Earthquake Magnitude Prediction with Seismic Nucleation Phase based on Machine Learning

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Understanding the mechanism of earthquake generation and predicting magnitude is an important research direction in seismology. In seismology, there are typical two models to explain how rupture grows and becomes an earthquake: nucleation model and cascade model. The nucleation model considers earthquakes start from weak faults pre-slip, then grow up. According to the hypothesis, the duration of seismic nucleation phase is proportional to the eventual size of the earthquake. We try to verify it with machine learning approaches and try to implement it on real magnitude predictions.

Machine learning, especially deep learning, has been proved that they can solve many problems that traditional algorithm cannot or hard to solve, but require higher computational power to train models to learn patterns in dataset. Hardware performance improvement in recent years energizes it and boom at about 2010. Machine learning have many applications like Autopilot, NPL (Natural Language Processing), stock market prediction, but seismic researches based on machine learning are few. Implement machine learning in seismology may bring some progresses in researches and applications.

In this research, we used the NIED Hi-net data, the JMA unified hypocenter catalogs, and the NIED seismic stations information to create the dataset of the model to detect seismic nucleation phase. Wave segments of seismic nucleation phase will become input, earthquake magnitudes will become output. Fourier transform is planned to be used for filter noise in wave. We are planning to use seismic wave data collected from Hi-net since 2004, but lack of high magnitude earthquakes might be a problem to build the dataset, which makes the trained model have bad performance in high magnitude earthquakes. Some Deep Learning models like MLP (multilayer perceptron), RNN (Recurrent Neural Network) and traditional Machine Learning models will be implemented to compare their performance. We have not decided to treat it as a regression problem, a classification problem or both. Magnitude or amount of energy release from earthquakes can be used as labels in a regression algorithm, while rounding magnitude can be used as labels in a classification problem. Some indicators of model performance like Mean Square Error and Confusion Matrix are used to evaluate and improve the model.

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