A Hybrid Forecasting Model for Non-Stationary Time Series: An Application to Container Throughput Prediction

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ABSTRACT

In time series analysis, an important problem is how to extract the information hidden in the non-stationary and noise data and combine it into a model for forecasting. In this paper, the authors propose a TEI@I based hybrid forecasting model. A novel feed forward neural network is developed based on the improved particle swarm optimization with adaptive genetic operator (IPSO-FNN) for forecasting. In the proposed IPSO, inertia weight is dynamically adjusted according to the feedback from particles’ best memories, and acceleration coefficients are controlled by a declining arccosine and an increasing arccosine function. Subsequently, a crossover rate which only depends on generation and an adaptive mutation rate based on individual fitness are designed. The parameters of FNN are optimized by binary and decimal particle swarm optimization. Further, the forecast results of IPSO-FNN are adjusted with the knowledge from text mining and an expert system. The empirical results on the container throughput forecast of Tianjin Port show that forecasts with the proposed method are much better than some other methods.

Keywords: Container Throughput Forecasting, Feedforward Neural Network (FNN), Genetic Operators, Particle Swarm Optimization, TEI@I

INTRODUCTION

With the rapid growth of international trade, containerization plays a more and more important role. The cost of port construction is sunk cost. It is very difficult for the port to change its application once the construction has finished. Therefore, to avoid waste, accurate forecast of throughput for a port is of crucial importance for its construction, investing and management. In general, there are two methods for port throughput forecasting: qualitative and quantitative. Qualitative methods, e.g., Delphi method and expert meetings, forecast the future development of the object mainly depending on the experts’ experience, knowledge and analytical skills. Quantitative methods usually establish mathematical forecasting models.
based on historical statistical data. Since the latter are more objective and precise, they have gotten more and more attentions. According to the difference of the throughput quantitative forecast methods, they can be divided into three categories: time series, causal analysis and combination forecasting. Time series methods, establishing a mathematical model only by throughput historical data, include autoregressive integrated moving average model (ARIMA), exponential smoothing, gray system method, seasonal adjustment method, etc. (Chen & Chen, 2010). Causal analysis methods examine the correlation between the throughput and a series of economic indicators of port hinterland, and build a forecasting model according to the relevant economic indicators. At present, such methods include regression analysis, the elasticity coefficient method, system dynamics, etc. (Peng & Chu, 2009). However, there is no one technology or method that is able to consistently outperform under any conditions. In this context, Wang et al. (2005) proposed the TEI@I methodology integrating qualitative and quantitative analysis, which has been successfully applied in an increasingly number of areas owing to its high forecast effectiveness.

In monitoring the changes in seasonal patterns and business cycles, short-term forecasts often yield better results than long-term forecasts (Franses & Van Dijk, 2005). However, it is not easy to forecast short-term throughput due to their typical non-stationarity and noise. The difficulty in forecasting throughput is usually attributed to the limitation of many traditional forecasting models, which has encouraged academic researchers and business practitioners to develop more effective forecasting models. In this case, the artificial intelligence models such as artificial neural network (ANN) have been recognized as more useful than traditional statistical forecasting models. For example, Lam et al. (2004) proposed and developed the neural network models for forecasting 37 types of freight movements of Hong Kong port cargo throughput, and it is shown that the forecasting results are more accurate compared with that of regression analysis. However, the researches in throughput forecasting area are still relatively little.

As we all know, neural networks are a kind of unstable learning methods. Even for some simple problems, different structures of neural networks (e.g., different number of hidden layers, different hidden nodes and different initial conditions) result in different patterns of network generalization. For the neural network design, the key is how to determine the various parameters which can solve an actual problem based on a performance evaluation criteria. However, it is difficult to design a neural network when the problem is particularly complex because there is few rigorous design criteria. Thus, it requires efficient automatic design methods for ANN with the development of macro-scale and complexity.

In different ANN models, the feedforward neural network (FNN) is the most widely used one. Evolutionary computation algorithms are demonstrated to be suitable for the optimization in FNN (Liu & Wang, 2011). As a popular evolutionary computation paradigm, the particle swarm optimization (PSO) utilizes a “population” of candidate solutions to evolve toward an optimal or near optimal solution of an actual problem (Kennedy & Eberhart, 2001). Because of its features of simplicity, easy implementation, and quick convergence, PSO has attracted more and more researchers and been applied extensively to various fields (Kuo & Han, 2011).

Despite of its success and popularity, PSO cannot improve the quality of the solutions as the number of iterations increases. Hence, a premature phenomenon may occur for the standard PSO, especially in optimizing complex multi-objective functions (Wei et al., 2009). Therefore, many improved PSO algorithms have been proposed. For example, Alfi and Modares (2011) presented a methodology for finding optimal system parameters and optimal control parameters by a novel adaptive particle swarm optimization (APSO) algorithm. Wang and Shoup (2011) proposed a poly-hybrid PSO optimization method with intelligent parameter adjustment.
Comparative Study of Classification Models with Genetic Search Based Feature Selection Technique

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