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Analysis of Dynamics Underlying the Observation Time Series by Using a Singular Spectrum Approach

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Abstract : The main purpose of time series analysis is to learn about the dynamics behind some time ordered measurement data. Two approaches are used in the literature to get a better knowledge of the dynamics contained in observation data sequences. The first of these approaches concerns time series decomposition, which is an important analysis step allowing patterns and behaviors to be extracted as components providing insight into the mechanisms producing the time series. As in many cases, time series are short, noisy, and non-stationary. To provide components which are physically meaningful, methods such as Empirical Mode Decomposition (EMD), Empirical Wavelet Transform (EWT) or, more recently, Empirical Adaptive Wavelet Decomposition (EAWD) have been proposed. The second approach is to reconstruct the dynamics underlying the time series as a trajectory in state space by mapping a time series into a set of R^m lag vectors by using the method of delays (MOD). Takens has proved that the trajectory obtained with the MOD technic is equivalent to the trajectory representing the dynamics behind the original time series. This work introduces the singular spectrum decomposition (SSD), which is a new adaptive method for decomposing non-linear and non-stationary time series in narrow-banded components. This method takes its origin from singular spectrum analysis (SSA), a nonparametric spectral estimation method used for the analysis and prediction of time series. As the first step of SSD is to constitute a trajectory matrix by embedding a one-dimensional time series into a set of lagged vectors, SSD can also be seen as a reconstruction method like MOD. We will first give a brief overview of the existing decomposition methods (EMD-EWT-EAWD). The SSD method will then be described in detail and applied to experimental time series of observations resulting from total columns of ozone measurements. The results obtained will be compared with those provided by the previously mentioned decomposition methods. We will also compare the reconstruction qualities of the observed dynamics obtained from the SSD and MOD methods.

Keywords : time series analysis, adaptive time series decomposition, wavelet, phase space reconstruction, singular spectrum analysis
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