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An Automatic Decision Support System Based on Genetic Algorithm for Global Apparel Manufacturing

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Abstract: The aim of this study is to develop a decision support system for apparel production. The system could help the managers to make decision more effectively and spontaneously within the minimum time in which plant is the prominent choice to fulfill a particular customer order in the hope of reducing the enterprise cost and meeting the customers' needs. The system is mainly composed of three major components, i.e., an input database, an analytical tool, and presentation tools. The input database contains the basic information which was directly collected from real data provided by a apparel company and gathered from the Enterprise Resource Planning (ERP) system for analyzing. The analytical tool employed in this study is the Genetic Algorithm (GA), which had been proven by many investigators to efficiently analyze the decision problems. Finally, visualized charts and reports are used to display the data for decision-makers. The system is supposed to be user-friendly, flexible, cost-effective, and suitable to the apparel industry.

Key words: Decision support system, genetic algorithm, global logistics, apparel

INTRODUCTION

In recent years, business has become a global activity. That is to say, the operation of an industry has drawn its attention worldwide. In light of this critical industrial transformation, many enterprises have been making efforts on the Global Logistics Management (GLM) to enhance their competitive capability. However, there are still many problems to be solved during the period of implementing the GLM. Take the apparel industry in Taiwan as example. Senior managers generally make decisions based on their personal experiences. This might sometimes work well under particular circumstances. On the contrary, it might also cause side effects, such as complexity of business environment, other driving forces, some intrinsic constraints of the company and employee, manual misjudgment, or other uncontrollable reasons. Therefore, it is very crucial to set up an electronic system that can help administrators or managers to make more reliable and stable decisions. As a result, Decision Support Systems (DSSs)[1-3] inevitably play an important role in the modern apparel industry.

Generally speaking, it takes time to develop a DSS that fits properly to all kinds of industries since different types of business environment possess various unique "business culture", and the industrial operations involve much complexity and need a lot of dominant knowledge and know-how. Moreover, the business environment varies rapidly. Thus, a tailor-made DSS that is easy to adapt it and update with changing business processes and operational environment seems to be unavoidable. In this study, we develop a production DSS for apparel industry, which is one of the most important industries in Taiwan. The system will be designed to help administrators or managers to make decisions within the minimum time while under the environment of global operations. To rapidly offer some useful solutions that satisfy the requirements of customers' needs and minimize the total cost of the enterprise, we use Genetic Algorithm (GA), which is verified by many earlier studies[4-14] to be very effective to develop a decision-making system and to solve the problems. The system will be designed to be quick on the uptake in operation, flexible, and suitable to the production of the apparel.

GENETIC ALGORITHM (GA)

The Genetic Algorithm (GA) used in problem solving requires encoding the variables. Binary encoding and enumerated encoding are usually used[6]. Take the binary encoding for example. Each bit stands for a gene. The stringed binary bits (genes) construct a chromosome, which represents a solution to a problem. The function of GA is to find the best solution for a problem from a pool

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Table 1: The different rossovers

One-point crossover		Two-point crossover		Uniform crossover	
Before	After	Before	After	Before	After
ABCDEF	ABCFED	ABCDEF	ABEDCF	ABCDEF	FBCDEA
FEDCBA	FEDABC	FEDCBA	FEBCDA	FEDCBA	AEDCBF

Table 2: The different mutations

Adjacent Two-Point Change		Arbitrary two-point change		Shift change	
Before	After	Before	After	Before	After
ABCDEF	ABDCEF	ABCDEF	AECDBF	ABCDEF	AEBCDF

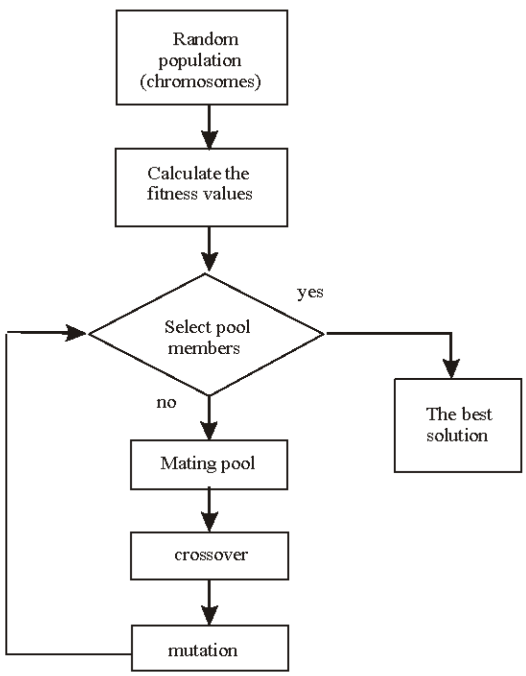

Fig. 1: The flow chart of the genetic algorithm

of solutions (chromosomes). A fitness value will be used to evaluate the "fitness" of a chromosome. The fitness of a chromosome reflects its suitability to produce "fit" offspring and its relative proximity to the solution for the problem at hand.

GA starts with repeating the genetic cycle of manipulating chromosomes from an initial random population of chromosomes to generate new generations consisting of "fit" offspring. The evolution process is shown in Fig. 1. Chromosomes will be selected through a special selection process for the mating pool. Parents from the mating pool will then undertake genetic crossovers and mutation to produce the offspring. There are mainly two types of selection process: (1) roulette wheel selection and (2) tournament selection.

Roulette wheel selection: The sum of fitness of the chromosomes is defined as the circumference of a roulette wheel selection. The chromosome is calculated for its fitness added to the fitness of the members in preceding population that lies within the same fitness for the segment on the roulette. The chromosome with the largest segment on the roulette wins the fitness game. The smallest segment is the loser.

Tournament selection: In the tournament selection, the chromosomes will be selected for the mating pool from the highest fitness to the lowest in decreasing order. The selection process will use the probability of reproduction (PoR) to maintain the size of mating pool to be the same as the population size. For example, if the population size is 4 and PoR is 0.5, then the string that has the biggest fitness value is chosen for the pool twice.

Crossover and mutation: Once parents are chosen to mate, the crossover process occurs. The crossover process is rooted in the probability of crossover PoC. Not all chromosomes can crossover and are, therefore, eliminated. A normal PoC rate is between 0.6 and 1.0[6]. There are three types of crossover, mainly (a) one-point crossover, (b) two-point crossover and (c) uniform crossover. Table 1 shows the different crossovers.

Mutation occurs after crossovers. The different mutations are shown in Table 2. The purpose of mutation is to increase GA's chance towards the best solution. Each bit can be randomly altered with a probability of mutation PoM. For example, if there are 4 chromosomes in the crossover pool with each chromosome consisting of 6 genes and PoM = 0.1. There are 24 genes in the pool and mutation will occur twice since 24′0.1 = 2.4 (rounded off). The PoM rate is 0.001 with PoC of 0.6 for a large population size of 100 and 0.01, 0.9 for a small population size of 30[6].

ANALYSIS

To build up a good DSS, it is very important to develop a good system structure. The system is composed of three components, i.e., the input database and parameters, the analytical tool, and the presentation tools.

Input database and parameters: This component contains the fundamental information needed for making decisions.

