SSRG International Journal of Civil Engineering
ISSN: 2348 – 8352 /doi:10.14445/23488352/IJCE-V7I1P102
Volume 7 Issue 1, 5-10, January 2020

A Review Paper on Construction Site Monitoring and Predictive Analysis Using Artificial Intelligence

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Received Date: 25 December 2019
Revised Date: 29 January 2020
Accepted Date: 04 February 2020

Abstract – *Project control and monitoring tools are based on expert judgments and parametric tools. Forecasting project performance is one of the most difficult tasks in predicting whether the project will be successful. The successful performance of a construction project cannot be achieved without challenges and obstacles. To meet these challenges and hit these obstacles, an organization must have a clear awareness of its performance. The project manager spends most of his time developing and updating reports instead of execution and taking in-time decisions to finish the work within the prescribed time scale. The development of an artificial neural network tool that will help the project manager in this task. Artificial neural networks (ANNs) would seem to offer a potentially powerful tool for estimating project control parameters from current project conditions. ANN's were found to learn from the relationships between input and output provided through training data and could generalize the output, making it suitable for non-linear problems where judgment, experience, and surrounding conditions are the key features.*

Keywords - *Neural Network (ANN), MATLAB, Artificial intelligence, Project performance, Coefficient correlation, critical success factors.*

I. INTRODUCTION

The construction industry is a huge and mixed industry that plays a vital role in any nation's progress. Construction projects are complicated, multidisciplinary, and time-consuming. They may involve owners, designers, contractors, subcontractors, specialists, consultants, etc. The number of participants also increases with the size of the project. It is commonly agreed that it has to be completed on time within budget and according to the specification for a construction project to fulfill. Most current project control systems measure quantitatively cost and schedule status and forget other important aspects of project performance like quality, safety, project team satisfaction, and client satisfaction, which are also as important as cost and schedule. Forecasting project performance is one of the most demanding tasks in predicting whether the project will be successful. The traditional planning and controlling methods practiced in the construction industry demand the project

Manager to base the estimate of various control parameters (e.g., cost, quality, and schedule variances) on status reports that become available from time to time. Project managers evaluate these status reports to predict the variations in these control parameters throughout the project. These methods are satisfactory, but when hundreds of tasks have to be precisely choreographed, these predictions become difficult to make. For effective control, project managers have to corn-pare future work performance against the original baseline estimate to identify likely problems and possible solutions. This paper aims to review these new projects that use Artificial Intelligence to improve project success or predict it.ANN as a concept existed for a long time; however, its civil engineering application started in the late 1980s, primarily in construction activities. ANN's were found to learn from the relationships between input and output provided through training data and could generalize the output, making it suitable for non-linear problems where judgment, experience, and surrounding conditions are the key features. ANNs typically comprise 3 layers, i.e., input layer with input neurons, a hidden layer with hidden neurons and output layers with output neurons originally future prediction in the construction industry has been done from the point of view of expert judgment, based on the opinion of those who are analyzing the project, the experts. A study uses artificial intelligence to make a model of this expert knowledge so the technology could ease the identified risks. With ANN's use, even less

experienced managers can make important decisions related to construction site monitoring performance very efficiently.

II. LITERATURE SURVEY

M. Deepak et al. (2019) studied the prediction of compressive strength and slump, having several mixtures with 28 days. ANN model with 7 different parameters that include Slag, Fly Ash, Fine Aggregate, Coarse Aggregate, Super Plasticizers, Cement, Water respectively as input while concrete slump and while compressive strength as output. Higher R values indicate the fact that neural network modeling is well suited. The MSE values are quite small means that the outcomes will be most appropriate. Furthermore, rendering for the compressive strength outcomes predicted by employing ANN- (1), ANN- (2), and ANN- (3) models, the outcomes of ANN-(3) models are closer to the real outcomes. According to the slump outcomes expected by employing ANN-(4), ANN-(5), and ANN (6) models, the outcomes of the ANN-(6) model are closer to the real investigation outcomes. L, RMSE, and mean square error (MSE) record values that can be computed and intended for matching experimental outcomes with ANN model results have demonstrated this condition. The conclusion shave confirmed the prediction of compressive strength values and the slump of mortars using ANN.

