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Study on Optimizing Construction Project Management using AI and Machine Learning

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Abstract

This research investigates how to integrate machine learning (ML) and artificial intelligence (AI) approaches to optimise building project management. The study looks at the roles, difficulties, demographics, and use of technology by construction professionals. The respondents' profile is diverse, as revealed by demographic research, which highlights the significance of taking this diversity into account when developing successful AI implementation strategies. The responsibilities that are held by different members of the project management community highlight the variety of skills needed to solve problems in building projects. The study also emphasises participation in different kinds of construction projects, highlighting the necessity of flexible project management techniques. Project success could be improved by using AI technologies and focused interventions in certain areas, according to analysis of project management issues. The analysis of how project management apps are used points to potential uses of artificial intelligence (AI) and machine learning, especially in frequently used programmes such as Microsoft Outlook and MS Project. All things considered, the study offers a solid basis for creating a workable framework that will enable building industry experts to improve project planning and execution using AI and machine learning technology.

Keywords: *Construction project management, Artificial Intelligence, Machine learning, Optimization.*

1. INTRODUCTION

The increasing complexity and size of construction projects in today's world of project management necessitate creative ways to improve productivity, accuracy, and decision-making [1]. In order to improve construction project management procedures, this research study critically examines the revolutionary potential present in the convergence of artificial intelligence (AI) and machine learning (ML). The integration of AI and ML technologies stands out as a possible route for reinventing existing project management paradigms as the construction sector grapples with emerging issues [2]. The goal of this research is to clarify the nuances of using AI and ML algorithms to expedite project planning, execution, and monitoring in order to promote a paradigm shift in the way that construction projects are thought out and handled. Through exploring the mutually beneficial relationship between innovative technologies and project management methodologies, this study seeks to provide significant insights that will drive the construction sector towards increased productivity, data-driven decision-making and sustainable project optimisation.

1.1. Concept of Construction Project Management

By analysing the most relevant and recent literature, the current research offers a thorough overview of the construction sector and summarises the traits and behaviours of CPM that are related to it [3]. It is crucial to emphasise that substantial volumes of a variety of data are gathered at every project stage in order to make CPM a data-intensive field. This has been particularly evident with the advent of wireless sensor networks (WSN) and building information modelling (BIM). As a result, it makes sense to use a range of AI techniques to fully utilise such data in a number of contexts [4]. These methods can effectively address the CPM characteristics during the course of the project life cycle. [5].

1.2. Optimizing Project Management with Machine Learning

The productivity and efficiency of building projects can be greatly increased by using machine learning into project management [6]. Let's examine a few of the major fields where machine learning is essential:

- **Predictive analytics:** To forecast project results, machine learning algorithms examine past project data, meteorological trends, and other pertinent variables.
- **Supply Chain Management:** By finding ways to reduce delays, streamline the procurement process, and keep costs under control, machine learning algorithms can improve supply chain management.
- **Quality Management:** By identifying trends and abnormalities in building materials and procedures, machine learning algorithms can help identify possible quality problems.
- **Equipment Maintenance:** By examining past data on equipment performance, usage, and maintenance records, machine learning algorithms can optimise equipment maintenance schedules.

1.3. Artificial Intelligence in Construction Project Management

The core of artificial intelligence (AI) is the study and application of the laws that control the behaviour of human cognition. Following fifty years of advancement, it is now a global issue with wide-ranging effects [7]. These days, this technology is being used in many other contexts. To name a few, these contexts include expert systems, knowledge-based systems, smart robot systems, and smart systems with databases [8]. Expert systems are the most ancient and comprehensive branch of artificial intelligence, and have been dubbed "the information handling and decision-making technology of the twenty-first century" [9]. Numerous uncertainties affected many issues in the field of civil engineering, especially in engineering design, construction management, and programme decision-making. These uncertainties could be resolved by practitioners' experience in addition to the requirement for calculations in physics, mathematics, and mechanics [10]. Artificial intelligence, however, has a unique set of benefits. By mimicking the knowledge of specialists, it may resolve complex problems to the professional level [11].

2. LITERATURE REVIEW

Akinosho et al. 2020 [12] Construction project planning makes substantial use of AI-enabled methodologies, which not only increase quality but also foster creativity through the creation of data-driven generative designs. Without the aid of AI approaches, designers and engineers could have missed these design solutions.

Jafari, Sharyatpanahi, and Noorzai (2020) [13]. The study highlights how important Building Information Modelling (BIM) is for improving stakeholder coordination and communication. The authors provide a methodology for managing and identifying differences in construction processes that makes use of BIM. The results demonstrate how well BIM works to lower errors, foster better teamwork, and increase project efficiency as a whole.

