Expert Systems with Applications 37 (2010) 6695–6704

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

Applying Moving back-propagation neural network and Moving fuzzy-neuron network to predict the requirement of critical spare parts ☆

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ARTICLE INFO

Keywords:
Moving back-propagation neural network
Moving fuzzy-neuron network
Critical spare part
Prediction

ABSTRACT

The critical spare parts (CSP) are vital to machine operation, which also have the characteristic of more expensive, larger demand variation, longer purchasing lead time than non-critical spare parts. Therefore, it is an urgent issue to devise a way to forecast the future requirement of CSP accurately.

This investigation proposed Moving back-propagation neural network (MBPN) and Moving fuzzy-neuron network (MFNN) to effectively predict the CSP requirement so as to provide as a reference of spare parts control. This investigation also compare prediction accuracy with other forecasting methods, such as grey prediction method, back-propagation neural network (BPN), fuzzy-neuron networks (FNN). All of the prediction methods evaluated the real data, which are provided by famous wafer testing factories in Taiwan, the effectiveness of the proposed methods is demonstrated through a real case study.

1. Introduction

The spare parts management plays an increasingly important role in factories. It not only directly influences the equipments operation and yields rate, but also influences the slack risk and inventory level. Therefore, spare parts management has always been the part that managers focus on. The spare parts can be classified into critical and non-critical, according to the criticality of the production machine.

The critical spare parts (CSP) are considerably expensive, and the price can be thousands dollars. The CSP also have the characteristics of huge demand variation, long purchasing lead time, and necessary for machine operations. When the machine works, the production efficiency would be reduced due to the decay and abrasion of CSP. If the number of CSP is insufficient to supply the production machine, it would be has low yield or break down, therefore the factories may face the extra costs and risks. However, to predict the demand of CSP accurately is a complicated issue, not only have to consider the quantity of work orders, but also have to deliberate about other unpredictable factors, including the quality problem of CSP or misusage. Therefore, it is crucial issue for enterprise to predict the demand of CSP accurately.

To solve this problem, this investigation proposed two forecasting methods in order to predict future CSP requirement accurately, one is Moving back-propagation neural network (MBPN) and another is Moving fuzzy-neuron network (MFNN). This investigation also compare prediction accuracy with other forecasting methods, such as grey system, back-propagation neural network (BPN), fuzzy-neuron networks (FNN), moving average method (MA). All of the prediction methods evaluated the real data, which are provided by famous wafer testing factories in Taiwan, the effectiveness of the proposed methods is demonstrated through a real case study.

This paper is organized as follows: Section 2 gives an overview of related literatures on the spare parts demand forecasting and inventory management. Section 3 illustrates the methodologies of this study to solve the prediction problem. Section 4 presents a case study and demonstrates the workability of our proposed method. Then the conclusion will be presented in Section 5.

2. Literatures review

Although the prediction of spare parts consumption is important in industries, researches focus on requirement prediction of spare parts are still very few, there are not many study concentrate in the requirement prediction of CSP. Investigations on semiconductor industries are even fewer. In general, there is no appropriate forecasting model for predicting the requirement of critical spare parts.

Prakash, Ganesh, and Rajendran (1994) evaluated the criticality of spare parts through the analytic hierarchy process (AHP) method, and they also categorized the parts through different

DOI of original article: 10.1016/j.eswa.2009.11.092

☆ Please note that this article was previously published in a recent regular issue [ESWA 36/7, Pages 4358–4367], this is the correct article and it is now published. Please use the original article for citation. The author regrets any inconvenience that this may cause.

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doi:10.1016/j.eswa.2010.04.037

partitioning techniques, including the ABC analysis, the fast, slow and the non-moving items (FSN) analysis, and the vital, essential and desirable (VED) analysis.

Kabir and Al-Olayan (1996) constructed a simulation model to determine the appropriate inventory level of spare parts and minimize the overall cost of inventory. Dekker, Kleijn, and Rooij (1998) indicated that spare parts can be divided into critical and non-critical demand, and they also developed a stocking policy with a deterministic lead time of replenishment, which is evaluated by simulation. Ghobbar and Friend (2003) applied 13 forecasting techniques to forecast the spare parts requirement of airline fleets, they also present a predictive error-forecasting model to deal with the inventory problem with intermittent demand.