Xie Xuecai et al. (2018) studied the problems in multi-factor complex disaster prediction and proposes a new method for risk prediction and factorial risk analysis. First, a new coal and gas outburst prediction model was established, consisting of 4 levels and 14 factors. Then, the Improved Fruit Fly Optimization Algorithm and the General Regression Neural Network algorithm were combined to establish the prediction model. After that, the sensitivity analysis method was applied to analyze the sensitive factors of coal and gas outbursts. Finally, an apriori algorithm was used to Analyze the sensitivity of 14 factors in the Pingdingshan No. 8 Mine. The analysis results show that B2 (Soft and fallen coal seam), A4 (Soft layer thickness variation), A3 (Change of coal thickness), B1 (Coal seam thickness), and A2 (Geological structure) it is found that in 45 coal and gas outburst accidents, there are obvious rules when the risk level is II ($0<Q\leqq 50t$), and other grades do not form obvious rules. There are 11 single factors, 15 double factors, and 2 three factors closely related to risk level II.

Chao Xiao et al. (2018) studied the use of artificial intelligence in construction engineering and management. The authors analyzed the selected articles from the time the article was published, journals, research fields in the construction domain, high productive researchers, and major AI techniques. Construction engineering and management fields have grown in recent years, especially after 2009, with more than 78% of papers published in the last ten years. It represents the past decade was quite productive and a growing trend in implementing AI techniques in construction-related domains. The authors have also observed that articles in early years were more focused on a single AI technique with its application in construction, compared with the latest published papers that usually applied multiple AI techniques to solve more complex construction-related problems.

Reenu M S et al. (2017) said that project activities have one goal or purpose and must be completed by a specific time, within budget, and according to specification. Project performance is predicted mainly based on the four performance metrics, i.e., cost, schedule, quality, and satisfactory performance. This research aims to develop an artificial neural network (ANN) models to predict cost performance, schedule performance, quality performance, and satisfaction level. Four models were developed for each of the performance metrics. ANN models were developed using MATLAB software. The models were trained and tested using the data collected from different projects. It was found that the neural network model predicted the actual cost growth, schedule growth, quality performance, and satisfaction level in construction projects. This will help the practitioners to estimate cost performance, schedule performance, quality performance, and overall satisfaction level even before the construction stage.

P.S.Kulkarni1 et al. (2017) studied Construction Management has to deal with various uncertainties related to Time, Cost, Quality, and Safety. The review suggests that the ANN's had been highly beneficial, incorrectly interpreting inadequate input information. However, it was clear that the modeler's data and experience' authenticity is important in obtaining good results. The review of past works dealing with recent applications of ANN in areas of Cost, Productivity, Risk Analysis, Safety, Duration, Dispute, Unit rate, and Hybrid Models is done, and it confirms the usefulness of ANNs in carrying out a variety of prediction, classification; optimization and modeling related tasks in areas of CM. ANNs are based on the input-output data in which the model can be trained and can always be updated to obtain better results by presenting new training examples. Providing a standard benchmark for determining the construction proposals' accuracy level will increase the ANN used in CM.

Ibukun g. Awolusi et al. (2016) performed a case study on an active construction project to implement and validate the framework and tool. The case study's findings show that the construction site's safety index increased from 37.0 to 62.8% and aligned with the actual site records of the project's total recordable incident rate, which decreased from 7.11 to 1.42. From the safety activity analysis results, the site's safety index decreased from 45.7%

to an index of 37.0% and then increased to an index of 62.8%. On the other hand, the project's TRIR obtained from the site decreased from 7.11 in 2013 to 1.42 in 2014. The trend of the results obtained in the safety activity analysis was consonant with the records of the project's total recordable incident rate (TRIR). Further research can be carried out to decrease the partiality in the activity observation process by engaging a panel of safety experts to create a standard checklist for the activity observation.

Seung c. is ok et. Al (2016) studied accurate prediction of earthmoving equipment's productivity is critical for accurate construction planning and project control. This research develops and compares two Method for estimating dozer operations' construction productivity (the transformed regression analysis and a non-linear analysis using a neural network model). The comparison of results suggests that the non-linear artificial neural network (ANN) can improve the equipment productivity, estimation model. This paper compares linear regression and neural network methods for dozer daily productivity estimation by modeling the data. The model developed in this research has been used to explain the dozer equipment productivity estimation with seven independent factors and demonstrate that the artificial neural network model can be used to estimate construction equipment productivity.

