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Accident Prediction In Construction Using Hybrid Wavelet-Machine Learning

Yeruva Ramana Reddy

Engineering Manager & Department of Civil Engineering

Indian Institute of Technology, India

***Abstract*— *The purpose of this study is to explore the feasibility of applying hybrid wavelet-machine learning to make predictions about the occurrence of accidents in the construction industry. Building remains one of Canada's deadliest industry despite recent attempts to enhance safety on construction sites. Safety on construction sites may be improved by the development of an Accident Warning System that can anticipate probable incidents and inform those who are at risk [1]. Workers' safety may be improved by keeping an eye on moving items in real time and giving rapid feedback to them on the results. It is a wavelet-machine learning model that is suggested. Using this model, we can anticipate where the observed items will be in the future. An accident warning is sent when the possibility for an accident has been recognized via the analysis of certain data points. As a result, the model is able to forecast accidents and notify those affected far in advance of their occurrence, giving them plenty of time to react [1]. The decision to issue a warning is made based on the projected repercussions of a possible mishap. Construction sites may benefit from the suggested system's ability to foresee and avoid accidents. It may be used to monitor construction site activities in order to limit the number of accidents and deaths on the job site.*

Keywords: Accident prediction, hybrid wavelet-machine learning, Construction sites, MARS, SVR

I. INTRODUCTION

Safety Management Systems (SMS) are designed to assist employers control workplace risk, but they may potentially raise a company's risk exposure. As a result of supporting the false assumption that risks have been adequately managed via the use of written artifacts (such as plans and risk assessments), this seemingly contradictory consequence might occur. The present state of the art for employing automated tracking to increase safety is centered on accident detection, in which the incidents are recognized as soon as possible. Accident prediction is the emphasis of the study reported in this article, which intends to take safety management to the next level by concentrating on predicting probable accidents in advance of their occurrence. Two nearby cranes' boom locations were previously predicted using accident prediction technology [1]. According to this research, a construction site accident may be predicted by the use of hybrid wavelet-machine learning techniques. The system relies on UWB tracking's real-time position estimation to estimate the possibility of an accident occurring using probabilistic modeling and risk analysis techniques. In the event of an impending mishap, the system will send an alert to all parties involved so that they have enough time to prepare and respond. The next part will offer an overview of the complete system; however the rest of this work will concentrate on the prediction model. It was possible for the model to tell when the crane booms were becoming too near to one another because of the model's use of axial rotational data. In order to designate a potentially harmful scenario, a minimum safety distance was established [2].

Despite the fact that safety management systems throughout the nation are always improving, there is definitely room for improvement when it comes to construction worker safety. Predicting the frequency and severity of future incidents based on historical data may help with action planning and safety measures to keep people safe in the future. Current research supports using time series analysis to make future predictions, where a time series refers to a collection of data points collected throughout time at regular intervals [3]. Initially, stand-alone machine learning (ML) approaches were used to project future values using time series in a variety of fields of study. Decomposition techniques like as Fourier transform, discrete wavelet transform (dwt, and empirical mode decomposition have, on the other hand, acquired significant traction in the previous decade. As a means of enhancing the models' correctness, these approaches dedicate themselves to investigating the original time series with regard to different frequencies [4]. In various fields, time series analysis was utilized to produce forecasts by a number of scholars. There are, however, very few studies on this topic in the literature. The combination discrete wavelet decomposition with a variety of machine learning algorithms, we may better forecast everyday occupational accidents across a range of time periods.

II. RESEARCH PROBLEM

The main problem that will be solved by this paper is to explore accident prediction in building projects utilizing hybrid wavelet-machine learning. Even though improvements are being made all the time to codes and standards, the accident rates for construction workers are often far higher than those of workers in other sectors throughout the majority of nations. With the use of discrete wavelet transforms (DWTs) and a variety of machine learning techniques (MLs), we want to add to the growing body of knowledge on construction site safety management [5,6]. There are a number of factors contributing to the consistently low safety record of the construction sector. To begin with, it has a fluctuating workforce that is tough to acclimate. Second, there are many duties, processes, and materials that can't be standardized in this job. Furthermore, each project is unique in terms of the site circumstances, designs, and requirements. to a large part, the contractual agreements. 1b.ird. Overall, there aren't enough instruments to perform a thorough accident investigation and devise preventative measures. Safety in the workplace is critical for a variety of reasons. All accidents result in pain and suffering for the victims. and the most crucial of them is the humanitarian one. Legal and regulatory ramifications such as fines, responsibility or criminal punishments may also have an impact on a construction company's reputation. Security also has an effect on the output and competitiveness of a firm firms with superior safety records tend to be more efficient and pay lower workers' compensation premiums [7]. There's no denying that accidents and injuries are expensive, and their impact on productivity must be considered. As a result, the construction sector stands to benefit greatly from increased safety.

