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A decision support system for order selection in electronic commerce based on fuzzy neural network supported by real-coded genetic algorithm

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Abstract

This research attempts to develop a decision support system for order selection. The proposed system is able to integrate both the quantitative and qualitative factors together. For the qualitative factors, the fuzzy IF–THEN rules are summarized from the questionnaire survey for the production experts and learned by a proposed fuzzy neural network (FNN) with initial weights generated by real-coded genetic algorithm (GA). Then, a feedforward artificial neural network (ANN) with error back-propagation (EBP) learning algorithm is employed to integrate the above two parts together. Both the simulation and real-life problem provided by an internationally OEM company results show that the proposed FNN can well learn the fuzzy IF–THEN rules. In addition, real-coded GA is proved to be better than the binary GA both in speed and accuracy. Considering both the quantitative and qualitative factors has more accurate results compared with considering only the quantitative factors.

Keywords: Order selection; Electronic commerce; Artificial neural networks; Fuzzy neural networks; Real-coded genetic algorithm

1. Introduction

The improvement of information technology and the introduction of Internet, have made the world community so close like the neighborhood. This causes that the business model became completely different from what we were familiar with. Most of the companies can reach any place around the world only through a 'mouse click'. Such an environment makes EC possible, which aims to achieve the quick response for all the customers. For supply chain management (SCM), which is a part of electronic commerce (EC), in order to enhance the commercial competitive advantage in a constantly fluctuating environment for all the supply chain partners, the managers of an organization must make the right decision in time depending on the information from the upper or lower stream companies. However, the decision lead-time ranges from several years to several hours based on the types of business. Thus, making an accurate decision in time plays a prominent role in EC.

Among the decisions critical to the managers, available-to-promise is supposed to be the first as well as the most significant decision. Conventional approach depends on the experience of production managers and the decision is made manually. Thus, how to automatically accept, or reject, the orders coming from all over the world becomes a tough job for the production managers in SCM, since each order posses its own characteristics. Not all the orders have the same contributions to the company. In order to overcome this practical problem by providing the production managers a real-time solution, this research intends to summarize the experiences of production experts on order selection as the fuzzy IF–THEN rule base. Then, they are combined with the quantitative factors via an ANN.

Therefore, this research is dedicated to developing a decision support system for order selection. The proposed system is composed of (1) quantitative factors collection, (2) fuzzy IF–THEN rules based model, and (3) decision integration model. The quantitative factors include profit, capacity, due date, and inventory, while the fuzzy IF–THEN rules are summarized from the questionnaire survey for the production experts and learned by a proposed FNN with initial weights generated by real-coded GA.

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Nomenclature

p	the sample number
X_p	the input vector of sample p
T_p	the target vector of sample p
O_{pk}	the output of kth output node
O_{ph}	the output of hth hidden node
W_{ih}	the connection weight from ith input node to hth hidden node
W_{hk}	the connection weight from hth hidden node to kth output node
Net_{pk}	the net internal activity level of kth output node
Net_{ph}	the net internal activity level of hth hidden node
Θ_j	the bias of jth output node
E_p	the cost function for sample p
E_{ps}	the cost function of s-level's α-cut set for sample p
E^{L}_{pks}	the cost function of the lower boundary for s-level's α-cut set of sample p
E^{U}_{pks}	the cost function of the upper boundary for s-level's α-cut set of sample p
$\bar{X}_p$	the fuzzy input for sample p
$\bar{O}_p$	the fuzzy output for sample p
$\bar{W}_{ih}$, $\bar{W}_{hk}$	the fuzzy weights
$\bar{\Theta}_h$, $\bar{\Theta}_k$	the fuzzy biases
η	the learning rate
α	the momentum term
$^{*}[\alpha]^{L}$, $^{*}[\alpha]^{U}$	the lower limit and the upper limit of the α-cut of fuzzy number

Then, the results from the above two parts are integrated through a feedforward ANN with EBP learning algorithm.

The simulation results showed that the proposed FNN could well learn the fuzzy IF–THEN rules provided by the production experts. In addition, real-coded GA is proved to be better than the binary GA both in speed and accuracy. The real-life problem for an internationally well-known OEM (Original Equipments Manufacturing) company, which manufactures the car lamps for most of car companies, like GM and Ford, illustrates that considering both the quantitative and qualitative factors has more accurate results compared with the results obtained by only considering the quantitative factors. Besides, the proposed system outperforms multiple regression model in precision.

The rest of this paper is organized as follows. Section 2 provides some necessary background information while the proposed system is discussed in Section 3. Section 4 presents the simulation results of FNN, while the evaluation results for real-life problems are summarized in Section 5. Discussion and concluding remarks are made in Sections 6 and 7, respectively.

2. Background

This section briefly reviews the general backgrounds necessary for the current study. Basically, the role of order selection in EC and SCM is first introduced. Then, the FNNs as well as GAs are discussed in sequence.

2.1. Order selection in electronic commerce

Internet has made a great change on business model due to increasing application of EC in recent years. Basically, EC emphasizes on flexibility, customization, and customer service. In order to achieve these goals, every organization is dedicated to adjusting their transaction and decision models. Among them, order management remains the first step in EC. Conventionally, order management cycle consists of eight steps as shown in Fig. 1 (Kalakota & Whinston, 1998). The most difficult part is the order selection, which is also critical to the SCM. From a structural standpoint, a supply chain refers to the complex network of relationships that organizations maintain with trading partners to source, manufacture, and deliver products. A company's supply chain encompasses the facilities where raw materials, intermediate products, and finished goods are acquired, transformed, stored, and sold (Bowersox, Closs, & Helferich, 1986).

A lot of build-to-order companies, can no longer constantly estimate the order types due to high degree of customization requirements. The characteristics of the orders are significantly different from the others. Thus, how to select the order with best characteristics becomes critical and difficult. This is especially important for the manufacturers. Towill (1996) mentioned that receiving the order or not was very significant to the organization, which might reduce the customer satisfaction if orders are over received. Gelenbe and Pujolle (1987) also revealed the same question for Integrated Circuit industry. Handfield and Nichols (1999) in their book, Introduction to Supply Chain Management, presented some more efficient technologies for decision support system in SCM. Available-to-promise is also included. Therefore, whether the organization can make the order selection in a few minutes or cannot become a competitive advantage. Otherwise, accepting the orders without considering conditions of the organization may not only cause a reduction in the profit but also the customer satisfaction. Thus, SCM should be able to make the decision based on the information it has in the database. It not only can make the quick response of inventory and capacity but also available-to-promise.

2.2. Fuzzy neural networks

Though there have been several FNNs being proposed like (Jang, 1991,1992; Jang & Sun, 1993) which presented