Fractal and Diffusion Entropy Analysis of Time Series: Theory, concepts, applications and computer codes for studying fractal noises and Lévy walk signals

Nicola Scafetta

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Scale invariance has been found to empirically hold for a number of complex systems. The correct evaluation of the scaling exponents of a time series is fundamental to assess the real physical nature of a phenomenon. The traditional methods used to determine these scaling exponents are equivalent because they all rely on the numerical evaluation of the variance. However, two statistical classes of phenomena exist: fractal Brownian motions and Lévy flights and walks. In this book I present the theory and concepts of alternative fractal methods of time series analysis. I introduce a complementary method based on the Shannon entropy: the Diffusion Entropy Analysis (DEA). Using synthetic, solar, geophysical, sociological, physiological and biological data, I examine the properties of these methodologies and discuss the physical ambiguities of the variance-based methods. I argue that the variance-based algorithms should be used together with DEA to properly distinguish fractal Brownian motions from Lévy flight-walk classes of noises and complex processes. Computer C++ codes are provided for generating complex fractal noises and performing multiple fractal analyses of time series.

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