Estimating seismic behavior of buckling-restrained braced frames using machine learning algorithms

Benyamin Mohebi[*], Farzin Kazemi[**] and Neda Asgarkhani[**]
[*]*Faculty of Engineering and Technology, Imam Khomeini International University, Qazvin, Iran.*
Email: mohebi@eng.ikiu.ac.ir
[**]*Faculty of Civil and Environmental Engineering, Gdansk University of Technology, ul. Narutowicza 11/12, 80-233 Gdansk, Poland*

Abstract. Over the last few decades, there has been a growing interest in exploring the seismic behaviour of Buckling-Restrained Braced Frames (BRBFs) as passive device for dissipating seismic energy. Machine Learning (ML) methods of Decision Forest (DF), Artificial Neural Networks (ANNs), Gradient Boosting Machines (GBM) and LightGBM were used to predict the seismic response of two-, to twelve-story BRBFs located in soil D. The partial dependence-based features selection method is proposed to increase the capability of methods for estimation of seismic response of BRBFs subjected to far-fault ground motions. The results showed that the GBM and DF methods with accuracy of 97% and 95%, respectively, can be used to predict the seismic response of BRBFs. Therefore, applying the proposed methods can facilitate the response prediction procedures and help designers, while decreases the total computational efforts.

Introduction

Buckling-Restrained Braced Frames (BRBFs) are used in the construction of buildings to provide lateral stability during earthquakes. The seismic response of BRBFs is of critical importance, as it affects the overall structural integrity of the building and the safety of the occupants [1]. One way to study the seismic behaviour of BRBFs is through Machine Learning (ML) methods. Decision Forest (DF) method and Artificial Neural Networks (ANNs) are two popular methods that have been used in this field. In the context of BRBFs, the DF method can be used to analyse the various parameters that affect the seismic response of the structure [2] and [3]. Another ML algorithm that has gained popularity in recent years is Gradient Boosting Machines (GBM). The GBM is a type of ML algorithm that uses decision trees to build an ensemble of models that work together to improve prediction accuracy [4]. LightGBM is a recent addition to the family of GBM algorithm. It is a fast, distributed and high-performance machine learning algorithm that is designed to handle large amounts of data [5].

Result and discussion

In this study, the seismic lateral responses of two-, to twelve-story BRBFs have been studied extensively using the proposed ML methods such as the DF, ANNs, GBM and LightGBM, which were improved by partial dependence-based features selection method. The proposed method can decrease the time of computational efforts in a big training dataset, while it can improve the ability of the ML methods for prediction of seismic responses with lowest achievable input features. This can improve the capability of the method for those of existing BRBFs without possibility of preparing the features of ML-based prediction model. Figure 1 presents the scatter plots of train and test data points related to the interstory drift ratio of the 4-story BRBF using improved ANNs algorithm.

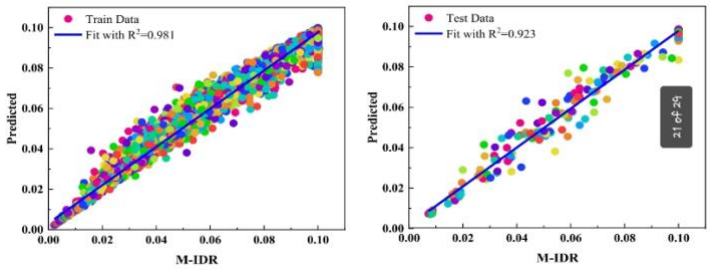

Figure 1. Scatter plots of train and test data points related to the interstory drift ratio of the 4-story BRBF using improved ANNs method.

References

[1] Kazemi F, Jankowski R. Seismic performance evaluation of steel buckling-restrained braced frames including SMA materials. J Constr Steel Res. 2023; 201: 107750.
[2] Kiani J, Camp C, Pezeshk S. On the application of machine learning techniques to derive seismic fragility curves. Comput Struct. 2019; 218:108–22.
[3] Nguyen NV, Nguyen HD, Dao ND. Machine learning models for predicting maximum displacement of triple pendulum isolation systems. Structures. 2022; 36:404–15.
[4] Oh BK, Glisic B, Park SW, Park HS. Neural network-based seismic response prediction model for building structures using artificial earthquakes. J Sound Vib. 2020; 468: 115109.
[5] Luo H, Paal SG. Artificial intelligence-enhanced seismic response prediction of reinforced concrete frames. Adv Eng Inform. 2022; 52: 101568