Association for Information Systems

AIS Electronic Library (AISeL)

ICEB 2004 Proceedings

International Conference on Electronic Business (ICEB)

Winter 12-5-2004

Monitoring the Supply of Products in a Supply Chain Environment: a Fuzzy Neural Approach

Chunling Liu

Bo Meng

Jizi Li

Monitoring the Supply of Products in a Supply Chain Environment: a Fuzzy Neural Approach

Chunling Liu [1], Bo Meng [1], Jizi Li [2]

[1]Computer School, Wuhan Universijy, Wuhan 430072, China
[2]school of Economics & Management, Wuhan University of Science & Technology, Wuhan 430073,China
liuchunring@yahoo.com

ABSTRACT

The fuzzy logic is applied to resolve the monitoring problem of products quality and products quantity increasingly varying as market requirement. A series of fuzzy rules are employed and the fuzzy system may generate suggested supply change rate. At the same time, the operation of supplier is also dynamically changing and the evaluation and selection for supplier are the basis of supply –chain co-operation. So whether it is scientific to select a supplier is crucial for sustaining and developing a company. Therefore, in this paper the neural network is introduced to dynamically assess suppliers and recommend to substituting for new ones when necessary, only supplementing fuzzy logic system with its advantages. This paper describes the methodology for the deployment of this proposed hybrid approach to enhance the machine intelligence of a supply chain network with the description of a case study to exemplify its underlying principles.

Keywords: *supply chain, product monitoring, fuzzy logic, neural network*

1. INTRODUCTION

It has been found by statistics that the top criteria of enterprises selecting suppliers are product quality. In other words, how the output products quality be is vital for a company's sustaining. With the variation of required output products quality and quantity, it is essential to decide the supply quality and quantity. Thereby, monitoring the supply products quantity and quality in a supply chain is a crucial factor for company to win competency and consolidate the supply chain.

An efficient supply chain network needs to have the capability of assessing the performance among various business partners, thereby enabling the effective selection of enterprise members to form a alliance for certain value chain activities such as the provision of certain products to a certain marketplace. In this respect, every partner contributes its core capability to the alliance in its certain dominant field. So the alliance members may make up for the demerits commutatively to cope with the increasingly complex setting of organizations and markets.

As such a 'smart' approach which allows a company to assess and to select business partners to jointly undertake a business project with the focus on customer demands is critical to leverage the operational performance of the network. To tackle the issue, a product monitoring approach is discussed in details in this paper and the monitoring problem for required products quality and quantity is analyzed based on the real time market, and meanwhile developed the performance assessment and selection suggestion of business partners focusing on fuzzy logic principle and neural network training. In short, the hybrid scheme which takes full advantages of the two reciprocal intelligence technologies, will support the whole supply chain network to compute the updated performance scores of candidate supplier partners, hereby comprehensively evaluate and select supplier partners and, subsequently, recommend of the exact quantity of supply goods for various partners. In order to further the proposed approach, an example is cited to fully demonstrate the feasibility of implementing the suggested methodology.

2. ASSOCIATED RESEARCH

Fuzzy logic is a problem-solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded micro-controllers to large, networked, multi-channel PCs of workstation –based data acquisition and control systems (Kaehler,1998). In other words, it is a method of reasoning that allows a fuzzy description of very flexible rules. But it must be sure that fuzzy logic does not mean fuzzy answers for only the reasoning process is set on vague terms. In fact, many objects and method to need decision and choice in the real world are hard to describe by discrete mathematic module. Fuzzy rules probed a methodology for dealing with the gray areas that involve fuzzy concepts. By allowing rules to have blurry boundaries rather than sharp ones, rules are more flexible, compact and intuitive for modeling complicated processes whose components cannot be clearly separated into categories. Fuzzy logic system involves information fuzzification, fuzzy reasoning and defuzzification. Therefore, as stated above, fuzzy logic does not mean fuzzy answers. Indeed, a discrete answer will be generated through the process of data fuzzifying, fuzzy reasoning and crisp computation.

In general, the knowledge exists plainly in a fuzzy-logic system that has the advantage of compact, intuitive in algorithm and low in data quantity of processing. However, fuzzy reasoning sacrifices some explanation for accuracy, reliability and compactness, and often cannot explain how outputs change in response to inputs. Fuzzy rules are usually established on field experts and the basis of factual experiments. However, these experts may not be able to state their decision-making process in detail and it may not be feasible and economical for the experts to be around all the time.

