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LONG-RANGE CORRELATIONS AND TRENDS BETWEEN CONSECUTIVE EARTHQUAKES

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One of the most interesting properties that time series of different kind of phenomena exhibit, is the long-range correlation, also known as long memory or long-range persistence, means that the auto-covariance function decays exponentially, by a spectral density that tends to infinity (Bardet et al., 2003; Cajueiro & Tabak, 2004). Self-similar processes have been used successfully to model data exhibiting long memory and arising in a wide variety of fields, ranging from physics (geophysics, turbulence, hydrology, solid-state physics, …) or biology (DNA sequences, heat rate variability, auditory nerves spike trains, …), to human operated systems (telecommunications network traffic, image processing, pattern recognition, finance, …).

For self-similar (or scale invariant) processes, the probabilistic properties of the process remain invariant when it is viewed at different time-scales. In mathematical expression, a stochastic process $\{X(t),\ t \in R^+\}$ is scale invariant or self-similar with Hurst parameter *H*, if for all $\lambda > 0$ it follows the scaling law: $X(\lambda t) \equiv \lambda^H X(t),\ t \in R^+$, where $\equiv$ means equality in all finite dimensional distributions (Borgnat, 2005).

The index *H* characterizes the self-similar behavior of the process, and a very large variety of methods has been proposed in the literature for estimating it (Bardet et al., 2003; Beran, 1994).

In this paper, we investigate the long-range correlations and trends between consecutive earthquakes by means of the scaling parameter so-called locally Hurst parameter, *H*(*t*), and examine its variations in time, to find a specific pattern exists between foreshocks, main shock and the aftershocks. The long-range correlations are usually detected by calculating a constant Hurst parameter. However, the multi-fractal structure of earthquakes caused that more than one scaling exponent is needed to account for the scaling properties of such processes. Thus, in this paper, we consider the time-dependent Hurst exponent, to realize scale variations in trend and correlations between consecutive seismic activities, for all times. We apply the Hilbert-Huang transform to estimate *H*(*t*) for the time series extracted from seismic activities occurred in Iran. The superiority of the method is discovering some specific hidden patterns exist between consecutive earthquakes, by studying the trend and variations of *H*(*t*). Estimating *H*(*t*) only as a measure of dependency, may lead to misleading results, but using this method, the trend and variations of the parameter is studying to discover hidden dependencies between consecutive earthquakes. Recognizing such dependency patterns can help us in prediction of main shocks (Figures 1 and 2).

Earthquakes are complex phenomena to analyze. Seismic data as time series exhibit complex patterns, as they encode features of the events that have occurred over extended periods of time, as well as information on the disordered morphology of rock and its deformation during the time that the events were occurring. It is for such reasons that seismic records appear seemingly chaotic. Numerous papers have reported that large events are preceded by anomalous trends of seismic activity both in time and space. Several reports also indicate that seismic activity increases as an inverse power of the time to the main event (sometimes referred to as an inverse Omori law for relatively short time spans), while others document a quiescence, or even contest the existence of such anomalies at all. If such anomalies can be analyzed and understood, then one might be able to forecast future large events.

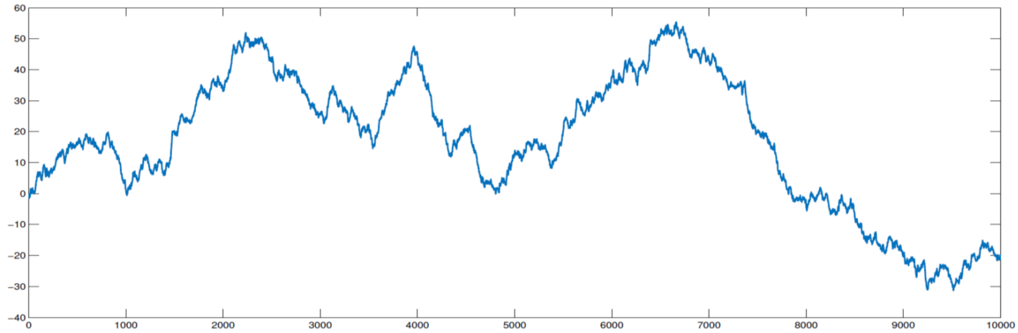

Figure 1. A simulated fractional Brownian motion with length T = 1000 and Hurst exponent H = 0.6.

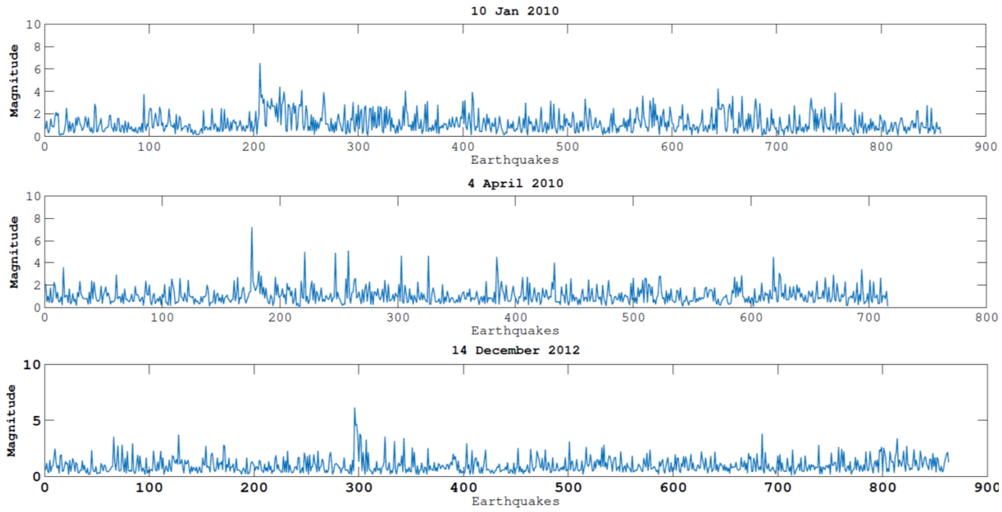

Figure 2. The magnitudes time series for seismic activities occurred in California, where the time intervals consist of 3 days before and 7 days after the main shock, that the main shocks occurred in: January 2010 (top), April 2010 (middle), and December 2012 (bottom).

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