Fractal Estimation in Time Series Data: A Visual Approach to the Detection of Self-Similarity

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Abstract

This presentation illustrates the indispensability of visual data representation to the analysis of fractal patterns in time series data. Fractals are self-similar shapes that repeat within themselves. Their visual appeal is well-known. In time series data, fractals are manifest in long-range dependencies between data points (persistence). Mandelbrot and many others have argued that such dependency shows the adaptiveness of the behavior of systems, and therefore, it needs to be investigated. This presentation will show how to detect fractals in time series data and in their autocorrelation function plots. An indispensable second part of this analytical process is the generation of a power function, based on a Fourier-transformation of the series. If a plot of the amplitude of the transformed series on its relative frequency is linear with a downward slope, it demonstrates persistence in the series, and hence fractality. In the absence of such patterns, these plots will show a zero slope (randomness), or nonlinearity, which points to short but not long-range dependency. In a data analysis, these three scenarios cannot be distinguished on a purely statistical basis and require visual inspection of the plots and the power spectra. This presentation shows fractal behavior in simulated time series at four different persistence levels (N=2,048), and in annual recordings of the flow of the river Nile (N = 663), daily recordings of births to teenagers in the state of Texas (N=1,460), and daily school attendance in a middle school in New York City (N=735).

Keywords: Time series, Fractals, Self-similarity, Persistence, Adaptive systems