III. LITERATURE REVIEW

A. *Wavelet analysis*

While windowed Fourier transforms provide a two-dimensional graphic illustrating the intensity of calculated as a function of period (or frequency), Wavelet analysis does not. Contrary to Fourier analysis, which examines correspondences between time series and infinitely long mathematical operations, wavelet analysis examines correspondences between time - series data and short-lived waves known as wavelets. There are several options for the fundamental wavelet form, but they all have zero means and are nonzero across just a small fraction of the real line [8]. The significance of wavelets in assessing non-stationarities in ground vibrations is discussed in Wavelet Analysis in Civil Engineering. To establish the issue and the model (based on linear hypotheses), the example of a tank is taken into consideration. Various research findings are also investigated, including fixed base, flexible platform, lateral and rocking movements of foundational principles, with and without fluid [8]. Identification of structural deterioration as well as bridge vibrations brought on by vehicle passage are investigated. Detailed solutions to increasingly challenging issues involving the interactions of soil and fluid are described, beginning with single degree of freedom systems and progressing to multiple degree of freedom systems using wavelet analytic methods. Nonlinear system wavelet randomized nonlinear and non - stationary vibration analysis, especially probabilistic analysis, has been the subject of several chapters dedicated to describing the fundamental ideas involved.

B. *A background in machine learning.*

Use of non-parametric supervised machine learning techniques such as MARS and SVR in this research predicted daily occupational accidents over time. [9] Each of these approaches has a unique functioning principle and a variety of differences. In spite of their widespread usage in the literature, these algorithms each have their own advantages and disadvantages, including the foundation on which they work, methods that they represent, and their applications. In order to forecast the number of workplace accidents in the construction industry, ANN, MARS, and SVR were used as machine learning algorithms and coupled with discrete wavelet transform.

i. *An artificial neural network*

Combining cells in the same way as in biological neural systems, an artificial neural network (ANN) is a dynamic system that may be represented as a combined set of differential equations. In the beginning, an ANN was proposed as a system of single-layer neurons, the smallest possible unit of an ANN. However, the difficulties of tackling non-linear issues with a single layer structure led to the development of multi-layer neural network models, such as the multi-layer perceptron (MLP) [10]. There are at least three levels in multi-layer neural networks: an input layer, a hidden layer, and an output layer. Based on the problem's description, the input and output layers' cell counts may change [10]. Two kinds of computations are used to implement ANN: feed forward and back propagation. First, a random sample is used to determine the weights, which are described as numbers expressing the impact of the input set on network outputs. Second, the weights are fine-tuned using a variety of samples introduced to the network in search of the optimal weights. The backpropagation method [11] is used to update the weights in the model when the total of error squares converges to zero.

In the literature on building site safety, the ANN technique has been used in a variety of ways. For example, ANN has been used to analyze the outcomes of construction accidents in relation to seven objective qualities, including at-risk behavior, incidents with partial failure, near misses, instances of missed workdays, first aid, therapeutic procedures, and fatalities. A fuzzy inference system was then constructed using conventional regression and ANN with 13 distinct networks. Researchers discovered that ANN was better at predicting more serious incidents. ANN, K-Nearest Neighbor (KNN), Decision Tree (DT), and Support Vector Machine (SVM) are some of the machine learning techniques that have been utilized by researchers in conjunction with a wearable insole pressure device to detect difficult working postures [11]. From a different point of view, neural networks and DT algorithms have been utilized to check whether or not the employees are utilizing personal protection equipment after it was discovered by three different deep learning algorithms. Neural networks were constructed with one input layer consisting of four parameters, two hidden layers each consisting of eight nodes, and one output layer for binary classifications. The greatest performance was attained by a single hidden layer neural network architecture on a dataset of 1500 annotated pictures and 4700 worker instances [12]. Other researchers have employed ANN in addition to the context of construction occupational safety, whether for security forecast in other sectors or for different aspects of project planning, such forecasting construction costs [12] and predicting the results of cost overrun in construction projects [12,13]. As a result, the method's widespread use in many fields of study is the key motivation for testing its efficacy in time series analysis for future estimates of construction-related occupational accident rates.

