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EARTHQUAKES PROBABILITY DENSITY MODEL IN COPULA METHODS IN EARTHQUAKES FORECASTING

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Recent advances made in forecasting earthquakes using clustering analysis techniques are being run by numerical simulations. In this paper, the Gaussian Copula clustering technique and self-organizing neural networks are used to obtain earthquakes cluster patterns such as doughnut shapes. Copulas methods and SOFM can involve recognizing precursory seismic patterns before a large earthquake within a specific region occurs. The observed data represent seismic activities situated around Iran in the 1970-2014 time intervals. This technique is based on applying cluster analysis of earthquake patterns to observe and synthetic seismic catalogue. Earthquakes are first classified into different clusters, and then, patterns are discovered before large earthquakes via Copulas and SOFM simulation. The results of the experiments show that recognition rates achieved within this system are much higher than those achieved only during the feature map is used on the seismic silence and the Doughnut pattern before large earthquakes.

Pattern recognition technique has been shown to elegantly and powerfully realize solutions to problems in seismology and earthquake forecasting. A few applications of advanced statistical methods to seismology have been carried out. For example AllamehZadeh et al. (2017), AllamehZadeh & Mahmudi (2017), Vazirzade (in press) have applied artificial neural networks to the explosion seismology for discriminating natural earthquakes versus explosions.

The self-organizing Map (SONN) (AllamehZadeh et al., 2017; AllamehZadeh & Mahmudi, 2017; Vazirzade, in Press) is a computational mapping principle that forms an ordered nonlinear projection of high-dimensional input data items onto a low-dimensional, usually 2D regular grid. The grid points are also called nodes. The display produced onto the nodes can be regarded as a similarity graph. Consider that some distance measure d(Xi, Xj) between any kind of items Xi and Xj can be defined: pairs of items that have a small mutual distance will then be mapped onto the same or nearby nodes. On the other hand, unlike in some other projection methods such as multidimensional scaling (MDS) (Nasrollahnejad et al., 2016; Behtaj et al., 2016) larger distances between items will in general not be preserved in the SOFM projection, not even approximately.

The other goal of pattern recognition in seismology is to identify earthquake prone area using Gaussian Copula. Allamehzadeh (2014) make previous applications of pattern recognition to earthquake locations in 2015, for strictly predictive purposes in central Asia and Anatolia. A pattern is a suite of traits that characterizes a group of objects, such as earthquake epicenters, and distinguishes this group of objects from another group, such as places that will not be epicenters. The other methodology is developed by Allamehzadeh and Mokhtari that has been applied to many seismic regions of the world for the identification of seismogenic nodes (Allamehzadeh et al., 2003, 2009; Madahizadeh and Allamehzadeh, 2011). Recent earthquakes in each of the regions studied have proved the reliability of the results obtained.

There are a variety of procedures used to generate observations (x,y) of a pair or random variables (X,Y) with a joint distribution function H. We will focus on using the copula as a tool. By virtue of Sklar's theorem, we need only generate a pair (u,v) of observations of uniform (0,1) random variables (U,V) whose joint distribution function is C, the copula of X and Y, and then transform those uniform variates via the algorithm such as the one in the preceding paragraph. One procedure for generating such a pair (u,v) of uniform (0,1) variates is the conditional distribution method (Figure 1).

The main purpose and contribution of the Copula function is the separation of the joint dependency and the marginal behavior.

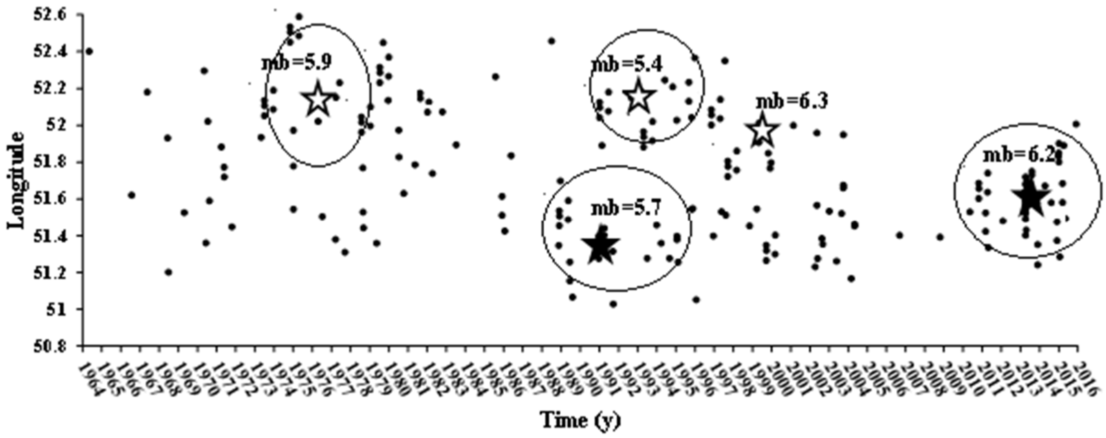

Figure 1. Visualization doughnut patterns before Mainshocks by using generalization and simulation algorithms points are forecasted large earthquakes by means of the Kohonen neural network and the same as Copula methods (by earthquakes data catalogue simulation). Circles are seismogenic nodes are obtained before large earthquakes. Space-time plot of seismicity for mb≥ 4.5 earthquakes.

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