Predicting the Location of a Possible Earthquake in Khorasan Razavi Province by Using Artificial Neural Network

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1. Introduction

Khorasan Razavi province is located in northeast of Iran, and it had the population of 5,994,402 people in 2011 census. According to land use in Khorasan Razavi province, 71% of the total area of the province is in moderate to high hazard which 24 cities with a population of 2,900,000 and 1,063 villages with a population of 580,000 are in relatively high-risk zones. The province has more than 5,500 large and small faults detected that 60% area, 75% of towns and 35% of villages are in the privacy of these faults. This is when the fact that only 28% of houses in the province have a steel and concrete structure and 72% of houses also used other materials that will seriously damage in earthquake. The situation indicates that in the event of a large earthquake, the province of Khorasan Razavi will be faced with disaster; therefore, in this study we have tried to use the features of occurred earthquakes in Khorasan Razavi in the years 1900-2014, and the places that are more likely to have earthquake are identified and have prioritized planning.

2. Study Area

The current research area is in Khorasan Razavi province in I. R. Iran which the following are the most important characteristics of earthquakes happened and the seismic situation with regard to faults privacy are pointed out.

- 40% of the area of Khorasan Razavi province is in the safe range and about 60% of its area is located near fault lines.
- Checking the focal depth of earthquakes occurred in the region shows that more than 90% of these earthquakes had focal depth of less than 40 kilometers long and 79% of them also have a focal depth between 10 and 40 km respectively.

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- The least of depth of the earthquake occurred in 1 km surface of the earth, the maximum depth was 64 kilometers and an average depth was 20.96 km of surface of the earth.

3. Material and Methods

A model of neural networks that was used in the classification and clustering of used data was Self Organization Feature Maps (SOM or SOFM). This was first presented by Kohonen and is known as Kohonen model. The root of Kohonen learning rule dates back to 1962 and unsupervised clustering issues. The primary goal of unsupervised Kohonen self-organizing neural networks is converting the input pattern with optional dimensions into a discrete model with one or two dimensions. The reason for selecting Kohonen neural network is that these networks are capable of categorizing large amounts of input data simultaneously and in parallel and recognizing seismic patterns. Using Kohonen neural network is due to internal statistical models in algorithms and unlike most statistical methods does not require many assumptions. It should be noted that the data used in the study through the information available on the website of International Institute of Earthquake Engineering and Seismology have been extracted from the characteristics of earthquake location (latitude), hours after the earthquake, the earthquake magnitude and depth of the earthquake in Khorasan Razavi province since the beginning of 1900 until the end of 2013. As well as a large number of earthquakes occurred in the area between 4-8 on the Richter scale are 199. Also, to evaluate the accuracy of neural network model used in the study, the statistical methods root mean square error (RMSE), mean bias error (MAE) and mean absolute error (MAE) are used.

4. Results and Discussion

After spatial prediction of a possible earthquake with a neural network, the predicted data have been processed by statistical analysis. Therefore, the Gaussian Mixture Model (GMM) was used. From seismic zoning maps percent it can be concluded that the maximum possibility of earthquake is predicted in the central region toward the west and the south east region of Khorasan Razavi province with a probability of 30% higher than other regions. Based on the model predictions it was good in cities of Mashhad, Fariman, Khaf, Gonabad, Kashmar, Khalil Abad, Torbat Heydarieh, Rashtkhar, Sabzevar, and Ghouchan and in other cities it is average. However, the total RMSE error model for Khorasan Razavi province is 0.460 that represents a model is a good fit. The results of MBE and MAE also confirm the results of RMSE criteria. The total amount of MBE model error is 0.274 and MAE model is 0.418 models that represent a good forecast.

5. Conclusion

The findings show that 12% of the urban population and 10% of rural population in zones with relatively high risk and most possibility of earthquake occurrence is in the central region toward the west of Province (Kashmar city and southeast of Sabzevar), southeast of Bardeskan and in southeast region (Khaf city) with 30% more than other

predicted regions, this is while in cities of Kashmar, Sabzevar, Bardaskan and Khaf, respectively 10, 16, 17 and 18 percent of houses have used steel and reinforced concrete materials and 89, 83, 82 and 80% of houses in the cities have used stone, brick, wood, clay and mud that in case of a possible earthquake could cause irreparable damages to life and property. The Kohonen neural network model could predict the probability of earthquakes in areas which areigher than other regions of the province.

Key words: Predicting the location of an earthquake, Neural networks method, Khorasan Razavi province

References (in Persian)

Abdulrahman, S. N., Alarifi, A., Nassir, S. N., Alarifi, B. C., & Saad, A. H. (2013). Earthquakes magnitude prediction using artificial neural network in northern Red Sea area. *Journal of King Saud University – Science*, *24*, 301–313.

Akbari Motlagh, M., Abbaszadeh, G., & Aminian, A. A., (2002). The vulnerability of Mashhad against earthquake and disaster management with an emphasis on international experiences. *Quarterly Spatial Planning and Sustainable Development*, *3*, 7-23.