ii. Multivariate adaptive regression splines

Multivariate Adaptive Regression Splines (MARS) is a nonparametric approach that assumes no functional link between different variables. MARS builds a dynamic link between variables dependent on regression data finite elements. A versatile regression model may be developed by utilizing function values that correlate to a wide variety of independent factors. MARS is a sophisticated algorithm that can provide reliable results even when dependent and independent variables have complicated (nonmonotonic) connections. Regression analysis is hampered by multicollinearity, which is the interplay of independent factors [14], since only one function is used to characterize the association between variables. The MARS technique, on the other hand, doesn't have this problem since it uses a piecewise polynomial function to figure out the basis functions. The MARS model is comprised of two primary stages: the forward selection and the backward elimination stages. There is a first phase where each result for every regression slope adjustment is expressed as a knot, such as the completion of one domain and therefore, the onset of the next. The second phase involves identifying important independent factors and the ways in which these variables interact with one another. This is done by removing variables that have little impact on the model's objective function (the sum of error squares, for example) and defining the model that best meets this objective function as the best model.

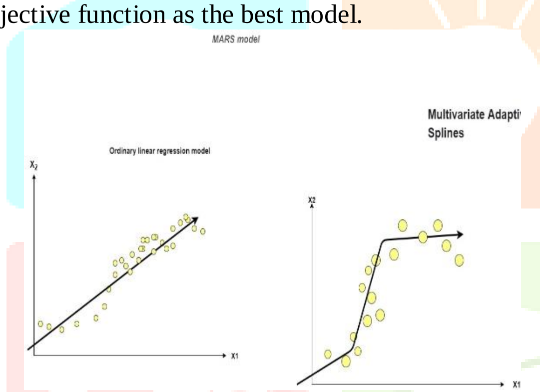

Fig i: An illustration of Multivariate Adaptive Regression Splines (MARS)

Despite its benefits, building safety literature is lacking on the MARS technique. Even in building subfields, the technique is constrained. A hybrid forecasting algorithm assessed factors to anticipate Taiwan's building cost index. In another research [15], MARS, linear regression, and SVM were used to determine the best surrogate model for the EnergyPLus dataset. Several ventilation and thermal load scenarios were applied to a passively built residential high-rise.

iii. Support vector system

Support vector machine (SVM) is an algorithm that was developed using the quantitative learning method and the notion of structural risk reduction [15]. The SVM approach is referred to as an all-purpose structured learning procedure that may be used to train a variety of projections, including radial-based functions, neural networks (sigmoid activation), splines, and polynomial predictors. Hyperplanes establish the classification of data points in SVM. It is impossible to generate a hyperplane for a non-linear issue without making an error, hence the error is tolerated throughout the whole procedure in order to derive the hyperplane with the lowest error. As a result, the hyperplane that maximizes the margin while minimizing the error is referred to as the ideal hyperplane [16]. In light of the fact that SVM is unable to generate a linear hyperplane for a nonlinear dataset, the current body of research acknowledges the crucial part played by kernel tricks, which are solutions applied to non-linear issues, in enhancing the learning capacity of algorithms [16]. SVM performance depends on the kernel function used. RBF is utilized for nonlinear situations and has a broader function space than other kernel functions. Practical and versatile, the RBF may quickly develop partnerships [16]. The RBF kernel is fast and generalizable. This study employed RBF kernel because of its universality.

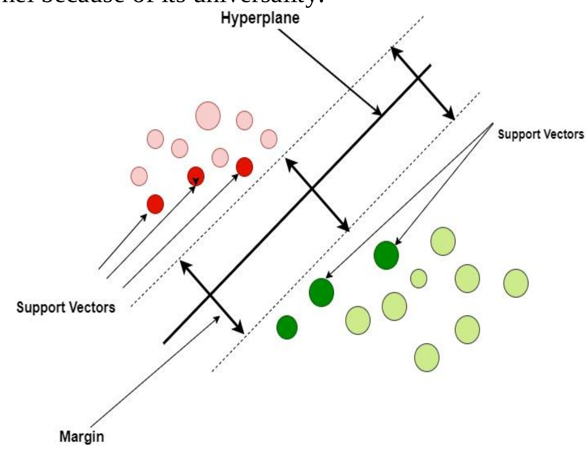

Fig ii: An illustration of Support vector machine (SVM)

