeable about BIM implementation to be certified to deal with it. BIM improved quantity take-off and estimation for 90% of consultants and 84% of contractors, and was cited as important for collaboration by 96% of contractors and consultants. Around 87% of respondents believed BIM was employed throughout the design stage, and 83%, 92%, and 93% considered using BIM in residential, non-residential, and infrastructure projects, respectively [16].

3. Artificial Intelligence (AI)

Artificial Intelligence (AI); is a rapidly advancing field that aims to create intelligent machines capable of performing tasks that typically require human intelligence. It encompasses technologies such as; machine learning, natural language processing, computer vision, robotics, and expert systems. Recent advancements in computing power, big data, and algorithmic improvements have accelerated AI's progress, leading to significant advancements in various domains. Key subfields of AI include machine learning, computer vision, natural language processing, knowledge-based systems, optimization, robotics, and automated planning and scheduling.

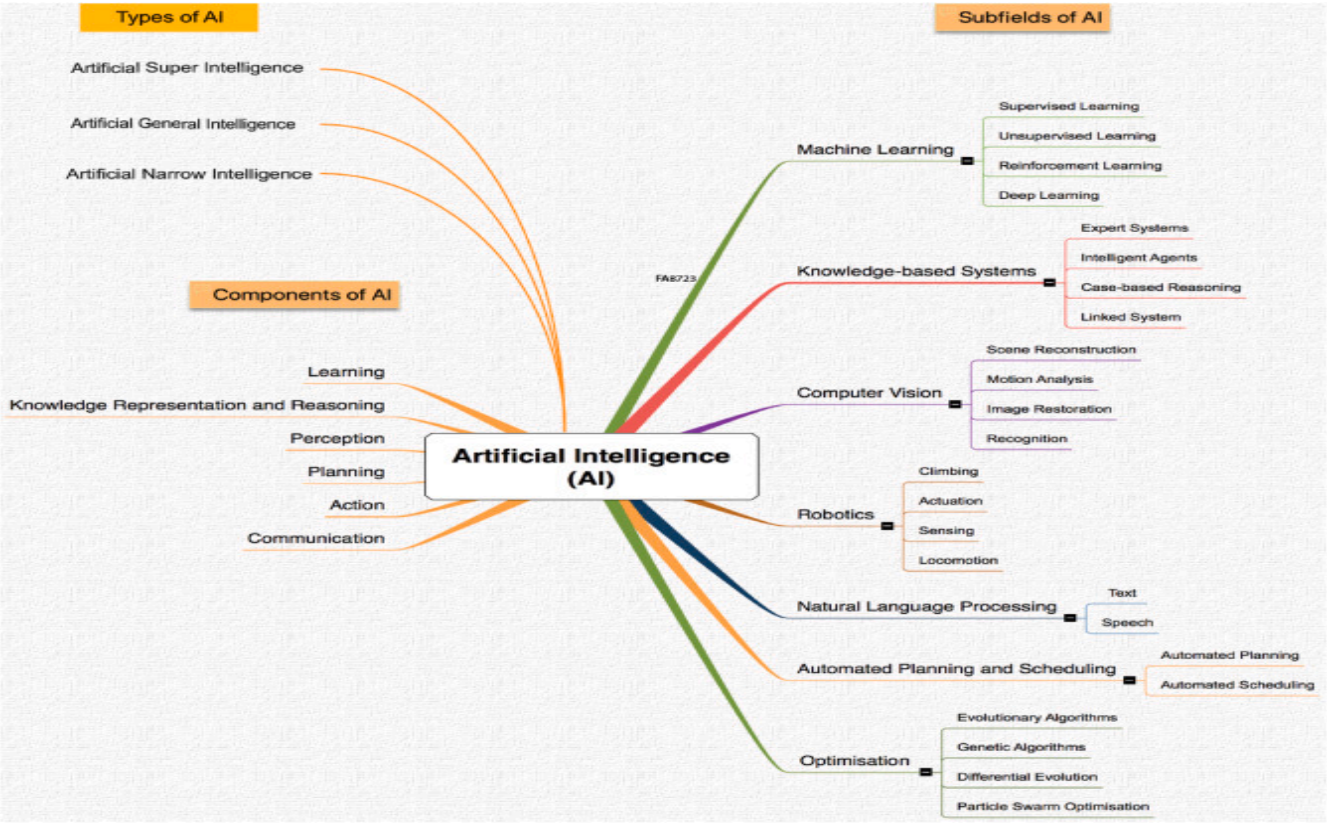

Figure 1 AI types, components, and subfields [11].

Machine learning involves the creation and application of computer algorithms that draw on past performance or historical data to model, control, or anticipate events without explicit programming.