Sai On Cheung et al. (2015) carried out a neural network-based prediction model. Information from the tender reports was used as input variables, and performance records of the successful bidder during construction were used as output variables. The two most sensitive input variables towards such prediction are "Difference between Estimate" and "Difference between the next closest bids." It was found that the neural network for the prediction of Works scores gave
the highest hit rate. This suggests the four input variables are reliable in predicting the contractor's ability to handle the physical works. The two most sensitive variables contributing more than 80% of the normalized sensitive weightings are "Difference between the successful bid and the Estimate" and "Difference between the successful bid and the next closest." Both variables are price related, thus suggesting the importance of tender for the proper completion of the works.

Zubair Ahmed Memonet et al. (2015) studied techniques that can be used in the construction industry to monitor and evaluate physical progress and establish how current computer technology can monitor the actual physical progress at the construction site. The research discusses the results of a questionnaire survey conducted within the Malaysian Construction Industry and suggests a prototype system, namely Digitalizing Construction Monitoring (DCM). DCM prototype system integrates the information from construction drawings, digital images of construction site progress, and planned work schedule. This model will improve the decision-making process and provides a better mechanism for advanced project management. The Digitalizing the Construction Monitoring (DCM) model is developed using the Relational Database Management System (RDBMS). The integration of digital images and drawings will enable construction managers to develop progress reports more consistently and accurately.

Daniel Magaña Martínez et al. (2015) studied Artificial Intelligence as a tool for project success estimation or critical success factor identification. Artificial Intelligence tools are really helpful for the project manager to control and monitor the project. However, some of the reviewed models have weaknesses and limitations that indicate project managers should still use expert judgment and compare artificial intelligence results with traditional tools before making a decision, so they can adjust them if necessary. Trending is fusing different artificial intelligence tools to take advantage of the strengths of a tool and cover the weaknesses of the rest. Best results are obtained when fusing artificial intelligence tools with specific project tools like CAPP, which permits real-time analysis, and PDRI, which allows the rating of how a project has been defined in its very early stages before a project begins.

Jiasheng Zhang1 et al. (2015)construction monitoring system is designed in this paper by studying hazard sources at a construction site, to identify, control, manage and prevent hazard sources, to grasp dynamic conditions at a construction site, to promote safety management of construction site, and to improve the informatization level of project monitoring. In construction site hazard source management based on the monitoring system, the innovation management method of combining construction engineering projects with advanced modern information technology is adopted to realize information, standard and perfect management of construction engineering project hazard source. Thus, the safety of project construction work can be improved, the accident rate can be reduced, and construction enterprises will transform into safety and information development. In the future, intelligent hazard source identification functions will be realized by the system. In another word, the virtual hazard source scene will be input into the system. The scene at the practical construction operation site will be collected, the acquired scene will be compared with the system scene, and the hazard source's existence will be judged. Thus alarm apparatus of the system will be triggered, and intelligent hazard source identification can be realized. Therefore, construction engineering project safety management can be improved to a larger extent, and construction enterprises will be

promoted to step toward a new era of safety and intelligence.

Megha Jain et al. (2014) studied neural networks are introduced as a promising management tool that can enhance current automation efforts in the construction industry, including its applications in construction engineering. Basic neural network architectures are described, and its application in the construction industry is discussed. Future possibilities of integrating neural networks and expert systems to develop efficient, intelligent systems are described. It is evident from this review that ANNs have been successfully applied to many construction engineering areas like prediction, risk analysis, decision-making, resources optimization, classification, and selection, etc. Based on the results of case studies, it is evident that ANNs perform better than or at par with the conventional methods. In many civil engineering situations, many problems are encountered that are very complex and not well understood. Most of the mathematical models fail to simulate the complex behavior of these problems.

In contrast, ANNs are based on the input-output data alone in which the model can be trained. Moreover, ANNs can always be updated to obtain better results by presenting new training examples as new data become available. Thus, ANN has several significant benefits that make it a powerful and practical tool for solving many construction engineering problems and are expected to be applicable in the future.

K. Petroutsatou et al. (2014) studied road tunnel construction as subject to underground uncertainties and risks. It is difficult to predict the final construction cost, especially at the conception phase where issues are evaluated. Important design decisions are made. A system assisting in the early cost estimation of road tunnels would be of great value as it would allow the quick costing of alternative and more economical solutions. The development of such an early cost estimation system is discussed in this paper. First, the basic parameters (geological, geometrical, and work quantities-related) affecting temporary and permanent support and final construction cost are determined. After that, appropriate real-world data derived from the analysis of 33 twin tunnels of 46 km total length constructed for the Egnatia Motorway in northern Greece from 1998to2004 and related to work quantities is collected and normalized. Appropriate price lists are then applied to calculate the costs; subsequently, cost-estimating models are developed using two types of neural networks: (1) the multilayer feed-forward network; and (2) the general regression neural network. The main conclusion is that the models developed are fit for the purpose and may lead to fairly accurate work quantities and cost estimates of road tunnels.

Pooja Agarwal et al. (2013) This branch of computer science is concerned with making computers behave like humans. Artificial intelligence includes game playing, expert systems, neural networks, natural language, and robotics. Currently, no computers exhibit full artificial intelligence (that is, they can simulate human behavior). Today, artificial intelligence's hottest area is neural networks, proving successful in several disciplines such as voice recognition and natural-language processing. Several programming languages are known as AI languages because they are used almost exclusively for AI applications. The two most common are LISP and prolong. Artificial intelligence is working a lot in decreasing human effort but with less growth. Until now, we have discussed the significant features of artificial intelligence, i.e., it's benefits, technologies, it's precise and a good definition. We can say that making a machine or saying a robot is not as easy as an ABC. It isn't easy to make a machine-like human who can show emotions or think like humans in different circumstances. Think sensibly, act wisely, think like humans, work like humans. At present, there is no computer showing full artificial intelligence, but the course of making machines like ourselves is on its path.

Kumar Neeraj jha et. Al (2011): studied an artificial neural network (ANN) method was used to construct the model, and the best was determined to be a 6-3-1 feed-forward neural network based on a backpropagation algorithm with a mean absolute percentage deviation (MAPD) of 11%. Few studies identify critical factors affecting the Schedule performance of construction projects in developing countries such as India. Also, few models are capable of predicting the schedule performance of an ongoing construction project. The existing models are either based on the studies carried out in developed countries or restrict themselves to a specific type of construction project. The application of ANN to predict the schedule performance of a construction project. The ANN models have a feed-forward network based on a backpropagation algorithm, in which the 6-3-1 structure has given the least MAPD of 11%. The high degree of predictive ability shows that the factors identified from correlation analysis are correct and can be used to predict the construction project's schedule performance. The significant factors in the schedule performance prediction models are project manager's competence; monitoring and feedback by project participants; commitment of all project participants; owner's competence, the interaction between external project participants; and good co-ordination between project participants.

K.N. Jha et al. (2009) studied to understand the factors that they must closely monitor to complete projects with the desired quality and also to predict quality performance during a project. With quality being one of the prime concerns of clients in their construction projects, there is a definite need to monitor its performance. Extension of past research

in which 55 project performance attributes were identified was based on an expert's opinion and literature survey, which resulted in 20 factors (11 successes and 9failures). The second stage questionnaire survey results have been used to develop the quality performance prediction model based on artificial neural networks (ANN). The purpose of this study was to identify the critical factors that affect the quality performance criteria on which could be used to develop a quality performance prediction model. Models to predict the quality performance criterion has been developed through correlation studies and ANN usage in MATLAB. The data that has been used for the prediction model development are free from outliers. The project manager's competence is a key factor in past studies to achieve better quality performance. The developed ANN models had a feed-forward network based on the backpropagation algorithm, and the 5-5-1 structure gave the least mean absolute percentage deviation (MAPD) of 8.044 percent. The high degree of predictive ability shows that the factors identified from correlation analysis are correct and can be used to predict the construction project's quality performance. The project professionals can concentrate on certain factors instead of handling all the factors at the same time to achieve the desired quality performance. The study may help the project manager and his team predict the quality performance of the project during its course.

