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Concrete Breaking Strength Prediction Using Machine Learning

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Abstract*: When it comes to estimating, classifying, and forecasting material strength based on changing material parameters, machine learning (ML) techniques have shown to be dependable methodologies. It is found that choosing the right machine learning technique depends on the characteristics of the problem and the available data. Therefore, fifteen different machine learning techniques were used to a specific dataset of concrete compressive strength in order to assess the accuracy of ML models to predict concrete compressive strength. Due to its excellent performance while dealing with continuous target variables and nonlinear interactions among the features and the target, the Support Vector Regressor (SVR) had the greatest prediction accuracy (88.18%) of all the ML methods employed. To guarantee the structural integrity of building projects, it is essential to predict the breaking strength of concrete. The goal of this project is to create a machine learning model that can forecast concrete's breaking strength depending on the mix's composition and curing circumstances. A dataset was created that included details regarding concrete samples, such as mix ratios, curing temperatures, curing times, and breaking strengths. recise estimation of concrete's compressive strength is crucial for the advancement and construction. A bibliometric analysis of the pertinent literature published in was conducted in order to comprehend the state of research in the field of concrete compressive strength prediction. The previous ten years have seen the first research in this sector. The database consisted of 31,35 journal articles published between 2012 and 2021 in the Web of Science core database. The knowledge map was created using Cite Space 6.1R2, a visualisation tool, to analyse the field at a macro level in terms of hotspot distribution, spatial and temporal distribution, and evolutionary trends, respectively. Next, we become specific and separate the prediction techniques for concrete compressive strength into two groups.*

Keywords: Predicting the breaking strength of concrete machine learning; compressive strength of concrete; prediction; gradient boost regression tree; artificial intelligence; bibliometric

I. INTRODUCTION

Any reinforced concrete structure's overall stability and suitability must be evaluated using concrete strength as a key criterion. One of the common techniques for assessing the strength of concrete is the compression test, which takes into account the water content, different ratios of fine and coarse aggregate, and cement. In the long term, testing concrete samples with different design strengths is costly. A variety of machine learning methods are actively used to classify and predict the provided datasets [1, 2, 3, 4, 5, 6]. By using statistical techniques, machine learning (ML) enables computers to learn from pre-Pexisting datasets [6]. One type of supervised learning technique used for data classification is the Support Vector Machine (SVM) learning algorithm. The ideal decision boundary is created by SVM .Predicting the breaking strength of concrete is crucial for ensuring the structural integrity of construction projects. This study aims to develop a machine learning model to predict the breaking strength of concrete based on its mix composition and curing conditions. A dataset containing information about concrete samples, including their mix proportions, curing temperatures, curing durations, and breaking strengths, was collected. The dataset was preprocessed to handle missing values and encode categorical variablesThis study throws a light on application of Artificial intelligent (AI) in construction industry. Prediction of strength of concrete using (AI) is an new innovation in civil engineering project is reduces human resources there by monitoring quality of concrete and strength of structural element.

II. PROBLEM STATEMENT

Concrete's strength is a key component used by the construction industry to create strong, long-lasting structures. Predicting concrete's breaking strength with accuracy is essential to guaranteeing the longevity and safety of these structures. At the moment, estimating the strength of concrete requires a lot of testing and analysis, which can be costly and time-consuming. As a result, the necessity for effective and precise techniques to forecast concrete breaking strength is increasing. This project's objective is to use machine learning techniques to create a predictive model that can be used to estimate concrete's breaking strength based on pertinent criteria such as composition. By giving contractors and construction engineers a dependable tool to predict concrete strength early in the building process, this model seeks to improve planning and optimization.

DATA BASE:

Cement, fine and coarse aggregate, blast furnace slag, water, fly ash, and superplasticizer are some of the components that go into making concrete. The models listed in Table 2 are trained using the concrete compressive strength data sets They collection includes 1030 records about the weight (kg) of fly ash, superplasticizer, blast furnace slag, water, and coarse and fine aggregate per meter cube mixture. In addition to the already listed. The Web of Science core database was chosen as the literature database source for this paper. In the literature search, the topic phrase was defined as an estimate of concrete's compressive strength. A total of 3135 publications served as the data source for the literature search, which was limited to the last ten years (2012–2021) in order to obtain a more thorough and macro perspective on the research. The search results were also vetted and cross-checked against the fundamentals of concrete strength prediction in order to remove any irrelevant content. Table 1 displays the database's specific screening process.

PROPOSED SYSTEM:

Using previous data to predict price of available and new launching product is an interesting research background for machine learning researchers. Sameerchand-Pudaruth predict the prices of laptops. He implemented many techniques like Multiple linear regression, k-nearest neighbors (KNN), Decision Tree, and Naïve Bayes to predict the prices. Sameerchand-Pudaruth got Comparable results from all these techniques. During research it was found that most popular algorithms Decision Tree and Naïve Bayes are unable to handle, classify and predict Numerical values. Due to less number of instances used, very poor prediction accuracies were recorded.