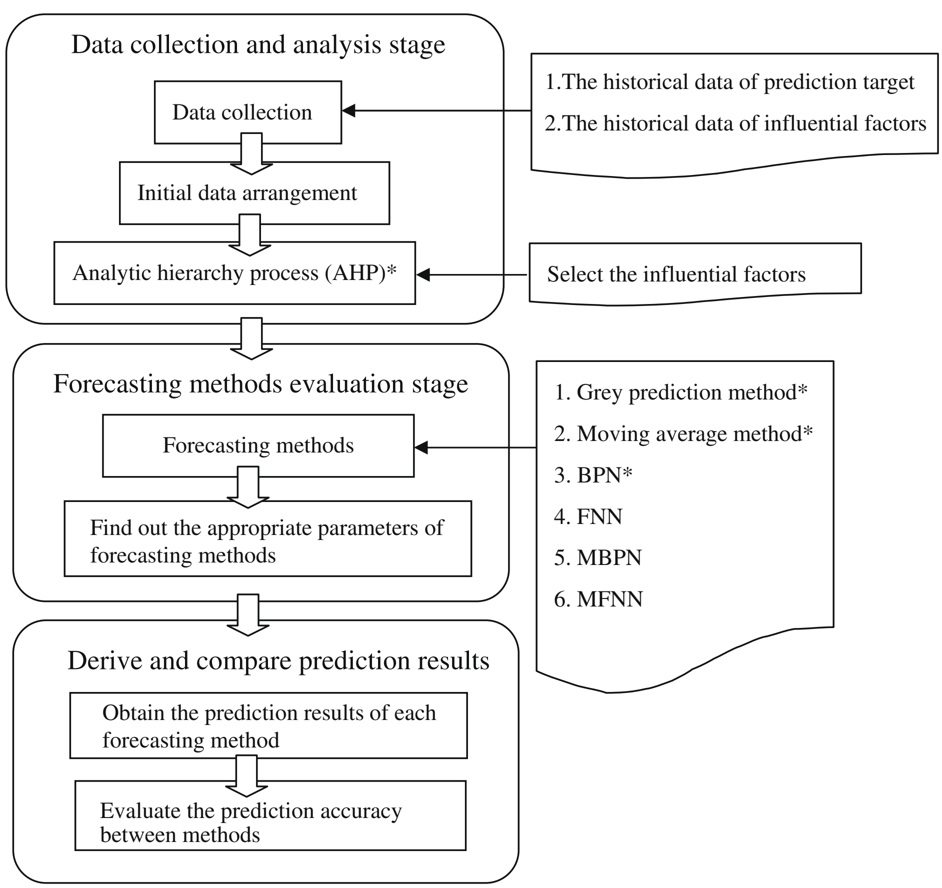
Aronis, Magou, Dekker, and Tagaras (2004) applied the Bayesian method to determine the stock levels among several locations and decide the distributions of spare parts. Caglar, Li, and Simchi-Levi (2004) constructed a mathematical model to solve the spare parts inventory problem, which can reduce the inventory cost under the limit response time. Hua and Zhang (2006) applied support vector machines to forecast the lead time of spare parts, and the actual data of 30 kinds of spare parts was collected from a enterprise of China.

Li and Kuo (2008) focused on the automobile spares parts inventory in a central warehouse, they proposed an enhanced fuzzy neural network (EFNN), which applied fuzzy AHP to determine the factor's weights, and generated and refined activation functions according to genetic algorithm. The results are then input to the neural networks for training and analysis. Chen and Chen (2009) applied the BPN, moving average method, and grey prediction method to forecast the demand of CSP, the results indicated that the grey prediction method has better prediction performance than BPN and moving average method.

Based on the above studies, the researches often concentrate in the cost of inventory and the lead time prediction of spare parts. The studies concentrate in the requirement prediction of CSP is very few. If the manager can forecast the requirement of CSP accurately, the inventory and cost problem may be under control. Hence, this investigation proposed Moving back-propagation neural network (MBPN) and Moving fuzzy-neuron network (MFNN) to predict the requirement of critical spare parts accurately, improving the efficiency of purchasing and inventory control.

3. Methodology

Several methodologies have been adopted to predict the desired target in different field, and the BPN and the grey prediction method have outstanding forecasting performance in many issues. Lin and Yang (2003) utilized the grey prediction model to forecast the output of opto-electronics industry in Taiwan. Ansuj, Camargo, Radharamanan, and Petry (1996) applied BPN and time-series methods to forecast marketing behaviors, and result demonstrated the BPN has superior forecasting accuracy than time-series methods. Sheu and Kuo (2006) utilized the grey prediction method to accurately predict the period of preventive maintenance in the semiconductor factories. Law (2000) used the feed-forward neural network, statistical regression, and time-series methods to predict the tourism demand, and the result shows that the BPN has better performance than other methods.



The methodologies marked with* has revealed in the Chen and Chen's study (2009)

Fig. 1. Research framework.