Research Report

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With the support of ERI and associate professor Hiroe Miyake I had a great chance to visit ERI and conduct interesting research. I have worked on ground motion prediction models (GMPM) using artificial neural networks (ANN). To find out differences in regions and benefit of the method I have used two datasets: 1) One for Japan (data from NIED - National Research Institute for Earth Science and Disaster Resilience) (Fig.1); 2) Data from Georgia (Institute of Earth Sciences and National Seismic Monitoring Centre, Ilia State University) (Fig.2). In case of Georgia due to the lack of enough strong motion records I have used hybrid dataset strong motion type together with broadband type data.

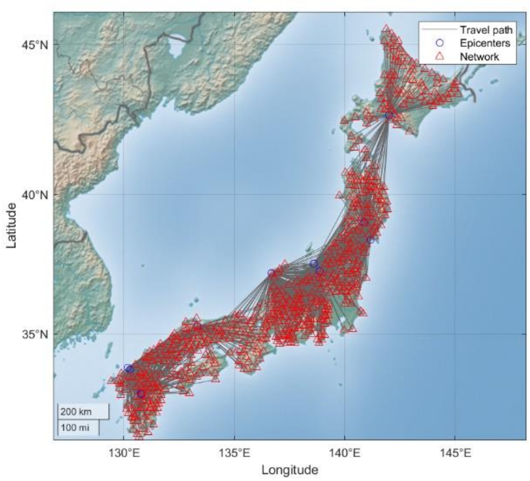


Fig.1. Japanese Data used for study.

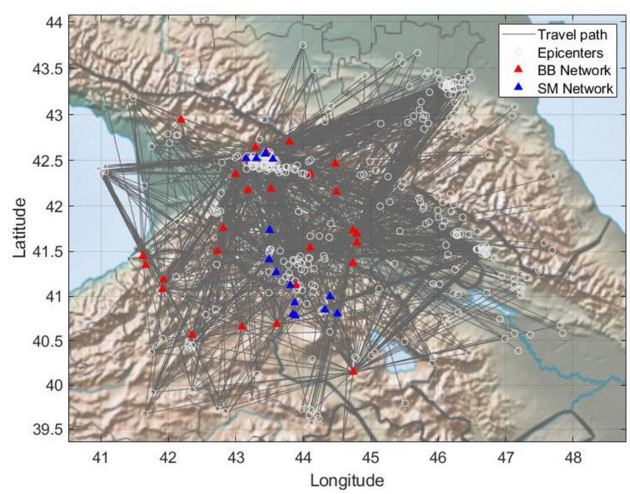


Fig.2. Georgian Data used for study.

AI can be especially useful for ground motion prediction models. In contrast with the classical approach for GMPM, with some methods of artificial intelligence (AI), such physical aspects can be considered which are impossible to take into account. As a result, we can obtain models with many parameters that have an influence on strong ground motion and at the same time we can reduce both epistemic and aleatory uncertainty. I have developed ground motion prediction models using AI for different ground motion parameters such as PGA (peak ground acceleration), PGV (peak ground velocity), SA (spectral acceleration), then try them for different numbers of hidden layers and obtain the best results for the selected model (Fig.3). For SA 5%-damped pseudo-absolute-acceleration spectra for different periods from 0.1s to 20s was considered.

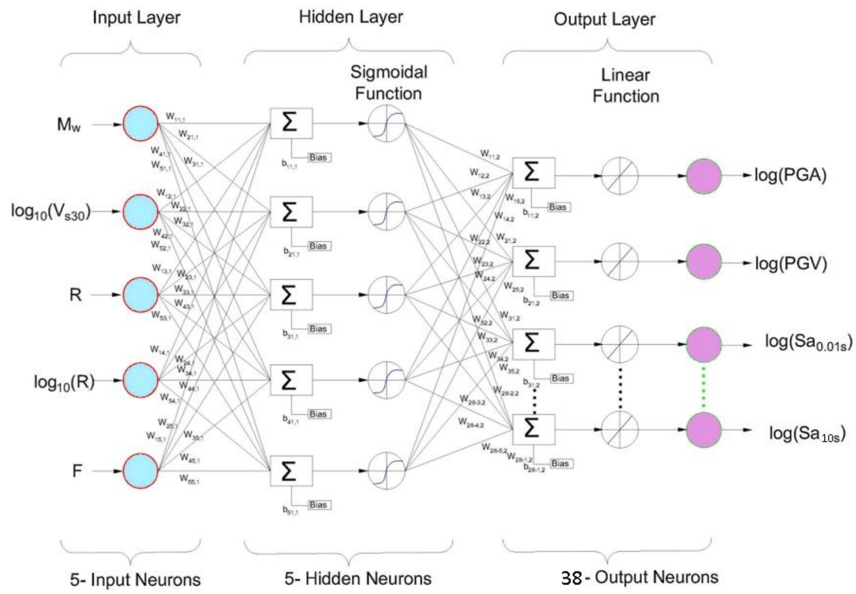


Fig.3. Proposed architecture of ANN GMPM model

ANN was selected for study because it can provide more accurate prediction of ground motion intensity measures for all distances and magnitudes. Also, in contrast with classical regression analysis ANN has a capability of adaptively learning from experience and extracting various discriminators in pattern recognition. For GMPM development fault type and local soil effect were also considered. In this method local soil conditions were considered based on average shear wave velocities over the top 30m of soil (Vs30).

