Title: Feasibility of Earthquake Prediction by Deep Learning Algorithm Applied to Precursory Ionospheric Disturbance

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Abstract

Recent observations of the ionospheric disturbance prior to large earthquakes suggests the possible prediction of large earthquakes based on the precursory ionospheric disturbances. It was shown that the seismic activity around the geomagnetic equator region could explain the deviation, especially the increase even in the precursory period, of the equatorial ion density enhancement from the seasonal/spatial behavior and the seismo-ionospheric coupling is related to the conductivity change between the lithosphere and the bottom of the ionosphere in the vicinity of the seismic region. Meanwhile, the recent progresses of machine learning algorithm and the computing power enable the practical application of deep learning technology in the field where complicated human thinking power is required such as board game chess or 'Go' and even car driving. To investigate the feasibility of earthquake prediction by deep learning algorithm applied to precursory ionospheric disturbance, a recurrent neural network (RNN) with long short-term memory (LSTM) unit as a building block was utilized. As dataset for the ionospheric disturbance and earthquake occurrence, we utilized the US Total Electron Content (US-TEC) product and the earthquake database derived from the Preliminary Determinations of Epicenters catalog of earthquakes provided by the U.S. Geological Survey-National Earthquake Information Center (USGS-NEIC), respectively. The US-TEC includes Kalman Filter data assimilation model, driven by data from ground-based Global Positioning System (GPS) dual frequency receivers. In this study, we introduce the building block and structure of the deep learning algorithm, and the preliminary results of applying the algorithm the ionospheric disturbance data and earthquake time series as a training set for the deep learning neural network.

Image

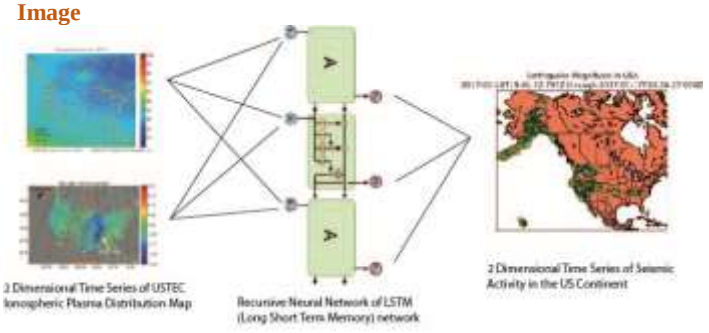


Figure 1: Conceptual Diagram of Earthquake Prediction by LSTM network trained by US-TEC ionospheric plasma distribution map and USGS NEIC seismic activity map as a training set.

Recent Publications (minimum 5)

1. Freund, F. (2010), Toward a unified solid state theory for pre-earthquake signals, Acta Geophys., 58(5): 719–766.
2. Kuo, C. L., J. D. Huba, G. Joyce, and L. C. Lee (2011), Ionosphere plasma bubbles and density variations induced by pre-earthquake rock currents and associated surface charges, J. Geophys. Res., 116: A10317.
3. Pulinets, S. (2012), Low-latitude atmosphere-ionosphere effects initiated by strong earthquakes preparation process, Int. J. Geophys., 131: 842.
4. Ondoh, T. (2003), Anomalous sporadic-E layers observed before M7.2 Hyogo-ken Nanbu earthquake; Terrestrial gas emanation model, Adv. Polar Upper Atmos. Res., 17: 96–108.
5. Kumar, J., Goomer, R., and Singh, A. K. (2018), Long short term memory recurrent neural network (lstm- rnn) based workload forecasting model for cloud datacenters. Procedia Computer Science 125: 676–682.



Biography

Sun Mie Park has expertise in variability of the Earth's ionosphere and magnetosphere. Recently, she has investigated the ionospheric variations response to earthquakes of different magnitudes and the possibility of earthquake precursor, using various observational data such as global GPS Total Electron Content (TEC). It has been shown that the ionospheric anomalies appear mostly several days prior to the earthquakes with magnitude M≥5.5. These pre-earthquake ionospheric anomalies are possibly associated with strong earthquakes. Email: smpark@kaist.ac.kr

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Notes or Comments: