Scaling Invariance Embedded in Short Time Series

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Abstract

Scaling invariance has made great contributions to diverse research fields. But how to evaluate scaling exponent from a very short time series is still an open problem. Finite length may lead to bias and fluctuations to statistical quantities and consequent invalidation of current used standard methods such as wavelet analysis, de-trended fluctuation analysis. By optimizing simultaneously bias and fluctuation, we proposed a balanced estimation of diffusion entropy. Calculations show that it can give us reliable scaling behaviors embedded in short ($\sim 10^2$) time series. It is used to find persistence in online rating series, physiological signals, and stock indices.

Keyword: Scaling invariance, very short time series, balanced estimation of diffusion entropy

1 Introduction

Scale-invariance embedded in time series has been making great contributions to diverse research fields, such as the efficient market hypothesis, evaluation of healthy state, and distinguishing coding genes in DNA sequence. But how to evaluate scaling exponents is still an open problem. A key challenge in practice is that time series in reality is generally very short. Some times we have long series, but phase transitions may occur in the recording duration. We should separate the series into short segments to find local behaviors. Finite length may lead to unacceptable fluctuations and bias in physical quantifies, and consequent mistakes in evaluated scaling exponents. In this talk, a series of tools are developed to evaluate (mono-/multi-) fractals in short time series.

2 Methods

First, a new method called balanced estimation of diffusion entropy (BEDE) is proposed to correct the bias and fluctuations in the initial diffusion entropy. Detailed calculations show its powerful in estimation of scaling exponents in short time series with several hundreds length.

Second, we test in detail the assumptions in BEDE, and the effects of de-trending procedures. Accordingly, the BEDE is improved to a new version called correlation dependent balanced estimation of diffusion entropy (cBEDE). It has a high-performance of ignorable bias and sharp confidence interval [-0.05,+0.05]. As typical applications, BEDE and cBEDE are used to evaluate evolutionary behaviors of scaling invariance in stock markets and physiological signals.

Third, we develop a method called factorial moment based multi-fractal evaluation tool, which can estimate with high-performance multi-fractals in short time series with several hundreds length.

3 Results and conclusions

The developed methods are used to investigate scaling behaviors in physiological signals (sleeping series and stride series) and stock market index in Shanghai Stock Market. One can find that the evolutionary series of scaling behaviors have rich patterns, while the traditional works use only one global Hurst exponent to represent the scaling behaviors. We found for the first time long-term persistence in online rating series of movie system, which provide a new criterion to check theoretical models. We hope our methods can make contributions on early warning signal detection.

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