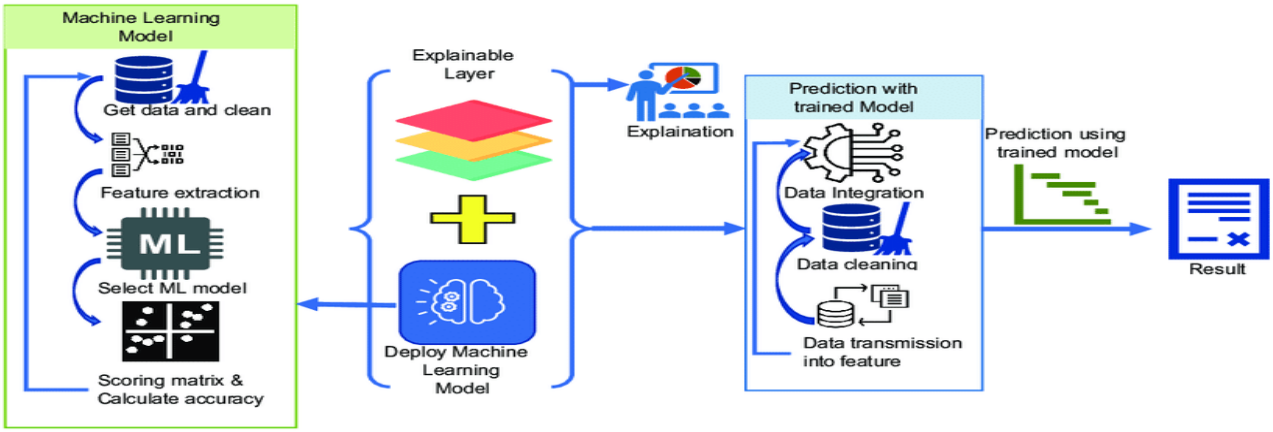

Figure 2 A conceptual framework Machine Learning model [30].

Computer vision simulates the human visual system artificially, enabling a high-level understanding of digital and multidimensional images.

Figure 3 computer vision framework [31].

Knowledge-based systems (KBS) are computer programs or systems that solve complex issues or make choices using knowledge and reasoning skills. Robotics is a multidisciplinary field that involves the design, development, and application of robots with artificial intelligence, sensors, and actuators. Key areas of robotics include robot design and construction, robot control, perception and sensing, artificial intelligence and machine learning, human-robot interaction, and applications in various fields. Automated planning and scheduling are fields of study in AI and computer science that focus on developing algorithms to enable autonomous systems to generate plans and schedules to achieve specific goals. Natural language processing (NLP) is a branch of AI that focuses on developing computer programs that replicate human language abilities. Optimization involves choosing options or making decisions that produce the best results given a set of limitations.

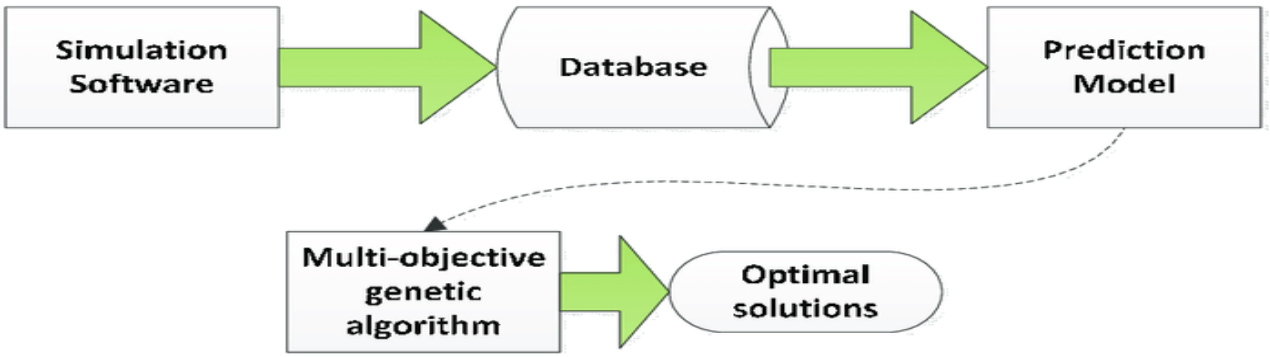

Figure 4 Optimization Framework

Evolutionary algorithms (EA) are a new class of metaheuristic algorithms developed together with AI in the 1950s.

4. Building Information Modeling (BIM)

Building Information Modeling (BIM) is a digital representation of a construction or infrastructure project, utilizing 3D models, data, and collaborative processes throughout its lifecycle. It has evolved from 2D CAD drawings to 3D modeling and information-rich models, with the term "Building Information Modeling" coined in the early 2000s to emphasize the importance of information and collaboration in the construction industry. BIM's effectiveness is attributed to its 3D visualization, data integration, collaboration and coordination among stakeholders, simulation and analysis, and lifecycle management.

BIM has become increasingly prevalent in the construction industry due to its benefits, including improved collaboration, reduced errors, cost savings, and enhanced project efficiency. The integration of AI techniques with BIM further enhances its capabilities, enabling more advanced analysis, automation, and decision-making in construction and building management processes. The integration of AI techniques with BIM further enhances its capabilities, enabling more advanced analysis, automation, and decision-making in the construction and building management processes.