DATAFLOW DIAGRAM:

Data flow diagrams are used to graphically represent the flow of data in a business information system. DFD describes the processes that are involved in a system to transfer data from the input to the file storage and reports generation. Data flow diagrams can be divided into logical and physical. The logical data flow diagram describes flow of data through a system to perform certain functionality of a business. The physical data flow diagram describes the implementation of the logical data flow.DFD graphically representing the functions, or processes, which capture, manipulate, store, and distribute data between a system and its environment and between components of a system. The visual representation makes it a good communication tool between User and System designer. The objective of a DFD is to show the scope and boundaries of a system.The DFD is also called as a data flow graph or bubble chart. It can be manual, automated, or a combination of both. It shows how data enters and leaves the system, what changes the information, and where data is stored.

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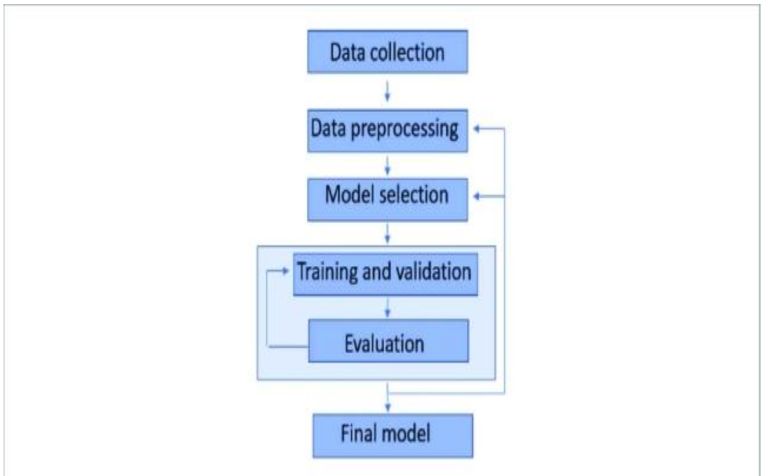

Fig1. Dataflow Diagram

MACHINE LEARNING :

Machine is subset of Artificial intelligence that provides functionality to learn automatically and improve the performance of without explicit program, machine learning algorithm can perform various application and improve the performance of the problem, it mainly focus on performance for that purpose it takes huge amount of data and use it and learn from themselves.

GRADIENT BOOSTING MACHINE (GBM)

A Gradient Boosting Machine or GBM combines the predictions from multiple decision trees to generate the final predictions.Keep in mind that all the weak learners in a gradient boosting machine are decision trees.But if we are using the same algorithm, then how is using a hundred decision trees better than using a single decision tree?How do different decision trees capture different signals/information from the data?Here is the trick **– the nodes in every decision tree take a different subset of features for selecting the best split.**This means that the individual trees aren't all the same and hence they are able to capture .

SUPPORT VECTOR MACHINES (SVM)

Support Vector Machine or SVM is one of the most popular Supervised Learning algorithms, which is used for Classification as well as Regression problems. However, primarily, it is used for Classification problems in Machine Learning. The goal of the SVM algorithm is to create the best line or decision boundary that can segregate n-dimensional space into classes so that we can easily put the new data point in the correct category in the future. This best decision boundary is called a hyperplane. SVM chooses the extreme points/vectors that help in creating the hyperplane. These extreme cases are called as support vectors, and hence algorithm is termed as Support Vector Machine.

III. CONCLUSION

The journey through the realm of concrete breaking strength prediction using machine learning has been illuminating and empowering. Throughout this module, we have delved into the intricate mechanics of concrete, understanding how its composition and properties intertwine to influence its breaking strength, a critical parameter in construction engineering. By leveraging machine learning algorithms, we have transcended traditional methods, opening doors to predictive modeling that offer unprecedented accuracy and efficiency. Through the lens of regression techniques, we have explored the nuances of data preprocessing, feature engineering, and model selection, gaining invaluable insights into the art and science of predictive analytics. Our exploration traversed a landscape of diverse algorithms, from classical linear regression to sophisticated neural networks, each offering unique strengths and applications in the domain of concrete strength prediction. We have witnessed the power of data-driven decision-making, harnessing the vast potential of Python libraries such as scikit-learn, TensorFlow, and Keras to translate theoretical concepts into practical solutions.

IV. RESULTS

MAE = 0.89, MSE = 4.37, RMSE = 2.09, MAPE=2% and R2 =0.94.

It has been determined that machine learning techniques exhibiting a MAPE value ranging from 2 to 7% on a test sample are deemed suitable for implementation. This level of model error is comparable to the standards set forth in normative documents for concrete. Feature engineering and feature selection technologies will help reduce the error. Additionally, also with an increase in the data set, it will be possible to use more complex models. The developed models can be offered to civil engineers, specialists in the field of materials science and materials technology as an additional source of information for making informed decisions regarding the development of improved concrete mix compositions and construction methods. These models can also be used for other materials that are exposed to aggressive environments. When changing materials and wanting to take into account a diverse range of their properties, it is advisable to use the technology of data drift, concept drift and domain adaptation. These methods will allow you to take into account new connections in the data without losing quality. The limitation is that we can have confidence in the results presented within the range reported in vitro. However, we believe that it reflects real-world conditions as closely as possible. The developed intelligent models can become part of a large scale forecasting system. Continuation of the research is planned in the direction of increasing the number of data in order to track the impact of additional factors influencing the strength characteristics of vibrocentrifuged concrete, as well as testing other machine learning models for prediction.

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