Seismic response forecasting using deep learning techniques for smart bridge bearing monitoring

Omid Yazdanpanah[1], Minwoo Chang[2]

[1]Hybrid Structural Testing Center, Myongji University, Republic of Korea, [1]Civil and Environmental Engineering , Myongji University, Republic of Korea

This paper presents a novel approach for the automatic prediction of displacement time histories of bridge bearings when subjected to seismic loads. The proposed method leverages a stacked CNN-bidirectional CuDNNLSTM neural network architecture, enriched by skip connections, along with MaxPooling1D, UpSampling1D, BatchNormalization, and LayerNormalization layers to enhance its performance. The framework utilizes the functional API provided by the Python Keras library to construct a model that takes input features such as horizontal and vertical ground accelerations, actuator loads in both horizontal and vertical directions, and the superstructure mass. To evaluate its effectiveness, the deep learning model relies on a substantial experimental dataset, comprising a total of 53 real-time hybrid simulations, distributed as 30 experiments for training, 13 for validation, and 10 for testing. After 1000 epochs, the proposed hybrid loss function, which combines mean square and mean absolute errors, consistently demonstrates a gradual reduction toward values close to zero when applied to the training and validation datasets. Moreover, there is a significant correlation of over 77% between the predicted displacement time series responses and those obtained from empirical measurements for unseen data. In summary, the proposed deep learning model offers several advantages, including time and cost savings in experimental efforts by reducing the need for additional tests. It also provides a rapid and accurate insight into the behavior of bridge bearings.