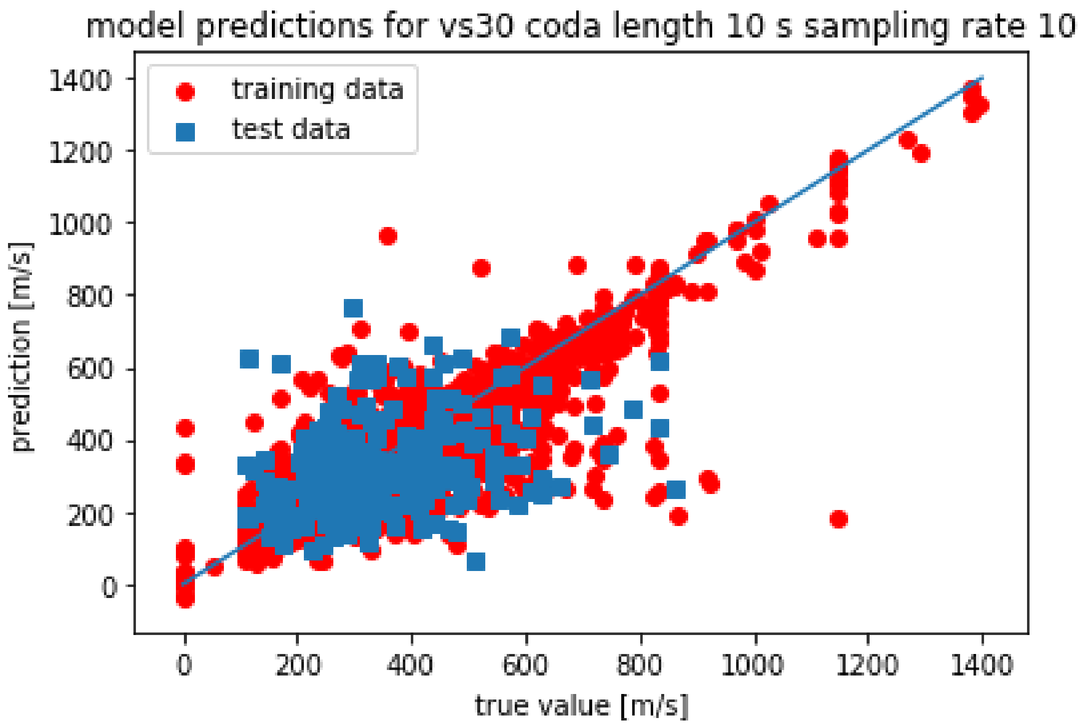
Data driven estimation of site effects using recurrent neural networks

*Mona Izadi[1], Shinichi Matsushima[2]

1. Department of Architecture and Architectural Engineering, Graduate School of Engineering, Kyoto University, 2. Disaster Prevention Research Institute, Kyoto University

The purpose of this study is to utilize artificial neural networks to propose a novel method of evaluating site effects. A Long Short-Term Memory (LSTM) Recurrent Neural Network (RNN) is designed using Tensorflow 2 library in python language. A dataset of 3 component strong motion records from all Kyoshin Network (K-NET) and Kiban Kyoshin Network (KiK-net) stations maintained by National Research Institute for Earth Science and Disaster Resilience (NIED, 2019) across Japan are obtained. In order to limit the dataset to the linear soil response range, only records with peak ground accelerations (PGA) between 10 and 120 gal are used. From each strong motion timeseries data, a 10 second time window, identified as coda wave, is extracted. Ideally, coda waves are composed of mainly surface waves and thus contain information on shallow subsurface structure.

Utilizing available borehole soil profile data, a vector of proxies is defined to represent the site effect characteristics at each station. These site proxies are time averaged shear wave velocity down to 30m depth (VS30), depth of seismological bedrock (Db), surface to bedrock ratio of shear wave velocity (Cv) and fundamental frequency (f0). Using these samples, a separate RNN is trained to predict each site proxy from coda waves. The dataset was divided into a training set of 95% of samples and a test set of the remaining samples. The RNN architecture consists of two hidden LSTM layers, one dense output layer and a sigmoid activation function. The target vector values are all normalized to fall within a range of 0 and 1. Once the network is trained, all predicted values are denormalized for performance evaluation. The best results were achieved when the RNN was trained over 100 epochs to predict VS30 values, with mean absolute error of 47.8 m/s on training set and 111.59 m/s on test set. The bigger error value on test set shows that the network is overfitting, and the performance is not ideal yet. This is expected to improve in further development of the study, by hyperparameter tuning on the one hand, and revised definition of coda wave time window on the other hand.


model predictions for vs30 coda length 10 s sampling rate 10
training data
test data
prediction [m/s]
true value [m/s]
0
200
400
600
800
1000
1200
1400