In contrast with fuzzy logic, neural networks can be used with data promising results where there are data, even without experts to make judgments about the data. They were found to be very useful at modeling large amounts of data that help to solve complex problems. Indeed, neural networks can be powerful for problem solving because of their predict-compare-adjust process by which the result is next to optimum.. In brief, neural network systems have great self-adjusting and self-studying ability and full parallel character in structure. However, knowledge is stored at net nods in the course of NN processing, therefore, NN system is difficult to describe itself specifically, large in quantity of information processing and much complicated in structure.

As stated above, the two intelligent technologies both have merits and defects. So a hybrid approach which focuses on the fuzzy logic scheme with the addition of the neural network technology will enable the two to complement and supplement each other with their own advantages. However, this research domain in which the synthetic approach is applied to support of a complex supply chain network has not received the attention it deserves. This paper attempts to provide some insights for the framework with a demonstration to show its feasibility.

3. THE FUZZY LOGIC APPROACH OF MONITORING PRODUCTS SUPPLY

3.1 Adapted background

The paper is focused on procurement-quantity allocation policy of goods supplied for distribution center prior to selling to the public. But the scheme proposed is also adapted for the problem of procurement-quantity allocation among suppliers in the process of products procurement of enterprises, given the total required quantity and sure quality.

Products quality is variable with the different suppliers in a complex supply chain environment and the different allocation of products supply quantities among them will lead to the fluctuation of the output products quality. In real supply situation, the overall products quantity and quality required in the distribution center are ever-changing in corresponding with real-time market dynamically. Since the change rate of these data is often vague , the products quantity allocated for suppliers is also blurry. Therefore, fuzzy logic system applied for thus complex supply situation may provide the validity of decision-problem-solving. In the following, the paper offers a simplified scenario of actual circumstances that only involves two suppliers. This case demonstrates that the fuzzy logic approach can deal with this situation and the same approach can be applied to multiple suppliers.

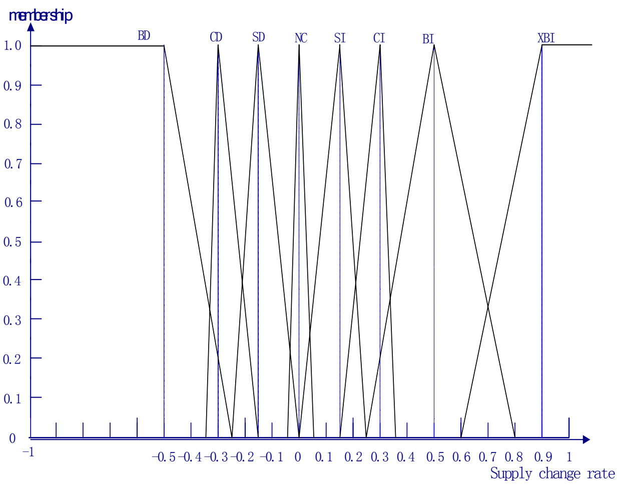

Figure 1: fuzzy pattern of supply change

3.2 Establishment of fuzzy rules

Product quality is variable with the different suppliers in a complex supply chain environment and the different allocation of product supply quantities among them will lead to the fluctuation of the output product quality. On the other hand, the product supply quantities of suppliers vary with every of the two criteria that mean product quality and quantity required by enterprises. In order to provide suggestion supply change rate, a series of fuzzy rules are created to monitor the overall quality and quantity of the supplying products. The fore wares and post wares of rules both encompass fuzzy terms. For example,

If (the overall product quality can be considerably improved and the overall quantity can be significantly increased) Then (Maintain the supply of company-B and increase the supply of company-A significantly)

The meaning of the above fuzzy rule is plain. As the product quality can be considerably improved, i.e. the product quality is considerably lower than the market can appreciate, it is acceptable to supply more units from company A (higher quality supplier), and maintain the quantity of supplier B (lower quality supplier), thereby increasing the overall product quantity at the same time.