K. C. Iyer et al. (2006) identify 55 attributes responsible for impacting the projects' performance. These attributes were then presented to Indian construction professionals in the form of a questionnaire. When schedule compliance is the prime objective, seven factors are observed to influence the schedule outcome significantly. Three factors: the commitment of the project participants; owner's competence; and conflict among project participants have been found to possess the capability to enhance performance level while the remaining four factors: co-ordination among project participants; project manager's ignorance and lack of knowledge; hostile socio-economic environment and indecisiveness of project participants tend to retain the schedule performance at its existing level. The extent of contribution of various success factors varies with the performance ratings of the project. At low levels of schedule performance rating, the "commitment of the project participants" has the highest positive effect on schedule completion. Still, its importance may not be felt so much when the performance level is high. When the performance rating level is already high, the "owner's competence" is observed to contribute most to enhance the performance further. This aspect identifies the value-adding factors to the schedule performance. It is suggested that the project manager very clearly assess the actual performance and concentrate on only value-adding factors to improve the schedule performance rather than waste non-value-adding factors. However, the findings given are about expected to give a broad guideline to any professional to select an appropriate factor for enhancement or sustenance of the desired performance level.

K.C. Iyer et al. (2004) Present a questionnaire survey conducted on the factors acting cost performance of Indian construction project. Factor analysis of the response on the 55 successes and failure attributes identified through literature review and personal interview extracted seven factors. The analyses' critical success factors are project manager s competence; top management support; project manager s coordinating and leadership skill; monitoring and feedback by the participants; co-ordination among project participants; and owner's competence and favorable climatic condition. However, factors adversely acting the cost performances of projects are conflict among project participants; ignorance and lack of knowledge; poor project-specific attributes and non-existence of cooperation; hostile socio-economic and climatic condition; reluctance in the timely decision; aggressive competition at the tender stage; and short bid preparation time. Further analysis indicates co-ordination among project participants as the most significant factor having a maximum positive influence on cost performance.

Florence Yean Yng Linga et al. (2004) studied the Artificial neural network (ANN) technique to construct the models to predict project performance, and these models are tested using data from five new projects. Research finds that six performance metrics can be predicted with a reasonable degree of accuracy: project intensity, construction and delivery speeds, turnover, system, and equipment quality. The key variables that a4ect project performance may be attributed to both contractors and clients. To ensure project success, contractors should have adequate strong level, a good track record for completion on

Budget and ability in financial management and quality control. Consultants should have a high level of construction sophistication and have handled DB projects in the past. Clients also play an important part in ensuring DB project success. They would need to have construction experience and handled DB projects in the past. They should also decide on the optimal level of design completion when the budget is 5xed, and tenders are invited. It is recommended that owners and contractors take note of the factors identi5ed in this study, which signi5cantly a4ect DB project performance.

H. Altabtabai et al. (1997) studied how artificial neural networks can be applied in construction project control. A project control system can predict and monitor project performance (e.g., cost variance and schedule variance) on observations made from the project environment is described. This project

control system has five neural network modules that allow a project manager to automatically generate revised project plans at regular intervals during the project's progress. These five modules are similar in design and implementation. The research presents the main issues involved in developing one of these five neural network modules, that is, the module for identifying schedule variance. Neural networks are well suited to decision-making in analogy-based problems using the intuition and experience of experts. This results from their ability to learn and generalize from experience. The experiments showed that neural networks are suitable for modeling complex relations between construction environment conditions and the project's performance as reflected in its WP. The results obtained from the schedule variance module were compared with the recommendations provided by the experts. The validation test showed the neural network solutions to be accurate. The test cases were limited to 15, and many test cases would provide greater confidence in these results. The GUI supports integrating the developed project control system with traditional project management software for scheduling (e.g., MS Project™ and Primavera™) and estimating (e.g., Precision Estimator™). Such integration facilitates the flow of data between a newly developed system and existing software. As a result, the integrated system is both feasible and practical for consulting engineers performing supervision and for construction managers responsible for project management and control functions.

III. CONCLUSION

Neural networks are a promising management tool that can enhance current automation efforts in the construction industry. Most of the researchers listed above studied how artificial neural networks can be applied in construction project control. A project control system capable of predicting and monitoring project performance, e.g., cost variance and schedule variance, project success estimation or critical success factor identification, road tunnel construction is subject to underground uncertainties and risks. It is difficult to predict the final construction cost, the strength of concrete, and used for disaster prediction based on observations made from the project environment. Artificial Intelligence tools are really helpful for the project manager to control and monitor the project. In most of the studies, researchers used a backpropagation algorithm for prediction.

There are applications of artificial neural network in areas of Cost, Productivity, Risk Analysis, Safety, Duration, Dispute, Unit rate, and Hybrid Models are done, and it confirms the usefulness of ANNs in carrying out a variety of prediction, classification; optimization, and modeling related tasks in areas of construction management.

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