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Synergy of Embedding Theorem and Optimized Neural Network Using Taguchi's Design of Experiment in Time Series Forecasting*

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Abstract

Takens' embedding theorem and artificial neural networks have been utilized to develop a technique to forecast seasonal time series. Embedding parameters as well as neural network parameters are selected using Taguchi's design of experiment method rather than trial and error. As a pre-step to Taguchi's design of experiment, Genetic Algorithm is applied to determine neural network's weights and biases and reduce the variability of the outputs of neural networks which occur due to random selection of initial weights and biases. The integration of embedding theorem and neural networks and improving the forecasting technique utilizing Genetic Algorithm and Taguchi's Design of Experiment provide a robust tool to effectively forecast time series with seasonality. The validity of introduced technique is examined by applying it to a real life seasonal time series. Based on the obtained results, the proposed technique produces better result, in the examined case, compared to Auto-Regressive Moving Average method.

Keywords: Forecasting, Artificial intelligence, Seasonal time series, Embedding theorem, Taguchi's design of experiment

1 Introduction

Some researchers have employed Artificial Neural Networks (ANN) to forecast deterministic time series. However, ANN does not provide satisfactory and effective results in direct forecast of complicated time series [1]. ANN is mainly suitable for prediction of systems whose solutions require knowledge that is difficult to specify but there are enough data or observations. To enhance the performance of ANN in forecasting complex time series, Takens' [2] Embedding Theorem can be utilized as pre-processing step to overcome the limitations of ANN in forecasting non-stationary and seasonal time series effectively.

Embedding theorem was first introduced by Takens [2] to extract the hidden information from apparently random data called chaotic time series. The key elements of Takens' embedding theorem is reconstructing the time series into a D-dimensional vector series with two parameters called the time delay (T) and dimension (D). Takens' theorem states that, if D is large enough, the vector series reproduces many of the important dynamical characteristics of the original series [3]. The reconstructed time series using embedding theorem can be fed into ANN as input and the trained network can be used for forecasting purposes.

Although much research in the area of ANN has been concentrated on developing ANN models and training algorithms to improve the accuracy and convergence of the models, there is still a conventional problem in ANN design. Determining a suitable set of structural and learning parameters values for an ANN still remains a difficult task; users have to choose the architecture and determine many of the parameters in a selected network by trial and error [4, 5]. Also, it is shown from the results of other researchers that there is not an exact method to determine the embedding parameters which are the best values to reconstruct a time series [6].

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