HYBRID NEURAL NETWORK–PARTICLE SWARM ALGORITHM TO DESCRIBE CHAOTIC TIME SERIES

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Abstract: An artificial neural network (ANN) based on particle swarm optimization (PSO) was developed for the time series prediction. This hybrid ANN+PSO algorithm was applied on Mackey–Glass series in the short-term prediction $x(t+6)$ and the long-term prediction $x(t+84)$, from the current value $x(t)$ and the past values: $x(t-6)$, $x(t-12)$, $x(t-18)$. Four cases were studied, alternating the time-delay parameter as 17 or 30. Also, the first four largest Lyapunov exponents were obtained for different time-delay. Simulation shows that this ANN+PSO method is a very powerful tool for making prediction of chaotic time series.

Key words: *Chaotic time series, time series prediction, Mackey–Glass series, artificial neural network, particle swarm optimization*

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1. Introduction

Chaotic time series are an important research and application area. Several models for time series data can have many forms and represent different stochastic processes. The prediction of time series is one of the most important aspects for the practical usage of scientific and engineering knowledge, including physical science. In the last decades many different techniques have been developed for the prediction of time series based on artificial neural network (ANN) models that includes back-propagation algorithm [16], radial basic function [7], recurrent network [26], genetic algorithms [24], fuzzy system application [14], and wavelet approach [6].

Time series contain much information about dynamic systems [12]. These systems are usually modeled by delay-differential equations. Some of them, for example, the Mackey–Glass equation [22], the Ikeda equation [13], and equation for an electronic oscillator with delayed feedback [9], are standard examples of time-delay systems [3].

The principal problem of the time series study consists of predicting the next value of a series known up to a specific time, using the known past values of the

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