In 2020, Perera, Nanayakkara, Rodrigo, Senaratne, and Weinand [14] explore how Blockchain technology may be used in the building sector. The study assesses whether the usage of blockchain technology is a significant reality or just hype. The writers examine the possible advantages and difficulties of using blockchain technology in building projects. Their study looks at how Blockchain might improve the building supply chain's efficiency, security, and transparency. The results offer insightful information about the viability and practicality of implementing Blockchain technology in construction processes.

Sacks, Girolami, and Brilakis (2020) [15] add to the body of literature by investigating the interplay between construction technology, artificial intelligence (AI), and building information modelling (BIM). The study looks at how these three domains work together and how it affects the construction sector as a whole. The writers go over how AI systems may use BIM data to streamline the building process, make decisions automatically, and enhance project results. The study emphasises how combining AI, BIM, and construction technologies can drive the sector towards increased productivity and creativity.

3. RESEARCH METHODOLOGY

The pragmatic philosophy in conjunction with the inductive research approach chosen for this study enable data collection to explore and identify themes and patterns, leading to the development of a framework based on data analysis that will help construction professionals and project managers effectively use artificial intelligence (AI) techniques and applications to better plan their projects.

3.1. Research Design

Adopting a mixed method research design facilitates increased trust and a range of opinions in the study's outcomes. This study uses a contemporaneous embedded mixed method research design, combining quantitative and qualitative research methods. Its features include the use of quantitative surveys with some questions that also demand a qualitative response.

3.2. Data collection

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Online questionnaires are the main method of data collection employed in this study for both qualitative and quantitative analysis. The secondary data was gathered from periodicals, newspapers, books, journals, and other sources.

3.3. Sampling Technique

Convenience sampling was employed since it depends on gathering data from a population that is easily accessible to support the research. The primary prerequisite for taking this survey is that the respondent must be a licenced professional in project management, planning, or construction.

3.4. Data Analysis

In this instance, internet surveys are used to gather both quantitative and qualitative data. Variations are anticipated in the data collected from the different respondents; they will be appropriately examined. Therefore, the study and analysis of comparison data is used..

4. DATA ANALYSIS AND RESULTS

4.1. Demographic features analysis

Table 1: Respondents' demographic attributes

		Frequency	**Percent**
Gender	Male	110	55%
	Female	90	45%
Age	18-25	30	15%
	26-35	50	25%
	36-45	40	20%
	46-55	45	22.5%
	56 and above	35	17.5%
Occupation	Project Manager	60	30%
	Project Coordinator	40	20%
	Project Scheduler	25	12.5%
	Other	75	37.5%
Educational Qualification	Bachelor's Degree	80	40%
	Master's Degree	60	30%
	Doctorate	15	7.5%
	Other	45	22.5%
Project Management Tenure	0-3 Years	50	25%
	3-5 Years	40	20%
	5-10 Years	55	27.5%
	Over 10 Years	55	27.5%
Project Size	Small (0-100,000)	70	35%
	Medium (100,000- 500,000)	60	30%
	Large (>500,000)	70	35%

With both frequency and percentage displayed, table 1 offers a thorough summary of the respondents' demographic features. Gender distribution is as follows: 45% are women and

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55% are men. In terms of age distribution, the 26–35 age group accounts for 25% of the total, while the 18–25, 36–45, and 56 and older age groups account for 15%, 20%, and 17.5% of the total. Project managers make up 30% of the workforce, project coordinators make up 20%, project schedulers make up 12.5%, and other positions comprise 37.5%. Educational backgrounds indicate that 40% of the population has a bachelor's degree, 30% has a master's degree, 7.5% has a doctorate, and the remaining 22.5% has other degrees. 25% have been in project management for 0–3 years, 20% for 3-5 years, and 27.5% for both 5–10 years and more than 10 years. The project size distribution shows that 35% of projects fall into the Medium category, 30% into the Small category, and both. This thorough analysis highlights the respondents' wide range of backgrounds, highlighting how crucial it is to take this diversity into account when developing strategies for implementing AI in construction project management.

4.2. Analysis of Current Role/Title Distribution

Table 2: Roles and Titles Distributed Throughout the Project Management Community

	Frequency	**Percent**
Project manager	31	15.5%
Project engineer	23	11.5%
CEO	10	5%
Planning engineer	10	5%
Project Architect	10	5%
Project Coordinator	10	5%
Project Supervisor	10	5%
5D BIM Specialist	8	4%
Associate consultant	8	4%
BIM Coordinator	8	4%
Consultant	8	4%
E&I Technologist	8	4%
Planner	8	4%
Project Management Consultant	8	4%
Project Officer	8	4%
Project Planning and BIM Specialist	8	4%
Sales Representative	8	4%
Senior Construction Solutions Engineer	8	4%
Senior Planner	8	4%

Table 2 displays the frequency and percentage distribution of positions and titles in the project management community. With 15.5% of the total, project managers make up the largest group, followed by project engineers (11.5%). Five percent of the responses are CEOs, planning engineers, project architects, coordinators, and supervisors. Positions like Senior Construction Solutions Engineer, Sales Representative, Senior Planner, Associate Consultant, BIM Coordinator, Consultant, E&I Technologist, Planner, Project Management

Consultant, Project Officer, and 5D BIM Specialist all have a 4% occurrence rate. The distribution of professional responsibilities within the project management community is highlighted by this, indicating that a diverse skill set and expertise are necessary to meet the demands and problems of building projects..

