APPLICATION OF SOFT COMPUTING AND NEURAL NETWORKS IN SUPPLY CHAIN MANAGEMENT

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Abstract

It is broadly recognized by many companies that supply chain management is one of the major core issues for an Business firm to compete in the marketplace. Institutional strategies are mainly concentrated on improvement of customer service levels as well as reduction of operational costs in order to maintain profit margins. Therefore supply chain performance has attracted researchers 'attention. A variety of soft computing techniques including fuzzy logic and genetic algorithms have been employed to improve effectiveness and efficiency in various aspects of supply chain management. For a production firm Meanwhile, an increasing number of ideas have been published to address related issues. The aim of this paper is to simplify the findings by a systematic review of existing research ideas concerning the application of soft computing techniques to supply chain management. Some areas in supply chain management that have rarely been exposed in existing ideas, such as customer formality management and reverse logistics, are therefore suggested for future research.

Key words : Supply chain, Inventory Management , Fuzzy logic, Customer satisfaction.

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1. Introduction

Different techniques have been employed to solve problems

Occurring in various dynamic segments of supply chain. As more soft computing applications are introduced and used, a growing body of ideas has been established that can guide the future design and deployment of supply chain solutions. This research aims at reviewing the common soft computing techniques applied to supply chain management, exploring the current research trends and identifying opportunities for further research. The main issues to address include: what are the main problems within supply chain that have been investigated using soft computing techniques? What techniques have been employed? What are the main findings and achievements up to date? What are the major obstacles that have ever been encountered and how might they be overcome? This paper is organized in five sections. Subsequent to the introduction in Section 1, the soft computing and supply chain management techniques are briefed in Sections2 and 3. Section 4 describes the research methodology used in this paper. Section5 examines the existing research of applying soft computing techniques to a variety of fields in supply chain management. Then the key findings are concluded. Finally, a summary of existing studies and a discussion on the future research directions are provided

2. Soft computing

Soft computing is a group of unique methodologies, contributed mainly by Expert System (ES), Fuzzy Logic (FL), Neural Networks (NN), and Evolutionary Algorithms (EA), which provide flexible information processing capabilities to solve real-life problems. The advantages of employing soft computing is its capability to tolerate imprecision, uncertainty, and partial truth to achieve tractability and robustness on simulating human decision-making behavior with low cost[1]. In other words, soft computing provides the opportunity to represent ambiguity in human thinking with the uncertainty in real life[2]. The major soft computing techniques are briefed as following.

2.1. Fuzzy logic

Fuzzy set theory was initiated by Lotfi Zadeh in 1965. In the 1970s a complete theory of evidence dealing with information from multiple sources was produced by Glenn Shafer [3].It

provides a mathematical framework to treat and represent uncertainty in the perception of vagueness, imprecision, partial truth, and lack of information[4].As the basic theory of soft computing, fuzzy logic supplies mathematical power for the emulation of the thought and perception processes[5]. Fuzzy systems are very useful not only in situations involving highly complex systems but also in situations where an approximate solution is warranted [3].To deal with qualitative, inexact, uncertain and complicated processes, the fuzzy logic system can bewell-adopted since it exhibits a human-like thinking process[6].From the area of data modeling, fuzzy sets have not only been extended to data summarization by developing more abstract concepts and fuzzy gradual rules, but also been applied to pattern recognition, e.g. fuzzy clustering algorithms [10]. In addition, a fuzzy multi-criteria decision-making algorithm has been developed for the network reconfiguration problem. It has been implemented in a proof-of-concept tool and applied to multi-criteria problems successfully[11].