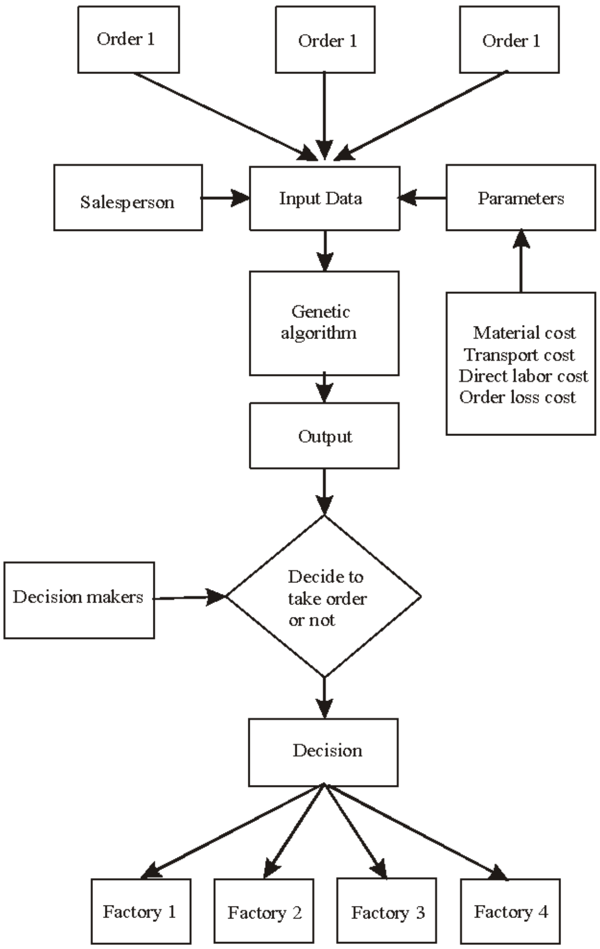

Fig. 2: Procedure for making decisions

The input data includes production cost, transportation cost, direct labor cost, material cost, order quantity, due date, lost cost of delayed order, and so on. The parameters we set include population size, crossover rate, mutation rate, and the number of generation. Additional rules can also be added to capture the reality of operations.

Presentation tools: Visualized charts are used to let decision makers easily understand the load of each factory. Besides, reports are generated to help managers make decisions. Several factories that best fit the requirements of an order will be shown in the report. The number of best factories can be set by the preference of decision makers.

Analytical tool: GA is employed to find a good solution within short time, which is demonstrated by many previous studies to be very effective to make decisions. The analytical tool plays a core role in a DSS. It will be explained in greater detail in the following.

The heart of any DSS is the model, or presentation of reality within the system. To effectively utilize a DSS, the user must process both an understanding of modeling, as well as an understanding of the subject matter being modeled. To do this, many meetings and several interviews were performed to capture scenarios of operations. To correctly represent reality, and alternatively, to keep the model simple enough to understand, manipulate, and solve, the system is modeled with the idea of "model simple, think complicated." The system is designed for ease of manipulation, such as easily changing data, running scenarios, and analyzing the results.

Fitness function: Each chromosome is designed to win or lose by two measures, i.e., Cost-Based Measures (CBM) and Due-date Related Measures (DRM). CBM is evaluated with the cost of on-time delivery including material, transportation, direct labor, operation expenses, and so on. A lower CBM value indicates a better match. On the other hand, DBR is evaluated with due date. In case that an order is delayed, a loss cost will generate. The cost of loss of a delayed order is primarily composed of several parts: extra transportation cost, overtime cost, and penalty cost. The extra transportation cost is the difference between a normal transportation rate and an air express transportation rate caused by a requirement of an urgent delivery. The penalty cost is according to the contracts. The loss cost per day is calculated as the product unit price and the order quantity by penalty factor. The fitness function can be expressed as

$$F = \sum_{i=1}^{n}\{O_i + \max[(C_i - D_i), 0] * Q_i * U_i * \mu\} \tag{1}$$

, where
is the on-time, normal production cost of *i*th order

- C_1 is the completion day of *i*th order
- D_1 is the due date of *i*th order
- Q_1 is the order quantity of *i*th order
- U_1 is the unit price of *i*th order
- μ is the penalty factor of a delayed order

In real cases, it is generally very difficult to find a global optimal solution. Instead, if we can rapidly find a good solution that is very close to the optimal solution, it will benefit the decision makers considerably. Therefore, we will find a good approximate solution. The method is to find a minimum fitness function.

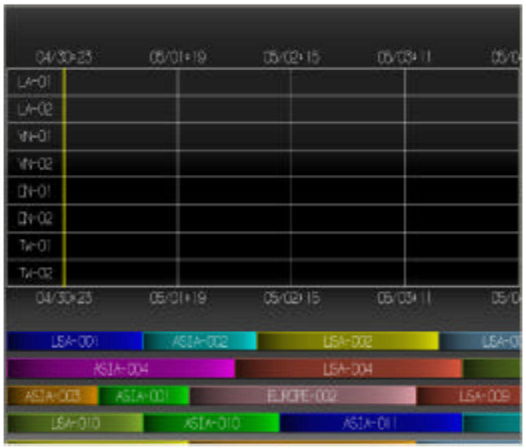

Fig. 3: A typical chart before scheduling

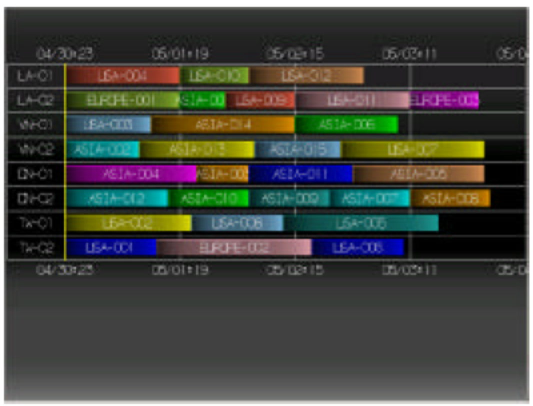

Fig. 4: A typical chart after automatic scheduling

RESULTS AND DISCUSSION

In this study, we used GA to solve the production decision problem. The DSS was developed by using Microsoft Visual C++. The operation system was Window 2000. Parameters were set to be as follows. Population size was 100, crossover rate was 0.8, mutation rate was 0.05, and generation was 100. Enumerated encoding was employed rather than binary encoding in this study. Two-point crossover and two-point mutation were used to find a solution.

The results are illustrated in visualized Gantt charts, which have real-time in the horizontal axis and factories all over the world in the vertical axis. The system can perform pre-scheduling manually. The decision-makers can just draw the mouse cursor to the position they like and release the cursor. The factories that do not fulfill with the requirements of the order, their colors will turn red to warn the decision makers. If decision makers are not satisfied with the result that schedule manually, they can change the scheduling by just moving the cursor to the suitable position. A caution line of red color will be generated to show the due date, reminding decision-makers of not scheduling the order after the delivery day. Different orders are illustrated in different colors. But the same factory will have the same factory name with numbers in order.

The system can also automatically choose and schedule the most suitable factory. Decision-makers can just select the agent item and enter. The automatic function can be performed by two ways. First, the system can execute the scheduling by the net change method, i.e., just reschedule the orders needed to change. The second method is regeneration. All the order will be rescheduled. Again, if the decision makers are not satisfied with the result, they can draw the mouse cursor onto the selected order and move it to the appropriate location. They can also insert a rush order or cancel an order easily. The information of orders is easy to check, too. Draw the mouse cursor onto the order at the cursor position, the detailed information of the order will be shown.

The system is not only convenient for production controllers to arrange production and check the production planning of all the factories around the world, but also easy for salesperson to check availability. For the sales department, the salesperson can easily see the availability of each factory and promise customers according to the remained capacity.

CONCLUSIONS

We have developed a decision support system for apparel production. Our aim is to help the decision-makers to make decisions within the minimum time but with maximum efficiency. In particular, the plant is the best one to fulfill a particular customer order under the requirements of reducing the enterprise cost and meeting the customers' needs.

The designed system is mainly composed of three major components, i.e., input databases and parameters, the analytical tools, and the presentation mechanism. The input database contains the basic information. The information is real data provided by a apparel company and gathered from the enterprise directly. The analytical tool employed in this study is the genetic algorithm. Finally, reports and visualized charts are used to display the data to the decision- makers. The system is designed to be helpful whether data-changing, scenario-running, or results-analyzing. As a result, we are sincerely in the hope that the Decision Support System will meet its success in the apparel industry in the years to come.

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