4.3. Analysis of Involvement in Various Construction Project Types

Table 3: Participation in a Range of Construction Project Types

	Frequency	Percent
Residential (apartments, houses etc.)	51	25.5%
Commercial and Institutional (warehouses, universities, shopping centres etc.)	46	23%
Highway and Rail	38	19%
Heavy (dams, water treatment plants etc.)	30	15%
Other	35	17.5%

The distribution of respondents' participation in different kinds of construction projects is shown in table 3, which provides both frequency and percentage information. The bulk, or 25.5%, are working on residential developments, such as homes and apartments. Projects related to commerce and institutions, such universities and warehouses, make up 23% of the total, while projects related to roads and trains make up 19%. Fifteen percent of the comments are related to heavy projects, such as water treatment plants and dams. Furthermore, 17.5% are classified as "Other" construction projects. The aforementioned breakdown illustrates the wide spectrum of construction sectors in which the experts surveyed are actively engaged, underscoring the necessity for flexible project management approaches that can address the unique obstacles presented by various project kinds.

4.4. Analysis of Project Management Challenges

Table 4: Challenges in Project Management - Frequency and Percent Distribution

	Frequency	Percent
Risk Management	23	11.5%
Change control	22	11%
Cost Estimating	20	10%
Conflict Management	19	9.5%
Stakeholder Management	16	8%
Procurement Management	16	8%
Project Scheduling	15	7.5%
Quality Management	15	7.5%

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Resources Management	12	6%
Communication Management	12	6%
Health, Safety, Security and Environmental Management	11	5.5%
Team Management	9	4.5%
Project Information Management	7	3.5%
Leadership	3	1.5%

Table 4 presents the frequency and percentage distribution of the issues encountered in project management. At 11.5%, risk management is the most common challenge, closely followed by change control at 11%. The study identifies Cost Estimating and Conflict Management as noteworthy obstacles, with corresponding frequencies of 10% and 9.5%. Project scheduling and quality management each contribute 7.5%, while procurement management and stakeholders share an 8% incidence rate. Health, Safety, Security, and Environmental Management make up 5.5% of the difficulties, while Resources and Communication Management make up 6%. Project information management is represented by 3.5%, and team management by 4.5%. At 1.5%, leadership emerges with the least frequency. This breakdown highlights the complex nature of project management obstacles by identifying particular areas in which focused interventions and artificial intelligence applications may be able to reduce difficulties and improve project success as a whole.

4.5. Analysis of Project Management Applications Usage

Table 5: Project Management Applications Usage - Frequency and Percent Distribution

	Frequency	**Percent**
Microsoft Outlook	49	24.5%
MS Project	48	24%
MS Teams	36	18%
Autodesk Revit	25	12.5%
Autodesk Navisworks	18	9%
Synchro Pro	13	6.5%
Asta Powerproject	11	5.5%

The frequency of use and percentage distribution of different project management applications among the professionals polled are shown in Table 5. With 24.5% of the total usage, Microsoft Outlook is the most popular tool, closely followed by MS Project (24%). Eighteen percent of respondents utilised MS Teams, compared to twelve percent who used Autodesk Revit and nine percent who used Autodesk Navisworks. The remaining 18% is made up of Synchro Pro, Asta Powerproject, and other programmes; Synchro Pro is used

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6.5% of the time. The data shows that there is a wide range of project management tools available, but that Microsoft programmes are used a lot. This suggests that there may be room for AI and machine learning to be integrated to improve the usefulness and efficiency of these widely used platforms.

5. CONCLUSION

The study used a mixed-method design that combined quantitative and qualitative techniques, as well as an inductive research strategy, to optimise building project management with AI and machine learning. A wide range of characteristics about the respondents, including their gender, age, occupation, level of education, length of project management experience, and project size, are revealed by the thorough demographic study. The way that positions and titles are distributed across the project management community highlights how different skill sets are needed to properly handle the issues that arise with building projects. Furthermore, the examination of participation in various types of building projects emphasises the significance of flexible project management techniques. The analysis of project management problems highlights the complexity of problems and identifies particular domains in which AI solutions may improve project outcomes. Lastly, the utilisation study of project management software points to the possibility of incorporating AI and machine learning to enhance overall efficiency in construction project planning, especially in commonly used programmes like Microsoft Outlook and MS Project. All things considered, the study offers insightful information for creating a workable framework for implementing AI in construction project management.

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