4.1 Dimensions of BIM Technology

Building Information Modeling (BIM) technology has revolutionized the architecture, engineering, and construction (AEC) industry by providing a digital representation of buildings and infrastructure projects in multiple dimensions. These dimensions enable collaboration, coordination, and decision-making throughout the project's lifecycle. The 3D dimension creates a virtual model of a building or infrastructure project, enhancing communication among team members. The 4D dimension links the 3D model with scheduling information, allowing stakeholders to visualize and simulate the construction timeline. The 5D dimension incorporates cost-related information, enabling stakeholders to generate accurate cost estimates and make informed decisions. The 6D dimension focuses on sustainability and facility management, integrating data, energy analysis, and operational information for lifecycle analysis, maintenance planning, and sustainability improvements. The 7D dimension includes asset management and facility operations, allowing stakeholders to manage and maintain the project throughout its operational phase. The 8D dimension includes safety, enhancing safety measures, reducing risks, and fostering a safer working environment on construction sites. AI and BIM can improve efficiency in construction and architectural design by following rules, analyzing designs, suggesting alternative solutions, and being creative. AI can also control budgeting and scheduling by making accurate time estimates and taking over budget monitoring, scheduling, and task coordination. As AI evolves, it will continue to play a crucial role in the construction industry.

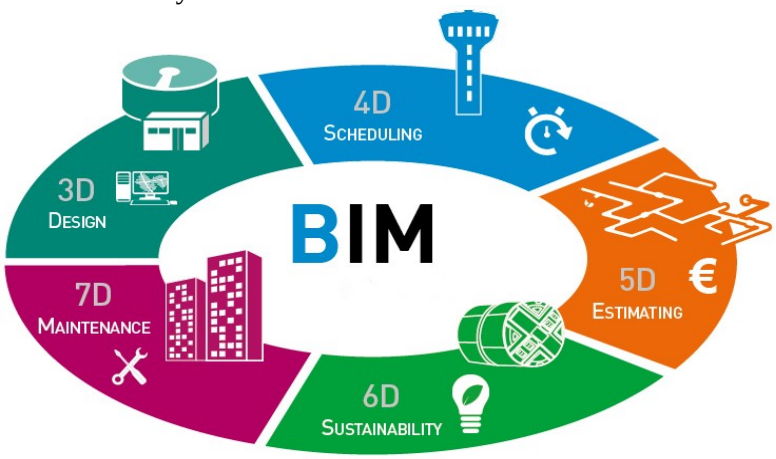

Figure 5 BIM Dimensions.

4.2 BIM Technology in the Construction Industry

Artificial intelligence (AI) has significantly improved coordination among diverse project stakeholders in the construction industry. AI algorithms can automatically detect clashes or conflicts between different building elements, ensuring compliance and reducing coordination errors. AI can also automate rule checking, design optimization, parametric design, material selection, resource allocation, schedule optimization, risk analysis, real-time collaboration, automated documentation, change management, facility management integration, energy analysis, cost estimation, 4D/5D BIM, safety planning, prefabrication and modularization, IoT integration, predictive maintenance, occupant comfort, and continuous improvement.

AI algorithms can automatically detect clashes or conflicts between different building elements, automate rule checking, optimize design options, and suggest optimized solutions. Parametric design tools automatically adjust design elements based on changes made to related components. AI can also optimize resource allocation, schedule optimization, and risk analysis, helping project teams make informed decisions. AI-powered collaboration platforms enable real-time communication and coordination among stakeholders, regardless of their physical location. Automated documentation generation ensures accurate and up-to-date information for coordination purposes.

AI can assist in managing design changes by analyzing their impact on coordination and suggesting appropriate adjustments. BIM technology can facilitate coordination between design and facility management by integrating BIM data with facility management systems, optimizing energy usage, and coordinating design decisions. AI can also analyze project data and historical cost information to provide accurate cost estimates, enhance coordination in 4D/5D BIM models, and predict equipment failures. In conclusion, AI capabilities can significantly improve project stakeholder coordination, leading to better outcomes, fewer errors, and greater efficiency in the construction industry.

4.3 Programs supporting BIM and AI in the construction sector

Autodesk Revit is a popular software for Building Information Modeling (BIM) that creates smart 3D models and elements with precise details and large amounts of data. It supports programming processes using Dynamo, which allows writing code that facilitates design processes using Revit. Artificial intelligence (AI) helps improve the flow and workflow of work in BIM models, automate tasks that require effort to implement, and collect data from work sites, analyze it, and provide proposals to complete implementation with accuracy and high quality.

Autodesk Navisworks Manage is a basic program for simulating implementation phases and linking time programs with 3D models and improved process flow for construction projects. It helps reveal conflicts from different BIM models and improves the overall efficiency of the building. Autodesk BIM 360 is one of the programs that greatly and effectively supports artificial intelligence (AI). It is based on technologies called Construction IQ, which helps the program understand high-risk quality problems and take actions to mitigate them by understanding key risk indicators, behaviors of elements, individuals, and potential environmental risks. All data collected and captured are analyzed using various artificial intelligence techniques Continuous and automatic based on Construction IQ. The forecasting and analysis capabilities of BIM 360 allow users to create custom views of project data relevant to their needs, and they can easily customize the project page to create a comprehensive, actionable overview of the project using a so-called "Design Card." This card helps take risk management to a higher level, identifying potential safety risks from visual safety inspection information.

