University of Tabriz

Journal of Civil and Environmental Engineering
Volume 54 (2025), Issue 4, 83-91

EXTENDED ABSTRACT

Analysis of Factors Influencing Concrete Resistance in the Construction Industry: Machine Learning Approach

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Received: 15 July 2024**; Reviewed:** 14 November 2024; **Accepted:** 28 December 2024

Keywords:
Urban management, Machine learning algorithm, Metaheuristic algorithm, Concrete compressive strength, Environment, Construction waste.

1. Introduction

Concrete, as one of the main materials in the construction industry, plays a vital role in the sustainability, safety, and welfare of urban spaces. This is because concrete has a direct impact on bearing gravitational and lateral loads, and improving the quality of concrete can prevent the premature destruction of buildings. Additionally, it can reduce the volume of construction waste and create a sustainable urban environment. However, numerous factors affect the compressive strength of concrete, and failing to identify these factors can lead to premature building destruction and adverse outcomes during natural disasters. A proper understanding of these factors is essential for enhancing concrete quality and ensuring the optimal performance of structures. Accordingly, the aim of this article is to analyze the factors influencing the quality and strength of concrete to improve the sustainability, safety, and welfare of urban spaces and to protect the urban environment. In this article, to achieve the research objectives, in addition to using a machine learning model based on the Extreme Gradient Boosting algorithm, metaheuristic algorithms have been employed to create an accurate predictive model.

2. Methodology

2.1. PSO algorithm

In this article, particle swarm optimization is used to tune the hyperparameters of the machine learning model with the aim of enhancing performance accuracy. This approach allows for the efficient exploration of the hyperparameter space, leading to improved model performance compared to traditional grid search methods. By simulating the social behavior of particles in a swarm, the algorithm effectively balances exploration and exploitation to find the optimal hyperparameters. The resulting model demonstrates superior accuracy and robustness in predicting concrete compressive strength, ultimately contributing to safer and more sustainable urban construction practices.

Publisher: Vice Chancellery for Research & Technology, University of Tabriz
https://doi.org/10.22034/CEEJ.2024.62446.2370
Online ISSN: 2717-4077
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2.2. Machine learning

Supervised learning is one of the three branches of machine learning, comprising two main components: 1) regression and 2) classification. In regression, the prediction of a data point is performed based on independent variables.

The Extreme Gradient Boosting (XG Boost) algorithm is a popular and powerful machine learning algorithm that falls under the category of ensemble learning. Specifically, it is a boosting algorithm that combines the predictions of multiple weak learners, usually decision trees, to create a strong predictive model. One of the key strengths of the Extreme Gradient Boosting algorithm is its ability to efficiently perform both regression and classification tasks

3. Results and discussion

After analyzing the relationship between certain variables and the compressive strength of concrete, the predictive model is trained based on the independent variables. For this purpose, after applying some preprocessing methods to the dataset, it is divided into a training set and a testing set, with 75% and 25% of the data allocated to them respectively. Some classification algorithms are used to build the machine learning model, and the results are mentioned in Table 1.

Table 1. Comparison of different models

Model	Accuracy (%)
Random forest	91.9
Decision tree	82.5
XGboost	93.7
Ada Boost	85.53
Gradient Boost	93.1
Linear regression	78.4
Lasso regression	78.9
XGboost + PSO	95.66

Based on Table 1, the combination of the XG Boost algorithm and the PSO algorithm shows better performance compared to the others. Additionally, feature importance analysis is performed to identify the effect of each variable on the compressive strength of concrete after training the model. The results are shown in Fig. 1.

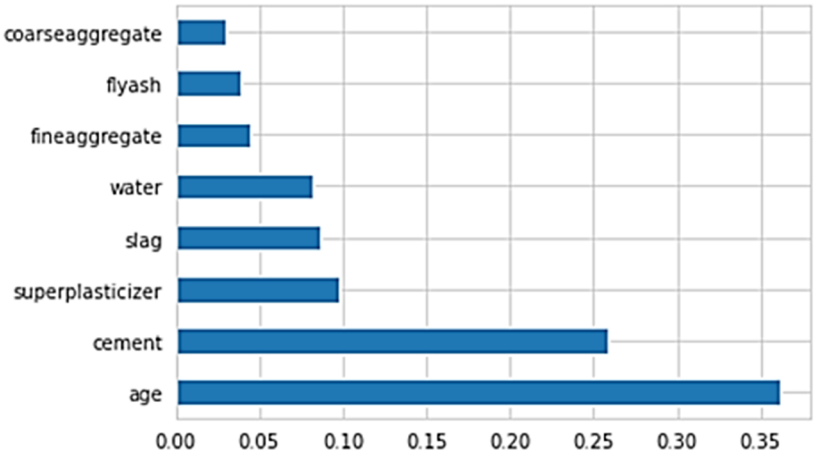

Fig. 1. Feature importance analysis

According to Fig. 1, it can be observed that the age variable has the greatest impact on the compressive strength of concrete, followed by the cement content. Additionally, other influential variables on the compressive strength of concrete are visible in Fig. 1.

4. Conclusions

Concrete compressive strength significantly impacts urban spaces and social life by determining the durability, safety, and longevity of buildings and infrastructure. Therefore, this study employs data analysis techniques to examine the characteristics influencing concrete compressive strength, aiming to extract valuable insights. Additionally, a predictive model was created by integrating machine learning and PSO algorithms. The resulting model has an accuracy of 95.66%, facilitating the prediction of concrete compressive strength. This not only helps decision-makers to quickly understand the compressive strength of concrete but also provides valuable information to enhance building strength. Consequently, implementing such programs to achieve adequate strength, enabling structures to withstand heavy loads and harsh environmental conditions, minimizes the need for frequent repairs and contributes to a sustainable and resilient urban environment. This stability increases residents' sense of security and well-being, enhancing social interactions and activities.