Output quality	Output quantity	Suppl-ier A	Suppl-ier B	Output quality	Output quantity	Suppl-ier A	Suppl-ier B
I	L	XBI	NC	OK	CH	SD	SD
I	CL	BI	SD	OK	H	CD	CD
I	OK	BI	CD	CS	L	NC	BI
I	CH	CI	CD	CS	CL	NC	CI
I	H	CI	BD	CS	OK	SD	SI
CI	L	CI	SI	CS	CH	SD	NC
CI	CL	CI	NC	CS	H	CD	NC
CI	OK	CI	SD	S	L	SD	XBI
CI	CH	SI	SD	S	CL	CD	XBI
CI	H	SD	CD	S	OK	CD	BI
OK	L	CI	CI	S	CH	CD	CI
OK	CL	SI	SI	S	H	BD	CI

Table 1:Control rules of supply change rate

The fuzzy rules that the actual output products quality and quantity vary as market requirement can be found in Table 1. One of the fore wares, the output product quality is divided into five degrees in fuzzy pattern which are inferior (I), considerably inferior(CI), ok(OK), considerably superior(CS), superior(S). The other fore wares, the output product quantity is also divided into five degrees in fuzzy pattern which are low (L), considerably low (CL), ok (OK), considerably high(CH), high(H). Additionally, the supply change rate of suppliers is fuzzified as 8 degrees that are extendedly-big increase (XBI), big increase (BI), considerably increase (CI), small increase (SI), no

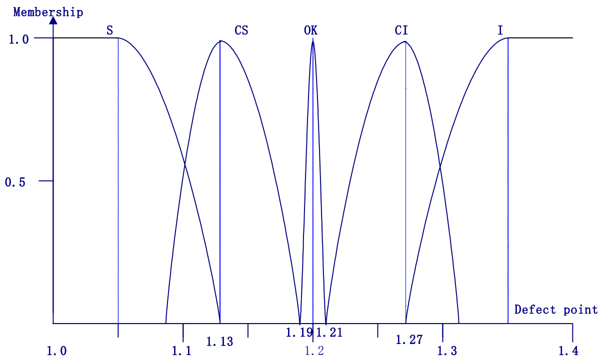

Figure2 : Fuzzy set for output quality

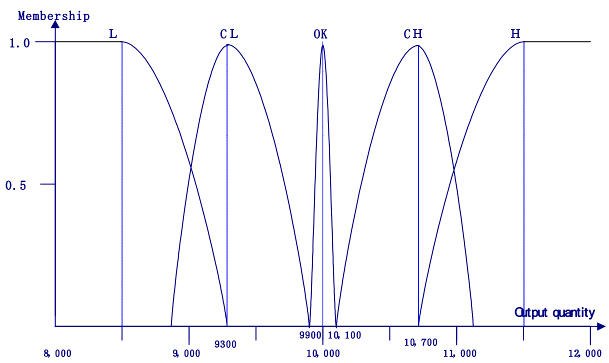

Figure 3: Fuzzy set for output quantity

change (NC), small decrease(SD), considerably decrease(CD), big decrease(BD). The fuzzy rules based on Table 1 may be created in fuzzy-CLIPS, For example,

(defrule quality-inferior-quantity-considerable-low)
(output-quality inferior)
(output-quantity considerable low)
⇨
(supplier-A BI)
(supplier-B SD)

Figure 1 shows the fuzzy pattern of supply change rate. It is stated that these data are determined on the basis of field knowledge and past experience.

3.3 Fuzzification and fuzzy reasoning

It is assumed that products quality of supplier A and B is examined by defect point (DP). And the DP of supplier A and B is separately 0.8 and 1.5. Any single quality-problem such as color mismatch of a certain component or malfunction of a certain feature can be regarded as a DP. It is key for seeking optimum allocation rate of supply goods among suppliers, when it is targeted for reaching the best price and maintaining quality level as high as possible. In this case it is promised that the integrated quality level is 1.2DP, and the promising output quantity is 10000 per day. The current supply quantity of supplier A is 4150 per day, while that of supplier B is 3850 per day. Then the overall output quality (Q_0) of the combined product is (4150*0.8+3850*1.5)/(4150+3850)=1.14DP.