For civil engineers in the United States, improving weak soils on the subsurface has several benefits. It is necessary to enhance the ground in order to achieve a variety of goals, including increasing bearing capacity and reducing settlement in soft ground, protecting against seismic liquefaction, controlling groundwater, stabilizing excavation bottoms, and cleaning up polluted ground [17]. An alternate strategy in the event of poor subsurface conditions is to skip the site altogether, adapt the structure's layout appropriately, remove and replace the inappropriate soils, or seek to transform the current ground. Geomaterial and geotechnical conditions have to be improved for numerous projects in order to satisfy the project's criteria. It is possible to design foundations to endure predicted earth deformations and to prevent movement of the superstructure. It is possible to design piling foundations to handle increased lateral loads from soil movement, or to have adequate vertical capacity even if the skin friction decreases owing to settlement. When exposed to ground deformations, shallow foundations may be engineered to act as a rigid body. When it comes to life-saving networks, the only option is to accommodate foreseen movements and put in place adequate reaction and repair mechanisms.

IV. SIGNIFICANCE TO THE UNITED STATES

The purpose of accident prediction in construction utilizing hybrid wavelet-machine learning is to reduce the number of fatalities. Accidents and injuries to construction workers are common when heavy equipment and massive structures are used. It is impossible to avoid every harmful situation, even with all the regulations and safety procedures in place. As a consequence, hundreds of people are injured and killed on building sites every year [17]. A substantial amount of earth must be disturbed before workmen can begin excavating for a new construction. The surrounding ground may become unstable owing to the excavation, depending on the soil and its consistency. As a result, the earth is prone to collapsing and taking employees with it. When anything like this occurs, however, a great number of people get injuries, become trapped, or even lose their lives. Predicting building projects, using machine learning, may lead to more effective use of limited resources, which eventually leads to successful construction projects by anticipating hazards and decreasing damages in advance. Using objective data and a weighted average of the identified risk variables, a hybrid wavelet-machine learning model may be employed to generate a quantified model. As a result of the multitude of outside works, there is a great deal of ambiguity [17]. As a result, when attempting to estimate the risk associated with a building project, quantitative methods are preferred over qualitative ones. Risk assessment and prediction using a quantitative technique based on a scientific approach and statistical analysis of data are also required in order to decrease project uncertainty and represent the distinctiveness of a building project. This is essential.

V. IT'S FUTURE

Intelligent models using machine learning models will continue to be essential for building site safety in the future. Predicting construction site accidents has mostly relied on statistical analytic approaches such as regression and time series analysis, which presume linear models. However, the nonlinear features of construction safety incidents, which are influenced by several complicated factors, cannot be accurately captured by this statistical analysis technique. US research on the use of machine learning to improve construction safety will continue to rise as new safety issues emerge [18.19]. The use of decision support tools based on machine learning in construction training might be beneficial at all levels. These tools may be tailored to focus on the financial aspects of the incidents. In addition, they may be made specifically for site supervisors, with an emphasis on certain technical elements. Some of these tools might also be used by workers interested in the proper and safe processes for a certain sort of employment [20]. It was because of these reasons that we began working on the applications of machine learning to building safety. Safety in the workplace can only be improved through preventing accidents. improved knowledge of the variables that cause accidents and the use of decision support systems to forecast the kind of accidents that may occur under certain conditions [18].

VI. CONCLUSION

This study examined how machine learning algorithms may play a significant role in predicting construction-related accidents. The results suggest that the use of innovative wavelet-machine learning hybrids may significantly reduce construction accident rates. Construction accident descriptors and nominal values were developed, as well as a technique for gathering accident data and creating case studies, thanks to the study. Machine learning may be used in two distinct ways to improve construction safety. As a starting point, a learning system may be used as a tool for learning about and gaining information about accidents. It is also possible to employ a learning system as a decision support tool in order to avoid accidents by anticipating their characteristics. In order to increase our understanding of accident causes and their linkages, and to get information for knowledge-based systems, we must learn about accidents in the first place. There are a variety of uses for these systems, including tracking. Analysis of accidents and the use of this information to help avoid future accidents. Additionally, making forecasts about the kind of incidents that may occur in the future is critical. so that a safety officer may take proper measures to avoid them in the case of a specific incident. The construction industry is in the midst of a time of rapid development, owing to advancements in different scientific and technological fields.

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