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701 E. Chocolate Avenue, Suite 200, Hershey PA 17033-1240, USA
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Chapter III

Time Series Forecasting by Evolutionary Neural Networks

Paulo Cortez, University of Minho, Portugal

Miguel Rocha, University of Minho, Portugal

José Neves, University of Minho, Portugal

Abstract

This chapter presents a hybrid evolutionary computation/neural network combination for time series prediction. Neural networks are innate candidates for the forecasting domain due to advantages such as nonlinear learning and noise tolerance. However, the search for the ideal network structure is a complex and crucial task. Under this context, evolutionary computation, guided by the Bayesian Information Criterion, makes a promising global search approach for feature and model selection. A set of 10 time series, from different domains, were used to evaluate this strategy, comparing it with a heuristic model selection, as well as with conventional forecasting methods (e.g., Holt-Winters & Box-Jenkins methodology).

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Introduction

Nowadays, the fierce competition between individuals and organizations is a trademark of modern societies, where the gain of strategic advantages may be the key to success. The ability to forecast the future, based on past data, makes an important leverage that can push organizations forward. *Time series forecasting*, the forecast of a time ordered variable, is an important tool under this scenario, where the goal is to predict the behavior of complex systems solely by looking at patterns in past data. Indeed, an increasing focus has been put over this field. Contributions from the arenas of *operational research*, *statistics*, and *computer science* has led to solid forecasting methods that replaced intuition, such as the *Holt-Winters* (Winters, 1960) and *Box-Jenkins* (1976) methodology. However, these models were developed decades ago, where higher computational restrictions prevailed. Although these methods give accurate forecasts on linear time series, they carry a handicap with noisy or nonlinear components (Shoneburg, 1990), which are common in real-world situations (e.g., financial data).

An alternative approach for time series forecasting arises from the use of *artificial neural networks*, connectionist models inspired in the behavior of the central nervous system, being attractive artifacts for the design of intelligent systems in *data mining* and *control* applications. In particular, the *multilayer perceptron* is the most popular neural architecture, where *neurons* are grouped in *layers* and only *forward connections* exist, providing a powerful base-learner with advantages such as nonlinear learning and noise tolerance (Haykin, 1999). Indeed, the use of multilayer perceptrons for time series modeling began in the late 1980s and the field has been consistently growing since (Lapedes & Farber, 1987; Cortez, Rocha, Machado, & Neves, 1995; Huang, Xu, & Chan-Hilton, 2004).

The interest in multilayer perceptrons was stimulated by the advent of the *back-propagation* algorithm in 1986, and since then several fast variants have been proposed, such as the *RPROP* algorithm (Riedmiller, 1994). Yet, these training procedures minimize an error function by tuning the modifiable parameters (or *weights*) of a fixed architecture, which needs to be set a priori. Moreover, the neural performance will be sensitive to this choice: A small network will provide limited learning capabilities, while a large one will overfit the training data, inducing generalization loss.

The neural network topology (i.e., connectivity) design is a complex task, commonly addressed by simple trial-and-error procedures (e.g., by exploring a different number of hidden nodes), in a *blind* search strategy that only goes through a small set of possible configurations. More elaborated methods have been proposed, such as the *pruning* (Thimm & Fiesler, 1995) and *constructive* (Kwok & Yeung, 1999) algorithms, which present an effort toward an automatic neural design. However, these *hill-climbing* procedures present two major drawbacks: They tend to get trapped into local minima, and they search through a small portion of architectures, rather than the entire search space.

A different alternative is offered by *evolutionary computation*, which denotes a family of computational procedures inspired in the process of natural selection. The evolutionary algorithms are innate candidates for optimization tasks, performing a global multi-point (or *beam*) search, quickly locating areas of high quality, even when the search space

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