International Journal of Core Engineering & Management
Volume-7, Issue-06, 2023 ISSN No: 2348-9510

USE OF ARTIFICIAL INTELLIGENCE IN ESTIMATING: EXPLORING AI APPLICATIONS AND THEIR POTENTIAL IN IMPROVING COST ACCURACY

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Abstract

Construction cost estimation is undergoing significant transformation by Artificial Intelligence (AI). However, traditional cost estimation methods, which heavily rely on expert human judgments and data from the past, tend to be prone to budget overruns because of such inaccuracies. Machine learning, artificial neural networks, and natural language processing are AI driven technologies that help increase the accuracy of the cost, improve the risk management and increase resource allocation using the advanced technologies. In this paper, we look into the different ways in which AI has been applied in construction estimating, and the positives and negatives to merging these technologies into construction. AI's ability to trim process time and reduce error is demonstrated via case studies, with discussion of future potential of AI integration with Building Information Modeling (BIM) and blockchain.

Keywords: Artificial Intelligence, Cost Estimation, Machine Learning, Neural Networks, Natural Language Processing, Construction, Predictive Analytics, BIM, Blockchain.

I. INTRODUCTION

The importance of accurate cost estimating is obvious in the construction project world, because errors in early phase estimates can result in budget blow-outs, project delays and, ultimately, complete project failure. Manually calculated estimators and historic data, while useful, fail to capture the full extent of variables in modern construction projects. While using past data and manual methods, this way of relying on the past is prone to human error and can hardly adapt to change in material prices, labor availability or unexpected conditions. With the complexity of construction projects increasing: larger scales, shorter timelines, more stakeholders, the likelihood of inaccurate estimates increases. That can cause a common industry problem: cost overruns.

In order to solve these problems, artificial intelligence (AI) is being leveraged by the construction industry to help estimate costs to have more accuracy and reliability. The fancy word here is 'AI tools,' like machine learning algorithms or predictive analytics that can take in data from many sources at speeds much faster than humans. These tools empower estimators to use real time historical project data, material cost fluctuations, labor market dynamics, regional economic conditions and even weather patterns to run real time analyses and predictions. Unlike existing traditional methods, AI driven systems are capable of handling the dynamic nature of construction projects, reacting to new data inputs as they emerge.

One of the great advantages of using AI with one's projects is that it is able to deal with uncertainty and variability. For instance, AI systems can create multiple project scenarios based on different inputs, like changes to material availability or labor market circumstances, and offer

estimators multiple cost scenarios. This capability makes construction managers choose the commercially most favorable and realistically possible project plan ability.
Finally, several real world examples of how AI is affecting the construction cost estimation.
As more and more of that building history gets recorded on the internet, major construction firms are embedding AI platforms into their workflows to predict costs with much higher accuracy. In fact, companies have been reporting a reduction in budget overrun up to 30 percent for using AI powered estimation tools. While the accuracy of AI goes up, so do the all around productive of the estimators because the automation of the data analysis frees up estimators to focus more on other important aspects of the project management. Additionally, the predictive power of AI has been incredibly valuable in reducing or mitigating risks, especially on large, complex projects where traditional estimation tools have a tough time with all the niggling influences. The power and application of AI makes estimators better than ever at predicting project costs with a level of precision that's not possible using traditional methods. Over the years, AI integration in construction estimation has markedly decreased overruns in budget, and improved productivity and risk mitigation in complex projects [1].

II. AI APPLICATIONS WITH CONSTRUCTION ESTIMATING

The construction estimating process typically involves the integration of Artificial Intelligence (AI) into three areas, designing a project, controlling a project, as well as projecting and managing project costs. Not only do AI applications enhance the accuracy of estimates, but they also enable construction professionals to better predict, remain nimble in the face of, and control the dynamic project variables. Construction cost estimation is being reshaped by several AI technologies, including Machine Learning (ML), Artificial Neural Networks (ANNs), and Natural Language Processing (NLP).