As seen from fig.3 each neuron can receive inputs that can be weighted with the corresponding connection weight. Then summation of the weighted inputs and bias parameters can be used as inputs for activation function. Passing through the activation function, given intensity parameters such as PGA, PGV or SA can be predicted.

A hybrid technique combining genetic algorithm and Levenberg–Marquardt technique was used for training the model.

After training and testing Selection of the best model was based on several criteria:

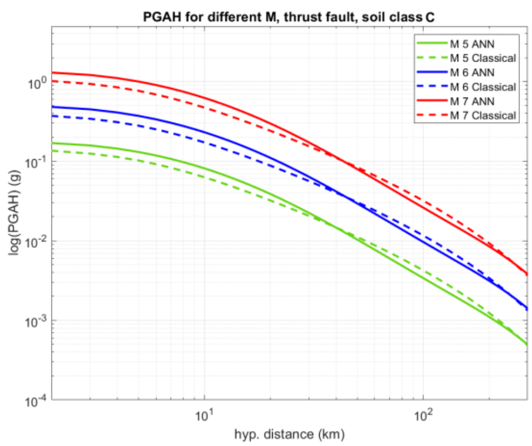
- Tried several activation functions (between input and hidden layers, and between hidden and output layers).
- Fast convergence (lower number of iterations), lower values of residuals.

I have used "**Tansig**" for hidden layer. By using it for the hidden layer, the model benefits from non-linear representations that enhance learning capabilities and convergence rates.

For output "**Purelin**" function was used. The choice of this function for the output layer enables the network to output continuous values effectively, making it well-suited for tasks that require regression, such as predicting ground motion parameters.

Finally, The **Tansig-Purelin** combination was likely the best fit for our data. It balances fast convergence with low error rates, which suggests it effectively captures both the nonlinearity in the ground motion data and the need for stable output values in the final layer.

After models were obtained for different ground motion intensity parameters, obtained models were compared with classical models. In case of Georgia, it was compared with my previous classical models published in 2022 (Jorjiashvili, N., Shengelia, I., Godoladze, T., Gunia, I. and Akubardia, D., Ground-motion prediction equations based on shallow crustal earthquakes in Georgia and the surrounding Caucasus., *Earthq Sci. Vol.35, Issue 6,* December 2022, Pages 497-509, Doi: [https://doi.org/10.1016/j.eqs.2022.12.001).](https://doi.org/10.1016/j.eqs.2022.12.001) In case of Japan, I have used results published in the most famous paper (Si, H. and Midorikawa, S. (1999). “New Attenuation Relationships for Peak Ground Acceleration and Velocity Considering Effects of Fault Type and Site Condition.” Journal of Structural and Construction Engineering, A.I.J., No. 523, pp.63-70). We have obtained quite good agreement with classical models with some difference which was expected (Fig. 4,5) .



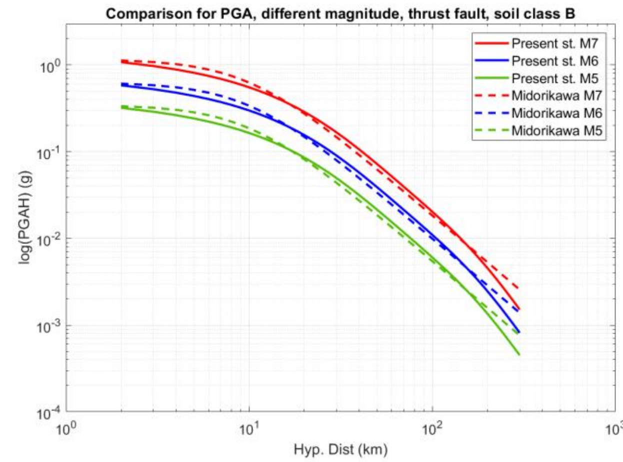


Fig.4. Comparison of ANN and classical models for Georgia Fig.5. Comparison of ANN and classical models for Japan

While staying at ERI I also had a great chance to participate in the workshop held in Kanazawa related to seismic hazard including the field trip at Noto earthquake 2024 (Mw 7.5) epicenter area.

I had two presentations at ERI. One of them was related to my general work and another was related to my work conducted in Japan.

I would like to acknowledge to the ERI staff, especially an associate professor Hiroe Miyake, who made great efforts to make my life in Japan more comfortable, valuable, and productive.

Finally, I would like to acknowledge the financial and in-kind support from the international office, which was also very valuable for me. Particularly, I want to thank Ms. Yoshie Kimura for her warm hospitality and help with everything.