Autodesk Forma is an industry cloud that standardizes building design, construction, and maintenance practices. It has key functions such as contextual modeling, conceptual design capabilities, automation, machine learning, and a Revit add-in. Bentley Synchro 4D Pro is another leading program that supports BIM building information modeling technology, allowing users to create 3D models of buildings and various facilities with speed and high accuracy. Touch Plan is a planning and scheduling program based on cloud storage that uses artificial intelligence (AI) to help construction, planning, and project management teams more efficiently and effectively. Touch Plan analyzes project data, providing insights that help the team make better decisions and improve project scheduling. ALICE is an AI-based system that revolutionizes the construction industry by self-automating tasks in creating and managing BIM models. It understands construction processes, creates detailed

3D models, and analyzes modeling data to improve construction processes. ALICE works with block diagrams and can create buildable 4D schedules if no BIM model is available. It also helps in construction optioneering, evaluating potential solutions based on project objectives and identifying the best path forward. It helps in making informed decisions, reducing time and cost per decision. Fire Flies AI is a digital assistant that automates customer service, provides a personalized user experience, and helps in better project management and cost reduction. It uses a machine learning system and natural word processing processes to understand customer queries and identify appropriate processes and services. The slogan is "Turn your meetings into an automated knowledge base".

4.4 Challenges facing the application of BIM and AI in construction

The application of Artificial Intelligence (AI) and Building Information Modelling (BIM) in the construction industry holds immense potential for driving innovation, efficiency, and productivity. AI can automate processes, analyze vast amounts of data, and make intelligent decisions, while BIM enables collaborative and integrated project management throughout the construction lifecycle.

However, the implementation of AI and BIM in the construction sector faces several challenges, including cultural challenges, security and safety challenges, lack of skilled manpower, high initial cost challenge, governance and morality challenges, and access to the internet and processing power. The construction sector is one of the least digitalized and slowest to adopt new technology, as most construction procedures are dangerous and expensive. To persuade construction organizations and contractors to adopt AI technologies, they must be adaptable to various building projects or sites and well-tested. This could involve utilizing blockchain and other digital technologies to increase transparency and trust.

Security and safety challenges arise from AI's ability to increase security and identify intrusions but also being a prime target for hackers, criminality, and privacy incursion. This can have significant economic and financial ramifications, as small errors in construction processes can have significant effects on quality, cost, and timeline, potentially leading to fatal accidents or serious injuries. Lack of skilled manpower is another challenge, as there is currently a lack of AI engineers with the necessary expertise to drive significant breakthroughs across industries. Government funding on STEM education can help mitigate this issue, and construction experts must work in collaboration with researchers and industry experts in the field of AI. High initial cost challenge is another significant issue, as AI-driven solutions like robotics are typically very high and require upkeep needs to be considered. Small businesses and subcontractors may not be able to afford these costs, making it crucial for businesses to calculate the cost savings and return on investment of such technologies.

Governance and morality challenges are also significant, as AI technologies can pose risks if not properly governed. For example, a large construction site robot might malfunction and collapse on a crowded site with many workers, potentially causing their deaths. The construction industry needs regulation to ensure that AI solutions do not provide an unfair edge to some businesses. Access to the internet and processing power is another challenge, as most construction sites are in isolated areas without access to electricity, telecommunications, or the internet. The deployment of 4G communication technologies has significantly solved this issue, providing even more reliability for construction sites.

5. Case study Methodology

The Egyptian construction sector is experiencing significant developments due to implementing key national projects, which positively impact the economy. To reduce costs and ensure quality and timely implementation, the focus is shifting to using artificial intelligence (AI) and building information modeling technology (BIM). However, their usage in Egypt is limited to a few multinational corporations. A questionnaire was distributed to one of these companies to support the study's theory on the importance of AI in construction. The study aims to generalize the use of AI in important national projects, creating a strong model for the importance of AI and providing incentives to other companies still using traditional methods. This will help the Egyptian economy benefit from the widespread use of AI in construction projects.

This research methodology involves a comprehensive literature review, case studies, and a questionnaire form to gather data on AI and BIM implementation in the construction industry in Egypt. The literature review will examine academic research, scholarly articles, and industry reports to establish a theoretical foundation and

identify key concepts. Case studies will analyze real-world examples of successful AI and BIM implementation in project management, such as scheduling, cost estimation, risk analysis, and resource allocation. A questionnaire form will be designed to gather quantitative and qualitative data from professionals in the construction industry, including project managers, engineers, and other stakeholders.

The data collected will be analyzed using descriptive statistics to identify patterns and trends, and thematic analysis to identify recurring themes and extract meaningful insights. Ethical considerations will be adhered to, ensuring confidentiality and anonymity of participants. Informed consent will be obtained from all participants involved in case studies and questionnaire surveys, and personal or sensitive information will be handled with utmost care and compliance with relevant data protection regulations.

