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Improving the Robustness of Scaling Exponents Estimated using Detrended Fluctuation Analysis

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Abstract

In trying to estimate scaling exponents researchers utilise the method of Detrended Fluctuation Analysis (DFA). This method has been used to analyse empirical data in various scientific disciplines such as hydrology, geology and meteorology. Some systems are hypothesised to exhibit the phenomenon of self-organised criticality (SOC). This type of dynamical system is spatiotemporally scale invariant. Dynamical systems exhibiting SOC have been shown to produce certain key characteristics, in particular, 1/f to the power α noise where α is called the scaling exponent . An accurate estimation of α, given an empirical time series, would allow one to draw conclusions about the underlying dynamics of the observed system. An estimated $\alpha \approx 0$ corresponds to the presence of white noise whereas $\alpha \approx 2$ to Brownian motion. The DFA method allows us to determine an estimate of this scaling exponent, if it exists. However the reliability of this estimate remains questionable. Testing generated sequences of trend functions contaminated with 1/f noise has been well explored. Using this we establish the presence of a bias in the DFA technique. We will then propose a method to remove this bias and establish robust estimates of the scaling parameter, and also whether not scaling is plausible. In doing so we will be able set up a null hypothesis test to determine whether an observed natural system exhibits the hypothesised characteristic features of SOC.

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