Machine learning-based estimation of interstory drift distribution in reinforced concrete structures

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Abstract. Nowadays, due to cost beneficial of Reinforced Concrete (RC) structures compared to steel structures, there is a growing interest for designing and improving the knowledge on the behaviour of this type of structures. This research overcomes the difficulty of estimation of Interstory Drift Distribution (IDD) in RC structures using Machine Learning (ML) algorithms of Artificial Neural Networks (ANNs), Extra Trees Regressor (ETR), Gradient Boosting Machines (GBM) and LightGBM. The aim of this research is to provide a general prediction model to estimate the IDD with the highest accuracy for using the behaviour assessment of existing or newly designed RC structures. The results of analysis showed that the ETR algorithm can accurately predict the IDD of two-, to ten-story RC structures and provide a plot curve of actual and predicted values of IDD with accuracy of 98.34%, while other improved ML methods have acceptable results.

Introduction

Exploring the lateral behavior of the Reinforced Concrete (RC) structures can improve the knowledge of civil engineers regarding the designing and performance of RC buildings. Therefore, it is on the interest of the engineers to have a prediction model for estimating the performance level [1] and seismic failure probability of the RC buildings [2]. The GBM (Gradient Boosting Machine) and LightGBM are both ML algorithms that belong to the family of gradient boosting algorithms. They are both used for supervised learning tasks, such as classification and regression. The main difference between them is in the way they handle large datasets. LightGBM uses a novel algorithm to achieve faster training and better accuracy on large datasets. Studies showed that using these methods can improve the accuracy of prediction leading to faster training and better scalability [3]. In addition, Artificial Neural Networks (ANNs) and Extra Trees Regressor (ETR) have the ability to learn complex non-linear relationships between inputs and outputs [4]. They are commonly used for supervised learning tasks and have also been used in civil engineering for tasks such as structural health monitoring, earthquake prediction, and structural design optimization [5].

Result and discussion

In this study, a ML-based model was developed for predicting the distribution of seismic response of RC structures. The methods of ETR and LightGBM were selected as the best methods to predict the peak IDD of RC structures. For this purpose, the seismic lateral responses of two-, to ten-story RC structures have been studied extensively using the proposed ML methods such as the ETR, ANNs, GBM, and LightGBM. The proposed method can decrease the time of computational efforts while provide a general prediction model for estimating the Interstory Drift Distribution (IDD) in RC structures with accuracy more than 98.34%. Figure 1 presents the IDD of the 6-, and 8-story RC structures using improved ETR algorithm with the highest accuracy.

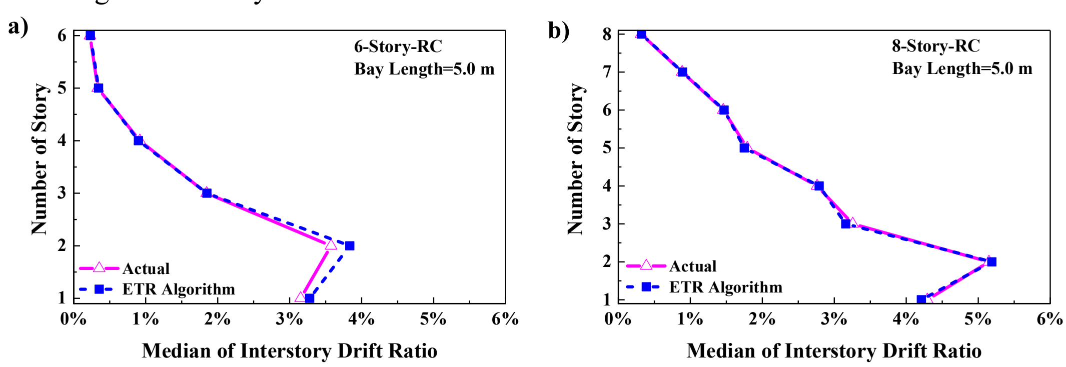

Figure 1. Distribution of the interstory drift ratio of the 6-, and 8-story RC structures using improved ETR algorithm.

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