5.1 Adapted Framework

The construction industry is utilizing Artificial Intelligence (AI) and Building Information Modeling (BIM) to enhance efficiency, collaboration, and decision-making. However, due to the sector's unique characteristics, an adapted framework is needed to integrate AI and BIM effectively.

The adapted framework provides a structured approach for optimizing AI and BIM implementation, considering specific needs, challenges, and opportunities. Data from a questionnaire will be analyzed using result analysis techniques to generate recommendations for Egypt's construction sector. These recommendations may cover areas like project management, collaboration, technology adoption, sustainability practices, regulatory compliance, and workforce development. The analysis aims to identify areas of improvement, highlight successful practices, and address challenges faced by the industry. The recommendations will guide decision-making and support the continuous growth and development of the construction industry in Egypt, fostering innovation and contributing to the sustainable advancement of the sector.

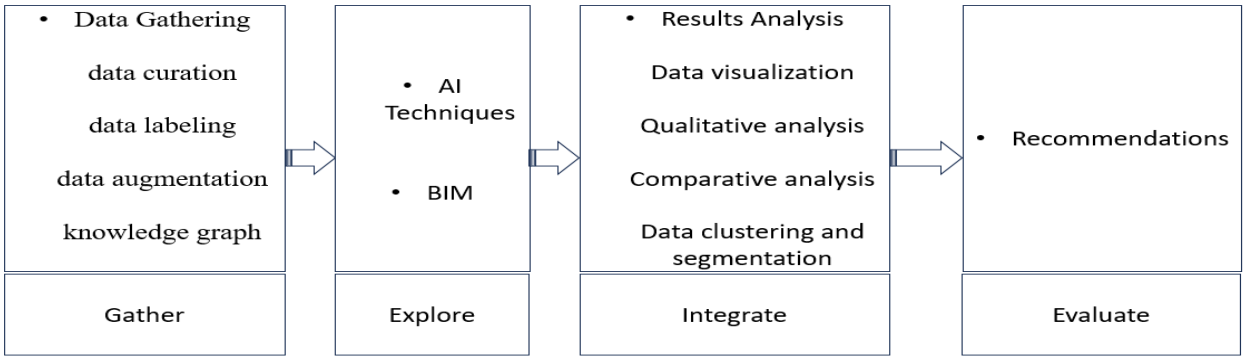

Figure 6 Adapted Framework for applying AI and BIM in construction

6. Result Analysis and Discussion

The results analysis from the questionnaire form is a crucial tool for extracting valuable insights and drawing conclusions from the data collected. It allows for the collection of opinions, perspectives, and preferences from a targeted group of participants within the construction field in Egypt. The analysis involves examining both quantitative and qualitative data to identify trends, patterns, correlations, and other relevant insights.

The results analysis provides a foundation for evidence-based decision-making and allows stakeholders to make informed choices based on the collected data. It helps gain insights into the challenges faced by construction firms, the needs of stakeholders, and the perspectives of all players within the Egyptian construction sector. These insights serve as a basis for crafting practical recommendations, tailored strategies, and targeted interventions to address identified issues and drive positive changes. The distribution of engineering disciplines among the respondents reveals an interesting breakdown of the engineering disciplines. 83% of the participants identified themselves as civil engineers, while 17% were architectural engineers. This distribution suggests a collaborative environment within the construction industry, where civil engineers and architectural engineers work together to deliver successful projects.

The survey reveals a diverse range of experience levels in Egypt's construction industry. The majority of respondents are early to mid-career, with 1 to 5 years of experience. This demographic is likely to bring fresh perspectives and expertise, potentially serving as mentors or leaders for younger workers. The smaller percentage of respondents with 5 to 15 years of experience indicates a mid-career segment with a solid foundation. The presence of respondents with more than 15 years of experience demonstrates veteran professionals' extensive knowledge.

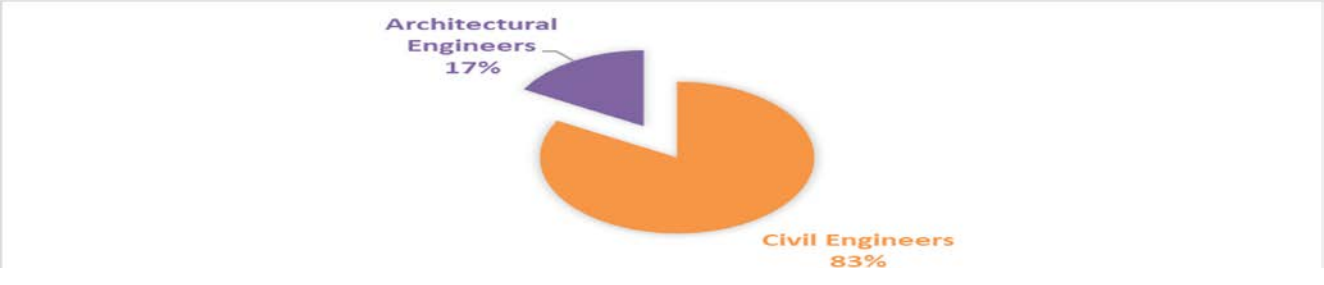

Figure 7 Engineering Disciplines.