Anvar, S. A., Dastgheibi Fard, G. H., Nikoui, E., & Moghare, R. (2007). Studies in the field of earthquake prediction using artificial neural network algorithms. *The Fifth International Conference on Seismology and Earthquake Engineering, Tehran*, 23-*26*.

Arian, M. (2003). Iran and geological reasons of earthquake. *Monthly Municipalities*, *12*, 38-45.

Asghari Oskoui, M. R., (2002). The application of neural networks in predicting time series. *Iran Journal of Economic Research*, 12, 69-97.

Azam, F., Sharif, M., Yasmin, M., & Mohsin, S. (2014). intelligence based techniques for earthquake prediction: A review, *Sci.Int. (Lahore), 26*(4), 1495-1502.

Bargi, K. (2013). *Fundamentals of earthquake engineering* (10_{th} ed.). Tehran: Tehran University Press.

Faraji, A., & Ghorkhlou, M. (2010). Earthquake and disaster management, case study: Babol. *Journal of Geography*, 25, 143-165.

Gerami, M., Sivandipour, A., & Taghdisi, H. (2012). Statistical prediction of earthquake hazard potential using artificial neural network. *Journal of Engineering Geology*, *1*, 1429-1444.

Jihad University of Mashhad, Khorasan Razavi. (2010). *Planning studies of Mashhad, Khorasan Razavi, analysis and evaluation of natural and environmental situations*. Mashhad, Report approved research projects in Khorasan Razavi, 149 pages.

Jihad University of Mashhad, Khorasan Razavi. (2010). *Planning studies of Mashhad, Khorasan Razavi, and Security in the Journal of the defense considerations.* Mashhad, Report approved research projects in Khorasan Razavi, 257 pages.

Kazemi-Posht Mosavi, H., Tahmasebi Sarvestani, Z., Kamkar, B., Shetayi, S., & Sadeghi, S. (2012). Evaluation of geostatistical methods for estimating and mapping

of mineral nutrient in some agricultural lands in Golestan province. *Journal of Soil and Water, 1,* 201- 218.

Khakpour, B., Hayati, S., Kazemi Biniaz, M., & Rabani Abolfazli, G. (2013). Adaptive-analytical comparison of the vulnerability of the urban tissues against earthquake using the models of hierarchical analysis and fuzzy (The case study: Lamerd City). *Journal of Preparation Environments*, *22*, 21-38.

Khalili Araghi, M., & Nobahar, E. (2011). Predicting housing prices in the city of Tabriz: Application of Hedonic pricing models and artificial neural network. *Journal of Research and Economic Policies*, *60*, 113-138.

Khatam, A. (2006). The destruction of Bam and its reconstruction following the earthquake of December 2003. *Cities*, *23*(6), 462–464.

Khatiri Yansari, M. R., Emami, B., Yazdi, M., & Shahkouyi, A. (2008). The methods used to predict earthquake precursors. *The first International Conference seismically retrofitted*,24-30., 29 Sealing until 1 November 2008, Tabriz.

Kia, S. M. (2008). *Neural networks in MATLAB*(3rd ed). Tehran: Kian Cooperative Publishing Services.

Kulahci, F., Inceoz, M., Dogru, M., Aksoy, E., & Baykara, O. (2009). Artificial neural network model for earthquake prediction with radon monitoring. *Applied Radiation and Isotopes*, *67*(1), 212-219.

Moghadam, M. (2009). *Assessment of land use changes in urban transport planning using artificial neural networks (Case study: Zanjan*).(M.A dissertatio) Meshkini, A. Zanjan university, Geography group.

Moustra, M., Avraamides, M., & Christodoulou, C. (2011). Artificial neural networks for earthquake prediction using time series magnitude data or SEISMIC ELECTRIC SIGNALS, *Expert Systems with Applications*, *38*, 15032–15039.

Negaresh, H. (2005). Earthquakes, cities and faults. *Journal of Geographical Research*, *52*, 34-51.

Pour Muhammadi, M. R., & Mosayebzadeh, A. (2008). Vulnerability of cities against earthquake and neighborhood partnership role in assisting them. *Geography & Development*, *12*, 117-144.

References (in English)

Shahnoushi, N., Zhaleh Rajabi, M., Firouz Zare, A., & Ghaffari, A. (2013). The effective factors in the development and differentiation of lesions bread bakeries using discriminant analysis and artificial neural network-based (Case study: Mashhad). *Journal of Agricultural Economics*, *3*, 101-132.

Shayan, S., Zare, G., & Haghpanah, Y. (2013). Iran and seismic retrofitting schools. *Journal of Geography Education*, *3*, 19-25.

Statistical Center of Iran. (2011). *Detailed results of the general census and housing*, Statistical Center of Iran.

Zomorodian, M. J. (2012). *Iran geomorphological processes internal structure and dynamics(6th ed.)* . Mashhad: Ferdowsi University Press.