III. ESTIMATING BY MACHINE LEARNING

Construction cost estimation is an area in which ML is the leading application of AI. By using ML models we can process large quantities of historical data, find patterns in it and using that information and predict future project costs. Chairman Linehan also touts the mechanisms as unlike traditional methods that achieve much of their performance based on very linear assumptions such as linear regression, while allowing a ML to handle non-linear relationships better and adapt to changing market conditions. ML optimizes cost predictions by taking into account such an extensive list of factors—labor costs, weather patterns, and the whims of fluctuating supply chain dynamics—than it would using just the blade run or head count.
For example, if we want them to predict this fluctuations in material prices, we can look into ML algorithms as they can predict on the basis of global economic factors like supply chain disruption or demand of raw materials. Secondly, these predictions permit construction companies to adapt their sourcing strategy by fixing prices for important materials before expenses ascent, so that they won't rack up budget overruns [2]. As demonstrated in a large construction firm case study, a 15% improvement in budget accuracy across projects of varying complexity can be achieved by adopting ML in estimating.
In addition, real time data from IoT devices on site physical conditions, which has been captured through ML. To illustrate, ML models can be trained to take in real time labor availability or equipment usage patterns, keeping estimators and project managers up to the minute.

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IV. COST PREDICTION USING ARTIFICIAL NEURAL NETWORKS (ANNS)

Artificial Neural Networks (ANNs) are becoming widely used in the construction industry by rapidly learning from complex datasets and modelling the complex relationship between variables. ANNs are more neural structures of the human brain, which can take in much data and produce highly accurate costs predictions. They know how to figure in all the variables involved in large construction project.

For example, ANNs can take into consideration all aspects of factors like availability of labor, material costs, project timelines, weather delays, etc but would do so all at once to estimate the total project cost. For megaprojects like large infrastructure developments or urban regeneration, ANNs have become especially valuable due to their ability to handle multi variable environments, for which cost overruns are historical.

and research has proven that ANN applied to cost prediction reduces cost variance by 20 percent [5]. Neither is the use of ANNs limited to prediction of total costs; they can also access specific line item costs, for example, the cost of labor or equipment, where there is more granular control over the budget.

Amongst the challenges with ANNs is the fact that the models need huge datasets to learn. At best, ANN predictions may be limited by the lack of historical data. To address this problem, some firms started working together with other stakeholders such as suppliers and out-sourcers to share data and enhance ANN performance.

V. NATURAL LANGUAGE PROCESSING (NLP) IN CONTRACT ANALYSIS

Natural Language Processing (NLP) is another AI application that has crept into construction estimating space, most often in the analysis of contracts and specifications. This type of work often involves large amounts of legal and technical documentation that needs to be carefully vetted to make sure the project will come in at the expected cost, understand any risks involved, and that the project will follow contract terms. All these documents need to go through review by a human being which is a time consuming process and human error in this review can result in very costly disputes.

