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Physics-informed LSTM architecture incorporating time and frequency characteristics for seismic response prediction

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ABSTRACT

An advanced long short-term memory (LSTM) architecture is presented to improve the accuracy of the prediction and dwindle the computation cost. The objective is to predict the structural displacement and restoring force of a building under seismic excitation. For input data, along with the time series ground acceleration, the proposed architecture manages frequency characteristics of the ground acceleration and response as an additional input which renders the architecture as a Multi Input Multi Output system. Moreover, the architecture involves a physical relationship between displacement and acceleration in its loss function to avert overfitting and to aim for precise prediction. The data used for deep learning architecture is constructed through numerical simulation in MATLAB. For nonlinear analysis, Bouc-Wen hysteretic model is adopted to interpret the three-story shear building structure. Taking into account that acquiring all responses from a given structure in real life is burdensome and cost-ineffective, a method that can estimate the characteristic of the structure with limited data should be considered. Therefore, before implementing the Bouc-Wen analysis, an Extended Kalman Filter method is carried out to estimate an essential structural parameter. After acquiring all the necessary data, the size of the constructed data is diminished to facilitate the speed and accuracy of the architecture's prediction. Considering the tendency and an important aspect of the original should be maintained in the downsized data, the Cross Power Spectral Density of the original data and the downsized data will be presented.

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