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Seismic indicators based Earthquake Early Warning System using Genetic Programming and Artificial Neural Networks

Earthquake Early Warning System (EEWS) holds potential for saving human lives and consequent financial damages. EEWS can be classified into two categories depending upon the methodology: a) P-wave arrival time based, and b) Seismic indicators or parameters based. The former approach generates warnings a few seconds before an earthquake while the later methodology predicts earthquakes a few days or weeks earlier. In this study Genetic Programming (GP) and Artificial Neural Networks (ANN) based methodology is employed with seismic indicators to develop an EEWS. Seismic indicators are based upon geophysical facts and laws, such as Gutenberg-Richter's law, seismic energy release, foreshock frequency, seismic rate changes and total recurrence time. These indicators are computed using the temporal sequence of past seismicity. The indicators are meant to express the internal seismic state of the region in numeric form, which is further modeled with the subsequent seismic activity through Computational Intelligence (CI) based algorithms. GP and ANN are concurrently employed to model the relationship between seismic indicators and earthquakes, thereby developing an EEWS, capable of generating warnings a few weeks before an earthquake.

In this novel combination of two different CI techniques, the role of ANN is to support GP through developing initial estimation of upcoming seismic activity. The approximation of ANN is further provided to GP as an auxiliary prediction for construction of a refined EEWS. The proposed model is designed in a way to generate earthquake warnings for the horizon period of 15 days. Initially, the model is trained for the regions of Hindukush and Chile. The prediction model is based on integration of the searching capabilities of GP and strong classification capabilities of ANN, in two layers. The first layer is complementing the succeeding layer, which results into an enhanced model for a challenging problem of earthquake prediction.

The proposed model also tackles the issue of predicting multiple earthquakes during single horizon period by computing seismic indicators for every earthquake. In this way, the capability of prediction model is enhanced for dealing with multiple seismic events during single horizon period. Upon occurrence of an earthquake before the completion of preceding horizon period, the model computes new seismic indicators inclusive of recent earthquake and generates renewed prediction without any delay. Such an approach enables this GP-ANN based model for predicting multiple successive earthquakes.

Primary author: Mr KHAWAJA MUHAMMAD, Asim (Centre for Earthquake Studies, National Centre for Physics, Islamabad, Pakistan)

Co-authors: Prof. MARTINEZ-ALVAREZ, Francisco (Department of Computer Science, Pablo de Olavide University of Seville, Spain); Dr IQBAL, Talat (Centre for Earthquake Studies, National Centre for Physics, Islamabad, Pakistan)

Presenter: Mr KHAWAJA MUHAMMAD, Asim (Centre for Earthquake Studies, National Centre for Physics, Islamabad, Pakistan)

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