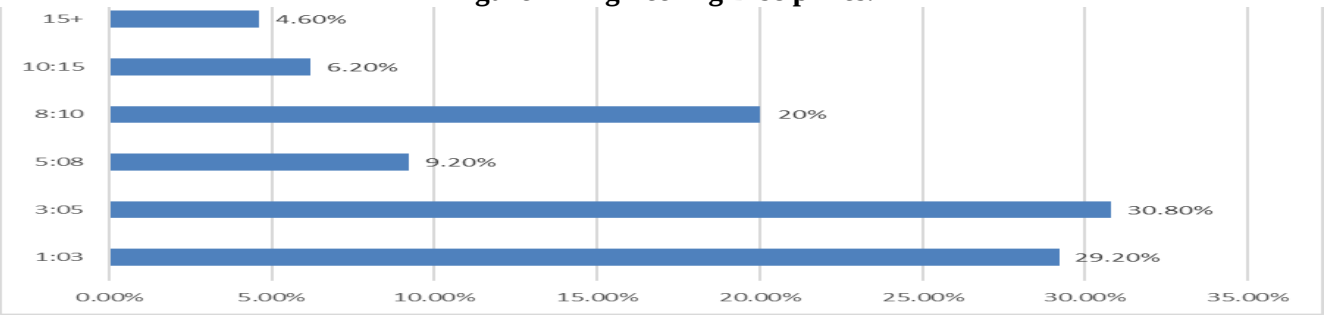

Figure 8 Respondents years of experience.

The questionnaire results from DAR AL-Handasah Company reveal a high level of familiarity with AI and BIM technologies. 98% of respondents answered "Yes," indicating their familiarity with AI and BIM technologies. This indicates a positive technological awareness and adoption of these technologies, as the company recognizes their potential to automate processes, improve decision-making, and enhance efficiency in construction projects. The company also recognizes the benefits of BIM, a collaborative approach that allows

stakeholders to visualize, analyze, and simulate building project aspects before construction begins. This high

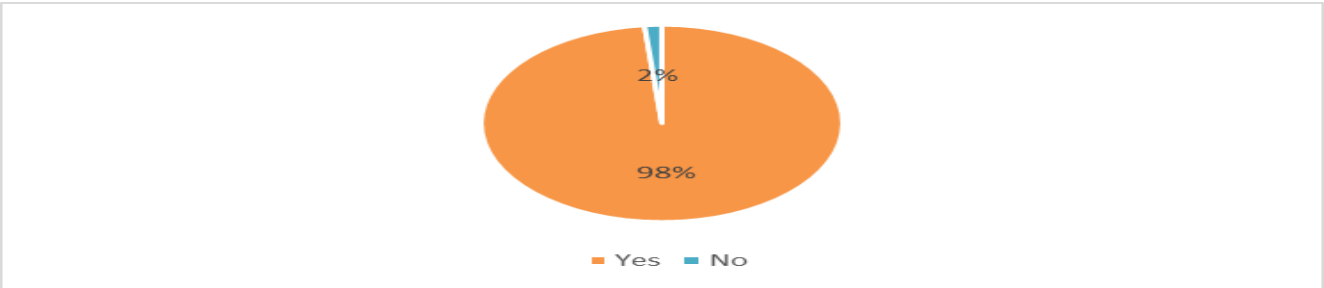

Figure 9 Percentage of respondents using AI and BIM Technology

familiarity indicates a progressive mindset within the organization, where professionals value the integration of technology to drive innovation and improve project outcomes.

The analysis of the most significant benefits of using AI in the construction industry from a questionnaire form revealed that 53 respondents chose "Improved design optimization" as the most significant benefit, while 48

respondents chose "Enhanced project planning and scheduling." 42 respondents chose "Enhanced decision-making process" as the most significant benefit, while 41 respondents chose "Increased accuracy in cost estimation" as the most significant benefit. 38 respondents chose "Minimized occurrence of errors and improved overall quality" as the most significant benefit, while 25 respondents chose "Streamlined construction processes" as the most significant benefit. 21 respondents chose "Better risk analysis and management" as the most significant benefit. The results highlight the multi-faceted benefits that AI brings to the construction industry, including improved design optimization, enhanced project planning, and scheduling, enhanced decision-making processes, increased accuracy in cost estimation, minimized errors and improved quality, streamlined construction processes, and better risk analysis and management. By leveraging AI technologies, the construction industry can unlock significant improvements in various aspects of project delivery and performance.