That is to say the actual output quality is 1.14DP while the required quality output is 1.2DP. Referring to Figure 2, the measured value should be categorized as considerably superior quality through fuzzified analysis by the fuzzy expert systems. In the same way, the current overall products quantity is 8000 per day, belonging to low quantity (L) in fuzzy sets (Figure 3).

The conclusion through reason by fuzzy rules (Table 1) after fuzzifying the actual output figures is maintaining the supply quantity of supplier A (NC), while significantly increasing that of supplier B(BI).

3.4 Defuzzified process

Fuzzy logic is a process that involves data fuzzification, fuzzy reasoning, fuzzy decision and, clarifying linguistic values. In order to achieve a crisp value for the problem, the next step is to defuzzify the results generated from the fuzzy interference process by applying a single discrete action. Crisping computation is also known as defuzzification process referring to transforming a fuzzy set to a crisp value.

Defuzzification can be done with several methodologies, such as mean of maxima, center of area and mean of increasing gravity. As for all methods, there are advantages and drawbacks with each. However, whichever of those you choose, special attention and consideration should be paid to the company's constraints on the system. The details of each method can be found easily on some references and will not be discussed again here. Referring to Figure 1, if the mean of maxima is considered, the supply change rate of supplier B is 0.5(BI in fuzzy set), while that of supplier A is no change (NC in fuzzy set). Therefore, the new supply quantity of supplier B is 3850+3850*1.5=5775

3.5 Evaluating the final results

The new overall products quantity after adjusting the supply of supplier B is

4150+5775=9925

The new overall products quality is

(4150*0.8DP+5775*1.5DP)/9925=1.206DP

From Figure 2 and Figure 3, it is not seen that the new output results are both within the OK level. The fuzzy sets are concretely classified in the paper with a view to achieving propel output result after one fuzzy resolving procedure. However, if the new supply quality is out of the OK range, another mending rule will be fired to obtain the appropriate output values.

4. ASSESSING SUPPLIER DYNAMICALLY WITH NN NETWORKS

4.1 modeling

Artificially neural network (NN) is a complex net system broadly interconnected by a great deal of simple processing cells (neural cells). The neural network which mimics many foundational functionalities of human brain is also a highly complicated nonlinear dynamic system. NN is especially adapted to deal with indiscrete and linguistic information-processing problem required for giving a thought to great many of factors and conditions at the same time, because of its abilities of large-scale parallel, distributed storing and processing, self-organizing, self-adjusting and self-studying.

However, as to the monitoring for product supply, it is far from sufficiency to only pay attention to the supply distribution among suppliers. Because the performance of suppliers is also an ever-changing factor and the evaluation and selection for suppliers is the operating basis of supply chain correlation. In this paper, a neural network module is introduced to assess the suppliers dynamically and suggest the replacement of suppliers when necessary, only supplementing the fuzzy logic system.

The comprehensive performance of suppliers is constrained by multiple factors such as price, in-time delivery, quality, technologic potential, service after selling, historic performance and etc. It is a non-structured information-searching problem to apply NN to the evaluation of suppliers' performance. It is practiced that application of NN in this respect is effective. A NN module includes two parts: network training and operation evaluation of suppliers. First of all , quantities of historic data required no less than 100 data sets should be collected around suppliers' performance and potential business problems. The next step is training the net on the basis of BP neural network. A reliable automatically operating network may be generated after repeated predict-compare-adjust process. A neural network consists of one input layer, one or more hidden layers, and one output layer. Connections exist between the nodes of adjacent layers to relay the output signals from one layer to the next. Once the net gravities are trained well, the neural network may be used to evaluate the operation and provide decision support for choosing promising suppliers.

As Figure 4 shows, the input layer in the module encompasses four characteristic values (that are price, quality, delivery efficiency, service after sell), each of which selects five recent related records. The output layer is the five assessment suggestions as for suppliers (that are Price decreases slightly, Suggestion to replace supplier, Further assessment of company, Quality

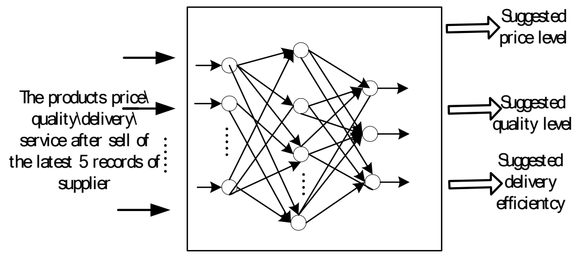

Figure 4: The neural network model of partner evaluation

increases slightly, Delivery time seems to be inconsistent). The database has acquired a great deal of useful data. Accordingly, NN model may create a reliable well-trained network.

