Application of deep and artificial neural network on rapid estimation of building responses

Masoud Mohammadgholiha[1] | Sepehr Asgarian[2] | Parisa Toofani Movaghar[3] | Siavash Soroushian[1]

[1]Department of Civil and Environmental Engineering, K.N. Toosi University of Technology, Tehran, Iran

[2]Department of Computer Engineering and Information Technology, Amirkabir University of Technology, Tehran, Iran.

[3]R&D Department, Trustructure Company, Tehran, Iran

Correspondence
Siavash Soroushian, Department of Civil and Environmental Engineering, K.N. Toosi University of Technology, Tehran, Iran
Email: ssoroushian@kntu.ac.ir

Summary

In light of the need for quick responses of cities to the natural hazards, rapid and accurate assessment methodologies are becoming more popular. Knowing so, an artificial neural network (ANN) and a deep neural network (DNN) as a form of artificial intelligence are used in this study to rapidly estimate the structural seismic responses such as drift, acceleration and velocity for urban or regional risk assessment applications. To do so, 126 multi-degree of freedom (MDOF) simplified 2D shear-building models combined with 222 ground motions (borrowed from the SAC project) ranging from 0.05g to 1.80 g peak ground accelerations are analyzed. The nonlinearity of models is created using the inter-story hysteretic model proposed in HAZUS methodology, considering the building type, number of stories and construction year. The total number of 27972 response-history analysis is conducted to generate a comprehensive dataset for machine learning algorithms. The proposed algorithm used the ground motion as well as structural characteristics such as PGA, Sa (0.2s), Sa(1s) and Sa(T1), story height, story mass, and period as input variables to estimate the responses of different structures. Through the development of neural networks, the computed structural responses (drift, acceleration, and velocity) are integrated with the input data to construct the output layer. In both methods, the 70%, 15% and 15% portion of the dataset used for train, test and validation of data, respectively. In the ANN approach, the average mean squared error (MSE) of responses for building types is 2.83e-3, while in DNN method, similar error is 1.43e-3 for validation datasets. Moreover, the accuracy and efficiency of the simplified and ML algorithms are evaluated by comparing the runtime, estimated repair cost and time in two actual damaged buildings in the 2017 Iran-Iraq border earthquake using previously verified risk assessment platform called TRUST. The results indicate that both ML and simplified analysis results are almost compatible with the actual costs of damaged buildings. While ML runtime is significantly lower than simplified approach.

KEYWORDS

Machine learning, ANN, DNN, mass shear model, citywide risk assessment

1 | INTRODUCTION

The major impact of destructive earthquakes as a natural disaster on buildings and infrastructures is inevitable. Also, rapid growth in urban areas has increased the risk of losses and casualties in regions exposed to large earthquake hazards. The concept of risk and disaster management in the