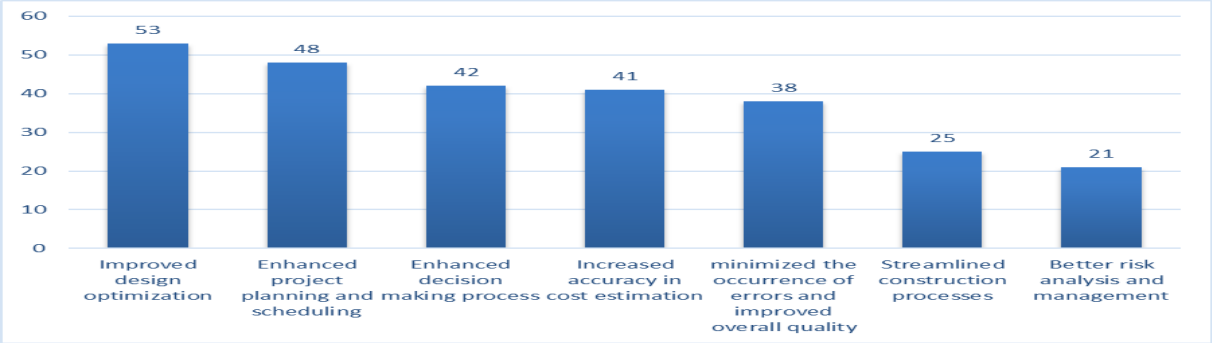

Figure 10 Aspects and areas positively affected by using AI.

All respondents agreed that AI and BIM technologies offer various benefits for Egypt's construction industry, such as boosting project communication, decision-making, and overall efficiency. AI can automatically discover clashes and conflicts between architectural parts, while BIM provides simulation and visualization of construction processes, improving resource allocation, streamlining procedures, and reducing delays. AI also provides predictive maintenance and optimization, improving safety and lowering costs. The awareness and spread of BIM and AI programs in the construction field were found to be high, with Autodesk Revit being the most well-known program among respondents. Other popular BIM software include Autodesk Navisworks Manage, Autodesk BIM 360, Bentley Synchro 4D Pro, Touch Plan, ALICE, and Fire Flies AI. Chat GPT and Civil 3D were added as additional tools. The effectiveness of BIM and AI programs in the construction field was unanimous, with all respondents stating that they are useful tools that assist in various aspects of their work in the construction industry. The study analyzed the effectiveness of Building Information Modeling (BIM) and Artificial Intelligence (AI) programs in the construction industry. All respondents agreed that these programs are beneficial and contribute positively to their work. The majority of respondents from DAR AL-Handasah company use BIM and AI technologies regularly, with 56 using them frequently. However, only one person uses them rarely.

The challenges faced by implementing AI and BIM in Egypt include a lack of awareness and education, insufficient technology infrastructure, high costs, limited collaboration, resistance to change, and a shortage of skilled professionals. Many construction firms and professionals are unaware of the capabilities and benefits of these technologies, and the high cost of software and hardware is a significant barrier to adoption. Additionally, there is a limited availability of skilled experts in BIM, which is essential for effective utilization. To improve AI and BIM adoption in Egypt, respondents suggested promoting education and training programs, industry collaboration, government support, data standardization, pilot projects, research and development initiatives, awareness and knowledge-sharing, and collaboration with international partners.

These strategies can enhance the skills and knowledge of professionals in the construction industry, promote innovation, and build confidence in the value and feasibility of adopting these technologies. In conclusion, the study suggests that Egypt can enhance the adoption and effective utilization of AI and BIM technologies in the construction sector by promoting education, training, industry collaboration, government support, data standardization, pilot projects, research and development initiatives, awareness and knowledge-sharing, and collaboration with international organizations.

7. Conclusion

The study highlights the potential benefits of AI and BIM programs in Egypt's construction sector, which is a significant part of the Egyptian economy. It provides a clear model of the benefits of AI and BIM technology, its significance, challenges, and expansion plans. The research and development field are still open for further exploration. The study also highlights the need for specialists in the construction industry to develop themselves, as advancements in AI and BIM technology will not impact their job opportunities but rather aid them in their work, make tasks easier, and allow them to develop fresh ideas for various projects.

The study also highlights the importance of BIM dimensions, such as 6D, 7D, and 8D models, in facility management and safety, paving the way for future research into this area. The report urges building specialists and business owners to embrace BIM applications due to their positive influence on their companies and the field in Egypt. To improve the utilization of AI and BIM technology in Egypt's construction sector, several suggestions can be considered. These include promoting education and training programs, fostering industry collaboration, encouraging government support, developing data standardization, implementing pilot projects, investing in research and development initiatives, raising awareness about AI and BIM adoption, and collaborating with international partners. By implementing these suggestions, Egypt can enhance the adoption and effective utilization of AI and BIM technologies in the construction industry, leading to improved project outcomes, increased productivity, and sustainable growth.