4.2 The analysis of a case

Here the further analysis about the reliably trained neural network from a case indicates the feasibility of the neural network system for evaluation and selection of suppliers. At first, the input data should be transformed as one scale. In concrete the five latest track records of a company gathered are scored in performance according to the promising price, quality, delivery efficiency and service level after sell for goods of suppliers. The performance score point (PSP) ranges from 1(lowest score) to 10(highest score). The PSP values are the input of the neural network module which will generate an assessment report for the user to make decisions. The case of Table 2 shows the recent PSP of supplier A. The output report (Table 3) may be obtained which can be referred to making decision, after inputting the PSP values into the NN modules. In Table 3, "1" output from the NN mode indicates a positive suggestion to the associated statement and "0" is the negative suggestion, whereas "0" means that the related parameter almost is no change.

Table 2:PSPof supplier A

Supplier A(latest record)	Product price PSP	product quality PSP	Delivery schedule PSP	Service after sell PSP
1st	7.5	6.0	8.0	8.0
2nd	7.5	6.5	7.4	7.5
3rd	7.5	7.0	7.5	7.7
4th	7.5	6.0	7.8	7.5
5th	7.5	4.5	7.5	7.8

Table 3:Assessment report of supplier A

Supplier A	NN output
Price decrease slightly	0.5
Replacement of supplier	0
Quality is increasing slightly	0
Need to further assessment	1
Inconsistent delivery efficiency	0.5

As for the report of Table 3, it is obvious that there is question about supply quality of supplier A. In general, if the supplier A is one of main suppliers of the company, the further investigation of the issue should be put on. And if the investigation shows that supplier A has tackled the current difficulty through some urgent steps. Then the evaluation result is determined. Hereby, users can easily and objectively evaluate collaborative partners, find out problem timely and seek business chances without specialists or experts' instructions, according to the output suggestion of the NN model..

5. CONCLUSION

The problems are analyzed in the paper how enterprises assess and select suppliers and how to decide the propel allocation among multiple suppliers about procurement quantity in complex supply chain environment so as to meet the requirement of the dynamical overall products quality. The fuzzy logic is applied to resolve the monitoring problem of products quality and products quantity increasingly varying as market requirement. A series of fuzzy rules are fired and the fuzzy system may generate suggested supply change rate. In the mean while, the operation of supplier is also dynamically changing and the evaluation and selection of suppliers are the basis of supply –chain co-operation. So whether it is scientific to select a supplier needs to be emphasized for sustaining and developing a company. Therefore, in the paper the neural network is introduced to dynamically assess suppliers and suggest to substituting for new ones when necessary, only supplementing fuzzy logic system with its advantages.

However, the hybrid approach in the paper is by no meant perfect. Fuzzy logic needs generating rules by experts while NN needs an array of historic data to train a network complexly. However, the paper is aimed at constructing an intelligently technologic flat for reference in the complicated supply chain management, aiding decision-making, thus making SCM more "agile" and enhancing management efficiency.

ACKNOWLEDGEMENT

We are most grateful to the School of computer, Wuhan University and professor ZENG Guang-qi of school of Electronics & Communication, Wuhan University of science & technology.

REFERENCES

[1] DHAR V. and H. HELLENDOORN, and M.REINFRANK(1996),An Introduction to Fuzzy Control,Heidelberg:Springer,149~163

[2] MARK BRACKSTONE, "Examination of the use of fuzzy sets to describe relative speed perception", ERGONOMICS,VOL.43, NO.4, P528~542,2000

[3] H.C.W.Lau,I.K.Hui,etc. "Monitoring the supply of products in a supply chain environment: a fuzzy neural approach", Expert Systems,Vol.19, No.4,P235~243,2002

[4] WH Wenbin, "Research on the fuzzy neural network in the decision support system", Systems Engineering and Electronics, Vol.25, No.12,2003

[5] Zadeh A, "Fuzzy sets and fuzzy information granulation theory", Beijing: Beijing Normal University Press, P121~183,2000