ARTIFICIAL-NEURAL-NETWORK BASED GROUND MOTION ATTENUATION MODELS

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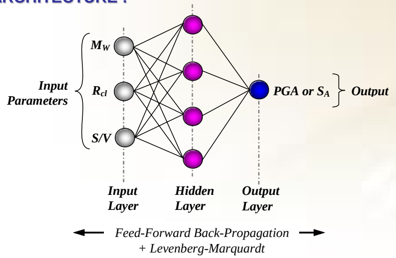
Objective

To develop efficient **artificial-neural-network (ANN) based attenuation models** to be used for seismic hazard assessment studies collectively with conventional empirical ground motion prediction relationships.

Artificial Neural Network-Based Model

Artificial-neural-network (ANN), being on the borderline between the artificial intelligence and approximation algorithms, has been recently emerged as an alternative tool for parameter predictions in nonlinear space ANN based attenuation model has the advantages over classical attenuation models that **ANN model does not need a specific equation form** (i.e., empirical form) and/or clear internal relation of a function.

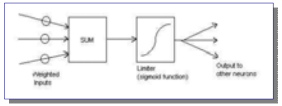
ARCHITECTURE :



TRAINING : The neural network model is trained according to the actual seismic records using Levenberg-Marquardt training algorithm.

The range of the training patterns are limited by the dataset as 4.0 to 7.4 for M_W, 0 to 250km for distance and 200,400 and 700m/sec for shear wave velocity (S/V) (as for rock, soil and soft-soil respectively).

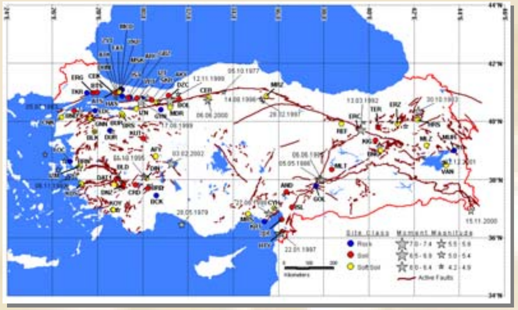
NETWORK : Each neuron receives a signal from the neurons in the previous layer, and each of those signals is multiplied by a separate weight value. The weighted inputs are summed, and passed through a limiting function which scales the output to a fixed range of values. The output of the limiter is then broadcast to all of the neurons in the next layer. So, to use the network to solve a problem, we apply the input values to the inputs of the first layer, allow the signals to propagate through the network, and read the output values.

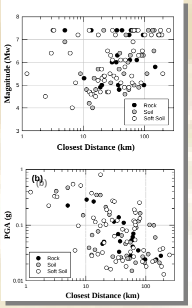


Ground Motion Database

• Development of regional ground motion prediction models is motivated by the significant increase in the number of records particularly following the recent Kocaeli (Mw 7.4) and Duzce (Mw 7.2) earthquakes in Turkey.

• A data set from **223 horizontal components from 112 strong ground motion records** of 57 earthquakes that occurred between 1976 and 2003 in Turkey has been compiled to be used in ground motion prediction.





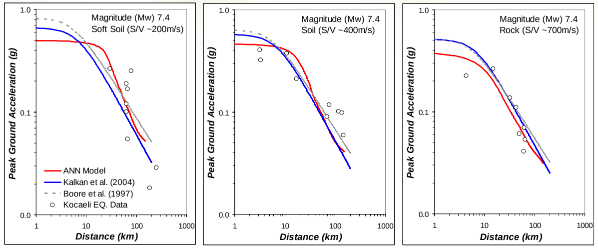
Comparative Results

Results of ANN-based attenuation models are compared with traditioanlly developed attenuation relationships of **Kalkan and Gulkan (2004)** and **Boore et al. (1997).** The form of the empirical equation in both references is:

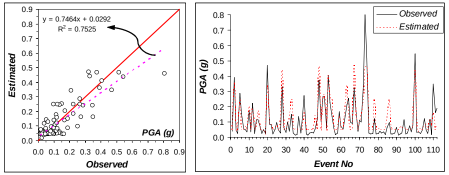
$$lnY = b1 + b2 (M - 6) + b3 (M - 6)^2 + b5 \ln r + bV \ln (VS / VA)$$

$$r = (rcl^2 + h^2)1/2$$

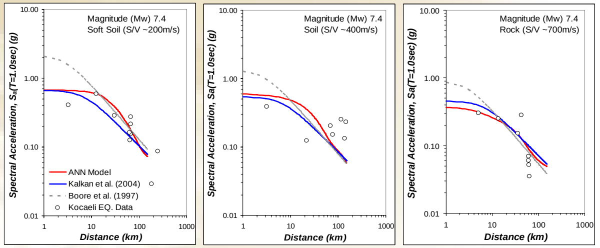
PGA Predictions



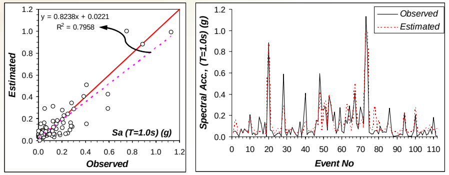
ANN-Model Performance



Sa (T=1.0 s) Predictions



ANN-Model Performance



Conclusions

- Comparisons with the actual earthquake data for both PGA and Sa (T=1.0s) yield promising results in favor of ANN-based models which may eventually serve as an alternative tool for ground motion prediction process.

- ANN model has some major advantages over the empirical model that it does eliminate the fix nonlinear equation form while progressively re-train the new-data and adapt to the updated data. Therefore can fully replace the empirical model for ground motion prediction.

- Though most simulations yield satisfactory results, ANN models need in general more training patterns (ground motion data) for better accuracy and stability.

References

- **Kalkan E. Gülkan P.** 2004, "Site-Dependent Spectra Derived from Ground Motion Records in Turkey", *Earthquake Spectra*, .20(4).
- **Boore, D.M., Joyner, W.B. and Fumal, T.E.** 1997, "Equations for estimating horizontal response spectra and peak acceleration from Western North American earthquakes: A Summary of Recent Work", *Seismological Research Letters*, **68** (1), 128-153.