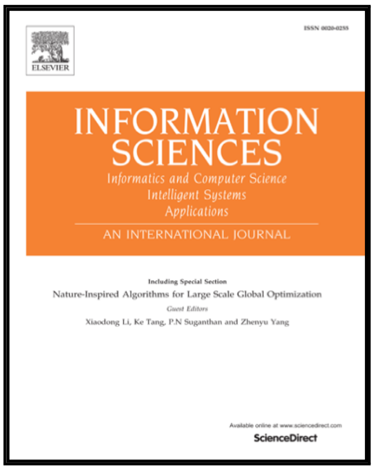

Wavelet-denoising multiple echo state networks for multivariate time series prediction

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Wavelet-denoising multiple echo state networks for multivariate time series prediction

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Abstract: Motivated by the idea of 'decomposition and ensemble', this paper proposes a novel method based on the wavelet-denoising algorithm and multiple echo state networks to improve the prediction accuracy of noisy multivariate time series. The noisy time series is first denoised by a wavelet soft thresholding algorithm and decomposed into a set of well-behaved constitutive series. Each constitutive series is then predicted by a separate echo state network with proper parameters that match the specified dynamics. Finally, the overall prediction is achieved by a linear combination of the constitutive series. For each constitutive series, we use the correlation integral method to select the phase-reconstruction parameters and to construct the appropriate input. Two sets of multivariate time series are investigated using the proposed model and some other related work. The simulation results demonstrate the effectiveness of the proposed method.

Keywords: Echo state networks, Wavelet denoising algorithm, Multivariate time series, Prediction

1 Introduction

Multivariate time series prediction is an open problem in which past observations of the same variables are collected and analysed to model the underlying relationships between nonlinear systems [4, 7, 33, 35]. It requires dynamic computational models to store and access the time history. The most widely used dynamic model is recurrent neural networks (RNNs) [4] that couple delay lines in a nonlinear architecture to achieve time embedding. However, one of the key problems associated with RNNs is the difficulty in adapting the weights. A variety of algorithms have been used to train RNNs such as the Levenberg–Marquardt method and quasi-Newton method; however, these algorithms suffer from high computational complexity, slow training speed, local minimum, and potential instability [23, 39].

In the past few decades, randomized algorithms for training neural networks have become popular [28, 38, 45, 51]. One such algorithm is the reservoir computing algorithm used in echo state networks (ESNs), which has been proposed for modelling nonlinear dynamic systems [21, 26, 30]. The main concept of this algorithm is to train the output weights alone by using a simple linear regression method while the other parameters remain fixed once they are properly initialized [27]. The nonlinear reservoir derives from the input signals and generates a high-dimensional dynamic echo response. Then, the echo state is used as a non-orthogonal basis to construct the desired outputs. Recently, ESNs are being widely used in the field of multivariate time-series prediction [6, 19, 50].

Despite the above mentioned advantages, the setting of ESN parameters, such as input-variable selection and reservoir-parameter initialization, is still an open issue [8]. Several problems exist,

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