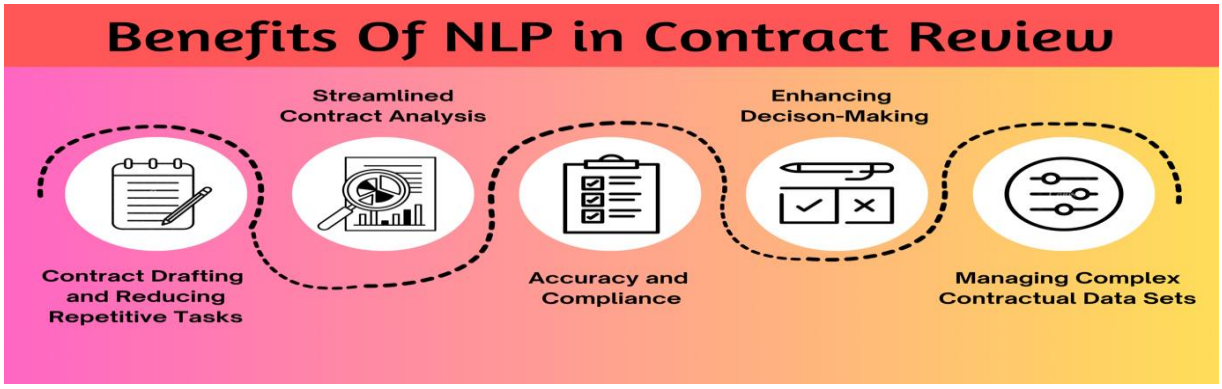


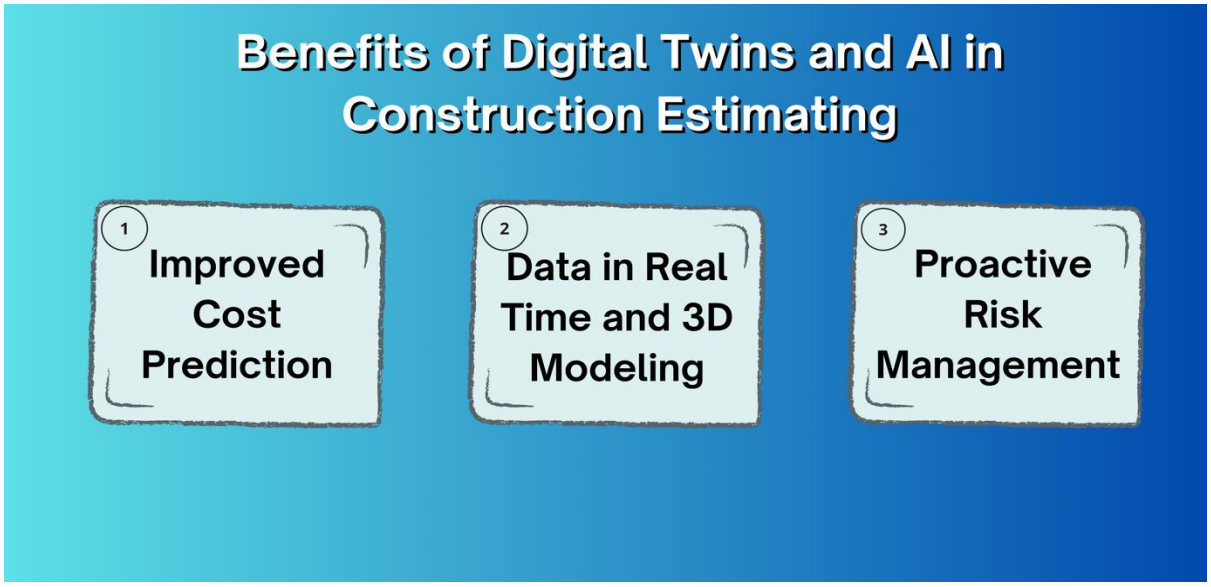
Fig.1.Benefits of NLP in Contract Review: Outlining how Natural Language Processing enhances contract analysis, decision-making, and compliance, while managing complex data sets and reducing repetitive tasks.

Using NLP algorithms, you can now scan massive amounts of legal and technical documents and

extract entire clauses regarding costs, risks, penalties and scope changes. NLP automates the document review process such that it takes into account important details, like escalation clauses, payment terms or potential penalty conditions, in the cost estimate. Such a strategy minimizes the opportunity to overlook important factors whose omission can lead to cost overruns and project delays.

NLP could for instance find clauses describing penalties for late completion, which are also included as potential risk costs in the budget. NLP Tools can also perform a more detailed risk analysis highlighting ambiguous or conflicting terms in contracts which may need some further negotiation or clarification before they can be moved and prevent any future disputes.
For example, in a real world situation a construction company using NLP software to review contracts for a large complex commercial development had been able to reduce people working on contract analysis by 50% freeing up legal and estimating people to focus now on the higher capacity tasks. In addition, the ability of NLP to learn from past contracts also allows it be increasingly accurate at detecting cost related risks as more data is processed [6].

VI. BENEFITS OF AI IN CONSTRUCTION ESTIMATING



VII. MORE ACCURACY AND EFFICIENCY

Cost estimation processes are significantly improved by AI, improving the accuracy and speed. Typically, traditional estimation methods require manual calculations as well as data entry making them highly prone to errors. For example AI automates both these, being faster while being more precise. A report from McKinsey goes a step further by showing the potential of AI in construction to save up to 20%, improving the accuracy of cost estimate and reducing the waste [7]. The main reason for this cost reduction is that AI is likely to be able to predict the future output given previous data, in which estimators can base their decisions upon.