References

[1] Chui, Michael. "Artificial intelligence the next digital frontier." McKinsey and Company Global Institute 47.3.6 (2017).
[2] Chien, Chen-Fu, et al. "Artificial intelligence in manufacturing and logistics systems: algorithms, applications, and case studies." International Journal of Production Research 58.9 (2020): 2730-2731.
[3] Jesús, Javier Martinez Torres, and Rubén González-Crespo. "The application of artificial intelligence in project management research: A review." (2021).
[4] Pan, Yue, and Limao Zhang. "Roles of artificial intelligence in construction engineering and management: A critical review and future trends." Automation in Construction 122 (2021): 103517.
[5] Order, Alphabetical, and Adel BELHARET. "Report on the Impact of Artificial Intelligence on Project Management."
[6] Ong, Stephen, and Shahadat Uddin. "Data science and artificial intelligence in project management: the past, present and future." The Journal of Modern Project Management 7.4 (2020).
[7] Makaula, Siphosenkosi, Megashnee Munsamy, and Arnesh Telukdarie. "Impact of Artificial Intelligence in South African Construction Project Management Industry." Proceedings of the International Conference on Industrial Engineering and Operations Management, Sao Paulo, Brazil. 2021.
[8] Salehi, Hadi, and Rigoberto Burgueño. "Emerging artificial intelligence methods in structural engineering." Engineering structures 171 (2018): 170-189.
[9] Prifti, Valma. "Optimizing Project Management using Artificial Intelligence." European Journal of Formal Sciences and Engineering 5.1 (2022): 30-38.
[10] Manzoor, Bilal, et al. "Influence of artificial intelligence in civil engineering toward sustainable development—a systematic literature review." Applied System Innovation 4.3 (2021): 52.
[11] Abioye, Sofiat O., et al. "Artificial intelligence in the construction industry: A review of present status, opportunities and future challenges." Journal of Building Engineering 44 (2021): 103299.
[12] Shaqour, E. N. "The role of implementing BIM applications in enhancing project management knowledge areas in Egypt." Ain Shams Engineering Journal 13.1 (2022): 101509.
[13] Amin, K. F., and Fonbeyin Henry Abanda. "Building Information Modelling plan of work for managing construction projects in Egypt." Journal of Construction in Developing Countries 24.2 (2019): 23-61.
[14] Hasan, Amjed Naeem, and Sawsan M. Rasheed. "The benefits of and challenges to implement 5D BIM in construction industry." Civil Engineering Journal 5.2 (2019): 412.
[15] Mohamed, Amira Elshazly. "The implementation of building information modeling (BIM) towards sustainable construction industry in Egypt" The pre-construction phase"." (2019).
[16] Nabil, Yasmin, Ahmed H. Ibrahim, and Suad Hosny. "Practices Improvement of Building Information Modeling in the Egyptian Construction Projects." (2023).
[17] Ingram, Jonathan. Understanding BIM: The past, present and future. Routledge, 2020.
[18] Marta, Andreani, et al. "7D BIM for sustainability assessment in design processes: A case study of design of alternatives in severe climate and heavy use conditions." Architecture and Engineering 4.2 (2019): 3-12.
[19] Luo, Haiying, and Haichang Luo. "RPA and Artificial Intelligence in Budget Management Based on Multiperspective Recognition Based on Network Communication Integration." Wireless Communications and Mobile Computing 2021 (2021): 1-13.
[20] Ma, Zhiliang, et al. "Construction quality management based on a collaborative system using BIM and indoor positioning." Automation in Construction 92 (2018): 35-45.

[21] Liao, Longhui, Evelyn Ai Lin Teo, and Sui Pheng Low. "A project management framework for enhanced productivity performance using building information modelling." Construction Economics and Building 17.3 (2017): 1-26.
[22] Smith, Peter. "Global professional standards for project cost management." Procedia-Social and Behavioral Sciences 226 (2016): 124-131.
[23] LeCun, Yann, Yoshua Bengio, and Geoffrey Hinton. "Deep learning." nature 521.7553 (2015): 436-444.
[24] Schmidhuber, Jürgen. "Deep learning in neural networks: An overview." Neural networks 61 (2015): 85-117.
[25] Oyedele, Ahmed O., Anuoluwapo O. Ajayi, and Lukumon O. Oyedele. "Machine learning predictions for lost time injuries in power transmission and distribution projects." Machine Learning with Applications 6 (2021): 100158.
[26]] Voulodimos, Athanasios, et al. "Deep learning for computer vision: A brief review." Computational intelligence and neuroscience 2018 (2018).
[27] Delgado, Juan Manuel Davila, et al. "Robotics and automated systems in construction: Understanding industry-specific challenges for adoption." Journal of building engineering 26 (2019): 100868.
[28] Bilal, Muhammad, et al. "Big Data in the construction industry: A review of present status, opportunities, and future trends." Advanced engineering informatics 30.3 (2016): 500-521.
[29] Cortellessa, Gabriella, et al. "Automated planning and scheduling." Intelligenza Artificiale 8.1 (2014): 55-56.
[30] An XAI based Autism Detection: The Context Behind the Detection - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/A-conceptual-framework-Machine-Learning-model-with-explainablity_fig2_354597806 [accessed 6 Dec, 2023].
[31] Complementary computing for visual tasks: Meshing computer vision with human visual processing - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/The-proposed-framework-to-train-a-computer-vision-system-with-human-brain-processing-for_fig1_224401073 [accessed 6 Dec, 2023].