2.2. Neural network

A neural network is a parallel distributed information proces-sing structure consisting of a number of nonlinear processing units called neurons. The neuron operates as a mathematical processor performing specific mathematical operations on its inputs to generate an output[12]. It can be trained to recognise patterns and to identify incomplete patterns by duplicating the human-brain M. Ko et al. / Applied Soft Computing 10 (2010) 661–674 662 processes of recognizing information, burying noise literally and retrieving information correctly[13].In terms of modeling, remarkable progress has been made in the last few decades to improve artificial neural networks (ANN). Artificial neural networks are strongly interconnected systems of so called neurons which have simple behaviour, but when connected they can solve complex problems. Changes may be made further to enhance its performance [13].Neural networks and fuzzy systems, usually regarded as elements of artificial intelligence, have their shortcomings. Some of these shortcomings may be overcome if fuzzy logic operations are incorporated into neural networks and neural networks are classified into fuzzy systems[13]. In fact, several authors have already combined fuzzy logic with neural network as neural-fuzzy systems[14]. It may be a new class of computing systems provided by the integration of all these evolving

disciplines for the emulation of higher-order cognitive power[5]. They have been applied in various products in a number of fields.

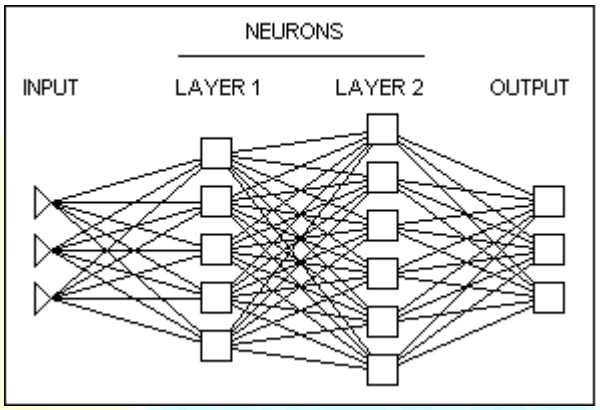


Fig: Neural Network Design

2.3. Genetic algorithms

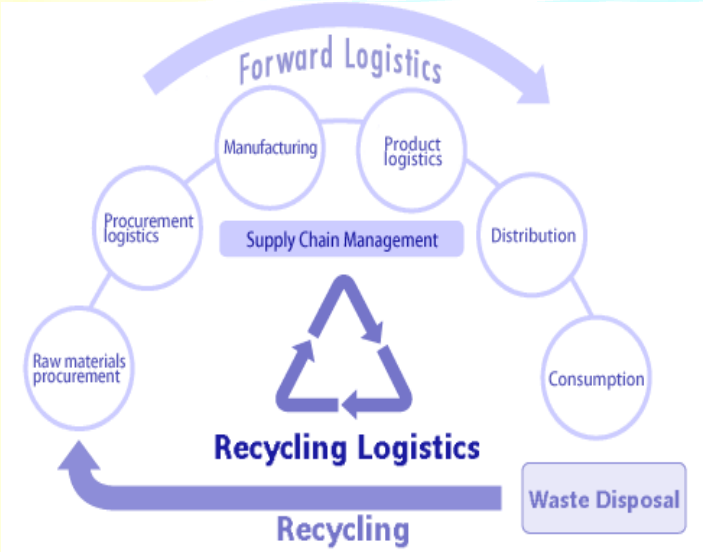
Evolutionary algorithms (EA) were invented to mimic some of
the processes observed in natural evolution. Evolution occurs on chromosomes – organic devices for encoding the structure of living beings. Processes of natural selection then drive those chromo-somes that encode successful structures to reproduce more frequent than those that encode failed structures. In other word,the chromosomes with the best evaluations tend to reproduce more often than those with bad evaluations. By using simple encodings and reproduction mechanisms, the algorithms can then display complicated behaviour and turn out to solve some extremely difficult problems[15].

3. Supply chain management

Kohler and Kotler Philip defined supply chain management as the management of upstream and downstream formalitys with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole. Ramson and Hoeking [20] described the supply chain management as a plan and control all of the processes that link partners in a supply chain together in order to meet end-customers' requirements.

As the sub-process of supply chain management, logistics deals with planning, handling, and control of another well-known definition of logistics as the strategic management of movement,

storage, and information relating to materials, parts, and finished products in supply chains, through the stages of procurement, work-in-progress and final distribution. As demonstrated in Fig. 1, the concept of supply chain refers to the idea of developing a logistics pipeline approach for finished goods to transfer through the supply chain[21]. The supply chain highlights the close partnership from upstream supplier, transport operator, manufacturer, to the downstream 3rd party distributor and retailer. Its objective is to produce and distribute the commodity in the right quantity, to the right place, and at the right time to minimize overall cost while maintaining customer satisfaction. The challenges encountered in the logistics processes and supply chain network will be discussed in later sections.



4. Methodology

The research methodology involves reviewing ideas for soft

Computing techniques applied to the related processes in supply chain management.

4.1. Sources and search methods

The databases that had been searched in this study include Science Direct, International journal of Computers & Operations Research, Fuzzy Sets and Systems, Decision Support Systems, Applied Soft Computing and Applied Mathematics and Computation. Initially, two groups of keywords were used to cross-search related ideas in specific databases.

4.2. Scope

The concept of supply chain management has been analysed by many researchers from various perspectives. However, it is beyond Fig. 1.The concept of the supply chain.Source: Rushton et al.[21]. M. Ko et al. / Applied Soft Computing 10 (2010) 661–674 663 the scope of this paper to address all problems in details. In an attempt to provide a more intensive review of existing ideas in this area, this paper mainly focuses on management-related issues.The studies with non-management-related subjects will not be discussed in this paper, such as robotics and automation, traffic flow prediction, public transportation policy, traffic congestion/
control, traffic flow and its pattern analysis.

4.3. Framework

The framework applied in this research is defined and developed by the Global Supply Chain Forum (GSCF)[22–24] sponsored by the Council of Logistics Management (since 2005 it is called the Council of Supply Chain Management Professionals). The logistics management plays a key role for transportation and shipping. Even in the modern production firms the key Business activity opportunity starts with the speed of the logistic design and development .Always the new idea will be paid much attention and keen ideological survey always prove a systematic arrangement proved to be the better solution. The following eight processes of supply chain management have been categorized by the GSCF:

FLOW OF MATERIALS IN PRODUCTION
DEMAND MANAGEMENT
CUSTOMER FORMALITY MANAGEMENT
BUSINESS ACTIVITYINTELLIGENCE
PATENT PROTECTION
INNOVATION MANAGEMENT
STRATEGIC MANAGEMENT
MATERIALS MANAGEMENT

5. The target subject processes

To refer to the eight processes of supply chain management
categorized by the GSCF, the review of existing ideas is classified into the following sections.

5.1. Production flow management

The challenge to improve production performance has drawn the attention of researchers to employ diverse soft computing techniques. This becomes evident from the over 60 ideas in production field which are included in this review.

As shown in Fig. 2, the initial paper with respect to application of soft computing in production flow management was accepted in 1990. There were only a few works in this area before 2001. Nevertheless, it demonstrates a steady rise in the number of ideas since 2003 and reaches a peak in 2008. The evidence seems to be strong that more studies canbe anticipated in the near future.Expert systems have beenused by early studies for dealing with inventory control and planning [27–31]. Then Fuzzy logic and neural network were applied to industry and had been discussed by Du and Wolfe[6]. A fuzzy model was developed by Li et al. [32]

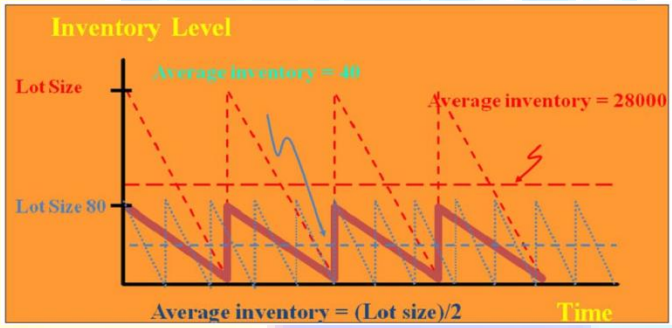


Fig: inventory Management cycle

to address single-period inventory problem. [39,40]. There were also a few studies concentrated on fuzzy order and production quantity with or without backorder problems[41– 48].

5.2.2. Vehicle routing/assignment

Dynamic vehicle routing and scheduling problems have drawn

Logistics managers and researchers' attention since 1990. It could be a key parameter for the delivery of goods in the right time. Delivery sequence constraints while Ho et al.[118] proposed a hybrid genetic algorithm to solve similar problem with multiple depots. Furthermore, Hu and Sheu[119] explored the potential advantage of fuzzy clustering techniques in classifying pre-trip customers by their demand attributes for further vehicle dispatching and routing operations.

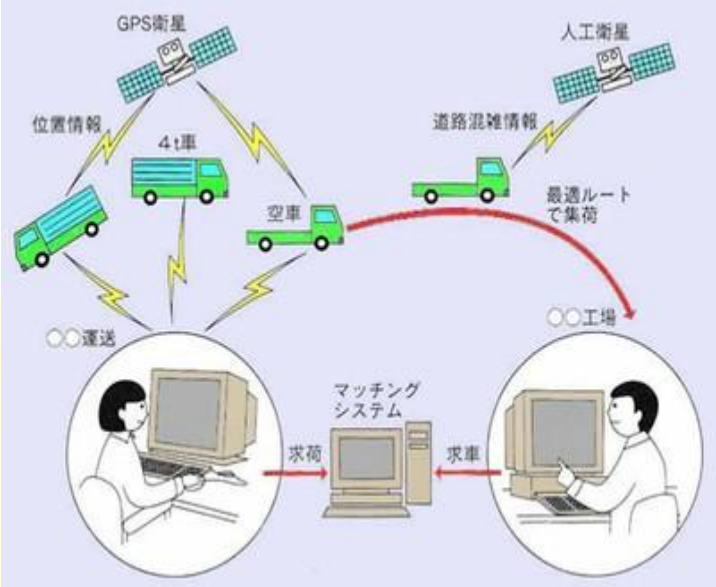


Fig: Vehicle routing and Assignment

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5.2.3. Other issues

To ensure an effective logistics decision-making process, analyzed both qualitative and quantitative information from customers. indicated possible synergies between various sciences, such as applied attics and artificial intelligence, to solve distributed decision-making problems. Additionally, found an optimal solution, by considering total transit time and shipping cost simultaneously, to allocate customers to available warehouses or distribution centres. Chen yieng developed a GA-based model to select distribution centre location while total relevant cost is minimised.

5.3. Demand management

Demand management plays a critical role within supply chain management. A reliable demand forecast can improve the quality of Business firmal strategy. The domain of demand management has been a major interest in soft computing since 1990s.Subsequently, considerable research has been performed on the subject of sales and demand forecasting.

As shown inFig. 6, the applications in demand management

fluctuated before 2004, yet an obvious growth has started since 2005. On this basis it may infer the possibility of more work to be published in this field in 2009 and after.

5.3.1. Sales forecasting

As an integral part of almost all Business activity business firms,forecasting is the process of predicting the future [135].

Production firms forecast future demand to prepare necessary manpower and raw materials for production. Service companies forecast customer arrival patterns to maintain appropriate staffing to serve customer demands. Therefore, forecasting is one of the major strategic activities in Business firmal decision-making processes for demand management. Artificial neural networks have been recognised as a valuable tool for forecasting. The major advantages to employ artificial neural networks in forecasting include its self-adaptive capability to learn from experience as well as to generalise results from sample data with noise. In addition, to compare with conventional statistical methods, artificial neural networks can model contin-uous stretigics to any desired accuracy[136]. Furthermore, as opposed to the traditional linear and nonlinear time series models, and designed finally.

Fig: Sales forecating

5.3.2. Bullwhip effect

The bullwhip effect is one of the most popular research

problems in supply chain management. It describes the distortion on demand forecasting throughout supply chain partners. Soft computing techniques proved to be effective to reduce bullwhip effect in supply chains[161–163].

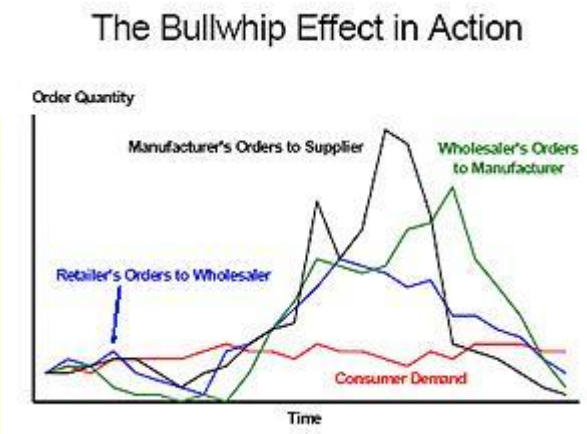

Fig: Bull Whip effect

5.3.3. Other issues

In addition to the above work, employed neural-fuzzy approach to forecast returns of scrapped products. Aburto and Weber [165] improved the forecasting accuracy of a replenishment system proposed to a supermarket developed a neural network-based model to forecast supplier's bid price in order to shorten the lead time in supplier selection process.

5.4. Product development and commercialization

Thesoft computing techniques that have been applied to the sub-processes of product development include product quality enhancement and cost reduction[180], the formality between the shelf space assigned to various brands and the market share[181],the optimal variable selections of R&D and quality design[182],and evaluation of supply chain performance for new product[183].

5.5. Returns management

Cummins R Man proposed a GA-based approach to solve

reverse logistics problem of managing returned products.Furthermore, Yeing developed an optimal solution to solve the reverse logistics network design problem while Min and Ko[187]addressed the similar problem from 3PL

service providers' perspective.

5.6 . Customer service management

Bottani and Rizzi[188] presented a fuzzy quality stretigic deployment approach to address customer needs, improve logistics performance, and ensure customer satisfaction.

5.7. Customer formality management

It seems that there is a lack of ideas addressing related issues in this area.

6. Distribution of ideas

In this section the distribution and growing trend of all reviewed ideas, as well as the employment of soft computing techniques, are analysed and demonstrated according to various criteria.

6.1. Distribution of ideas in subject processes

As illustrated, numerous research ideas have contributed to seven broad categories of supply chain management. The production flow management is the most popular area targeted by soft computing applications. The research ideas about order fulfillment are slightly more common than the ideas regarding demand management. It is clear therefore that ideas for those three major subject processes in supply chain management are considerably more than those in other subject processes. Additionally, shows the proportion of ideas focusing in major subject processes. It reveals that production flow management, which makes up 38%, is the most popular subject in supply chain management to attract researchers' attention There are 30.1% and 18.4% of research ideas concentrating on order fulfillment and demand management respectively. Table 2provides a breakdown in detail for the connection between researchers and respective research area on an annual basis. The number of ideas and the researchers working in related areas has steadily increased since 2002.

6.2. The growing trend of research in supply chain management

As demonstrated there were only a few studies in the supply chain management area using soft computing approaches in early 90s.

6.3. The employment of individual soft computing technique

As clearly demonstrated in, genetic algorithm has become the most frequent soft computing technique that has been applied to both production flow management and order fulfillment. Neural network has been often applied to demand management. In general, compared with other soft computing techniques, genetic algorithm is relatively popular for researchers.

6.4. The ideas published by main journals

As revealed in, 14.1% of these research ideas were published by European Journal of Operational Research while 11% of total ideas were published by both International Journal of Production Economics and Computers & Industrial Engineering .Expert Systems with Applications, Computers & Operations Research, Fuzzy Sets and Systems and Decision Support Systems are also the major journals recognised by researchers.

7. Discussion, conclusions and future research

Some of the research ideas involve more than one domain.

Therefore it is difficult to classify individual research to a single category. It is attempted to place each work in the closest representative category. However, this classification scheme aims to draw a general picture for the distribution of related ideas. It does not impact the associated findings derived and the uncovered opportunity for future research.

Both genetic algorithms and fuzzy logic approach are the most popular techniques adopted to solve supply chain management problems, particularly in the production management and order fulfillment issues. Neural networks are broadly used to improve sales forecasting performance.

The numerous and complex data sources are always needed to solve most of the problems in supply chain management. Soft computing tools seem promising and useful to analyze this data and to support manager's decision making in a complex environment.

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