VIII. ENHANCED RISK MANAGEMENT

Probabilistic Risk analysis and Artificial Intelligence (AI) are extensively used in construction project management to reduce risk due to cost overrun. By analyzing historical data, AI driven systems can find potential risks for a project, such as labor shortage, material delay or weather disruption, and deliver early warnings to project managers. However, by effectively addressing these risks construction firms can allocate more effectively contingency funds and avoid unexpected expenditures [8].

IX. CASE STUDIES

a) Case Study 1: AI in Infrastructure Projects

AI driven cost estimation tools were used to forecast labor and material costs at scale in a large infrastructure project in the United States across a multi-year highway construction initiative. AI's ability to analyze both historical data on project completion plus current market conditions was crucial to the success of an inherently complicated project involving a shifting supply chain with logistical undertones. Based on data from previous infrastructure projects, the AI system considered factors like regional labor availability, transportation logistics and material supply chain volatility — but paid particular attention to steel prices, a crucial part of the project.

Intermitted fluctuation in steel price was identified under potential risk when the Global market trend is increasing the requirements and the supply chain disruptions, which was identified by the AI model. The AI system could predict potential cost spikes therefore allowing project managers to make proactive decisions. More specifically, the companies were able to buy steel in bulk ahead of expected price increases, buying lower rates before the market changed. The strategic procurement saved the project about 15 percent on material costs, a very large sum for such a large and budget driven project. Additionally, by running AI driven insights on labor costs, the AI driven insights enabled optimal labour schedules by indicating off periods where labour costs are lesser, making better allocation of resources as well as reducing overall labour expenses. This case demonstrates how AI not only mitigates the risk of cost overrun but also actively identifies market foresight and strategic planning in order to create cost savings [9].

b) Case Study 2: AI in Residential Construction

To improve the accuracy of the cost estimates for construction of new homes, Artificial Neural Networks (ANNs) were used to analyze data from hundreds of completed projects, by a residential construction company. Data from project specifications, material and labor costs, seasonal variations, and subcontractor performance records was used to train an ANN model. Finally, ANNs have the great advantage of being able to continually learn from new data inputs and become more accurate the more projects are accomplished.

Using ANNs, the company was able to make a big improvement in prediction of cost accuracy, making the accuracy rate to the ANN model 92%. The precision at this level meant that we could better plan and allocate resources for several simultaneous residential projects occurring at the same time. With the help of the ANN model, the company could predict potential cost shift swings (e.g. unexpected labor shortages, or material price fluctuation) prior to scheduling and procuring, which would enable the company to adjust its procurement and scheduling strategies accordingly.

This led to the reduction of 12% overall project costs, mostly resulting from more efficient

procurement practices and better resource utilization. The company was able to order their materials prior to due dates (or purchase alternatives) and avoid disruptions and excess costs all from predicting which materials would experience a price hike or shortage. Furthermore, the improvement yielded by the precise cost predictions allowed the company to refine its bidding process, presenting more competitive - but still realistic - project bids, which resulted in an enhancement of its project acquisition and customer satisfaction. The value of ANNs in improving profitability and cost efficiency in a highly competitive residential construction market [10] was demonstrated in this case study.

X. CHALLENGES IN IMPLEMENTING AI IN CONSTRUCTION ESTIMATING

a. Data Quality and Integration

The success of AI in construction estimating relies very much upon the availability and quality of data. To produce accurate predictions, AI models rely on large datasets, and if the data is incomplete, outdated, or inconsistent, the accuracy of that AI model is going to suffer. Construction firms often do not have standardized data collection methods, which don't allow AI systems to be embedded into current workflows. To solve these challenges companies must invest into data management practices including the accuracy and consistency of the data fed into the AI models [11].

b. Resistance to Change

Although there are clear benefits to using AI, many construction firms are not ready to jump on board new technologies. And typically, it's because of fears of job displacement and the presumed difficultly of AI systems. These barriers can be overcome by firms through training programs that will equip employees with the knowledge of how AI works and what roles it will play in their organisations. In addition, AI tools must be designed as an addition, not an alternative, to human estimators, making AI augment, not abrogate, decision making [12].

XI. FUTURE POTENTIAL OF AI IN CONSTRUCTION ESTIMATING

a. Integration with Building Information Modeling (BIM)

The construction industry already uses Building Information Modeling (BIM) to create in great detail 3D models of projects. BIM integration with AI can bring the roof right to the next level when it comes with real time data analysis and the predictive insights. Project managers can use AI to analyze BIM models and locate potentially design or material flawed situations, allowing them to eliminate costs before construction starts [13].

b. Blockchain for Transparency and Accountability

On the other hand, the addition of AI in blockchain technology provides the additional benefit of reduction in construction cost estimation. Blockchain is a distributed, secure and transparent ledger of all project transactions, making cost estimates based on real, up to date information. This level of transparency reduces the risk of dispute over cost discrepancies and increases the accountability among project stakeholders [14].

XII. CONCLUSION

- Artificial Intelligence (AI) in construction estimating is a game changer: vastly improving accuracy, efficiency and risk management. Construction firms have made large numerical adoption of AI by using technologies as machine learning (ML), artificial neural networks (ANNs), and natural language processing (NLP) to optimize their cost estimation processes. These are not only tools that help reduce the likelihood of a cost overrun, but also tools to help adapt to the complexity and uncertainty that characterise modern construction projects.

- Using AI, estimators can study large datasets derived from past projects, understand the market now, and forecast future cost trends to an extreme level of precision. ML can also dynamically modify its estimates to the change in the material costs, availability of labor, and external variables, which are more accurate than the traditional estimates. ANNs are even more accurate at estimates as results of processing a massive number of variables all at once, and are especially helpful for large scale or complicated projects where linear methods do not stand up. Like, NLP reduces the analysis of contracts and specifications, mitigating risks from overlapping terms, penalties and changes to scope, which are frequently a source of cost escalations.

- The future of AI in construction estimating is looking promising with the introduction of the latest technologies to create the foundation point with the integration of the Building Information Modeling (BIM) and blockchain. By pairing BIM with AI, we can have highly detailed digital models of construction projects that can provide real time cost analysis as design and project detail changes. Likewise, blockchain can also contribute to greater transparency and responsibility in project data, so cost estimates are based on verified information and there is a reduced risk for disputes. Combined, these technologies can change the way we do cost estimation, moving the construction industry toward a data driven and collaborative future.

- Finally, the use of AI driven solutions can help construction firms not only claw their way forward but also ensure projects are delivered more consistently on budget and on time. The first step has already been taken by AI to efficiently transform the cost estimation process and as its capabilities develop, this will also transform to shape the construction industry into an industry of a more efficient and sustainable and cost effective construction.

REFERENCES

1. World Economic Forum, "How AI is Revolutionising the Construction Industry," WEF Report, February 2023.
2. "Artificial Neural Networks for Construction Project Cost Estimation," International Journal of Engineering & Technology, February 2022.
3. Mohammed S. Hossain, "AI and Predictive Analytics in Infrastructure Projects," International Journal of Construction Innovation, November 2022.
4. Xinyuan Cai and Mengchu Tao, "The Future of AI in Construction Projects," Construction Technology Review, February 2023.

5. AI and Automation in Estimating, Digital Builder by Autodesk, February 2023.
6. TayibeSeyman-Güray, "Investigating AI Applications in Construction Industry," Proceedings of ICCAUA2023, February 2023.
7. McKinsey Global Institute, "The Impact of AI on Construction Productivity," McKinsey Report, January 2023.
8. AI for Construction Estimating: Maximizing ROI," ConstructEstimates, February 2023.
9. Deloitte Insights, "AI in Construction: Benefits and Challenges," Deloitte Construction Report, December 2022.
10. Predictive Analytics in Construction Estimation, Apiko.com, February 2023.
11. Royal Institution of Chartered Surveyors (RICS), "Labour Shortages in North American Construction," RICS Report, January 2023.
12. Autodesk, "How AI and Automation Are Supercharging Construction Estimating," Digital Builder, February 2023.
13. AI Integration in BIM and Cost Estimating," Buildertrend, January 2023.
14. AI and Blockchain for Construction Project Transparency, IIMAGINE, February 2023.