Application of Improved Genetic Algorithm in Solving a Type of Connector Transportation Problem Based on MATLAB

Cheng Xiangyu, Zhang Yan, An Chunyu

***Abstract*—The transportation problem of real-life situation is complicated. Optimization target is usually not unique. We often need to take these optimization objectives of cost and time into account. This paper proposes and implements double-objective genetic algorithm based on MATLAB. The double-objective optimization problem is about the sale and transportation of a type of connector of China Information and Electronics Development Inc. Ltd., Hefei. For the target matrix's difference on units and quantity degree, the solution combined manual weight and adaptive weight avoids the appearance of error on search-behavior unexpectedly to be too biased to a specific target. By a real instance, we verify that the algorithm is accurate and reliable, can effectively solve the large-scale real transportation scheduling problems.**

***Index Terms*—Genetic algorithm, Transportation problem, MATLAB**

Manuscript received November 7, 2011; revised January 13, 2012.

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I. INTRODUCTION

TRANSPORTATION problem is a type of NP-hard (non-deterministic polynomial-time hard) problem. For small-scale transport problem, graphic method or table dispatching method does work; but for large-scale transport problem, the result got out by graphic method or table dispatching method is random and blind, we may not find the optimal solution by those methods. In the light of actual conditions, transportation problem can not be usually very simple. In normal conditions, transportation problem has some properties such as large size matrices, multi-objective optimization, objective matrices' unit and magnitude being inconsistent. In view of these properties, a solution of adaptive weight multi-objective genetic algorithm based on MATLAB is put forward in this paper. The genetic algorithm's accuracy and reliability are verified by the data from China Information and Electronics Development Inc. Ltd., Hefei and others. We can figure out the optimal solution of these practical problems by the genetic algorithm.

II. PROBLEM DESCRIPTION

A. Practical Problem Faced Is Described Below

China Information and Electronics Development Inc. Ltd., needs to sale and transport a type of connector. Let us figure out the optimal transportation scheme.

ISBN: 978-988-19251-9-0
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

B. Constraint Conditions

Suppliers of the connector include: Guangzhou Winmax Electronic Technology Co. Ltd, Xian Huada Electronic Connector Co. Ltd, Beijing Jingzhe Electronic Technology Co. Ltd, China Aviation Optical-Electrical Technology Co. Ltd, and Shenzhen Connector Technology Co. Ltd. They are represented respectively by the following symbols: *S*1, *S*2, *S*3, *S*4, and *S*5.

Quantities of the connector that these companies supply to China Information and Electronics Development Inc. Ltd. are listed in the following table (TABLEI):

TABLE I

SUPPLY QUANTITIES OF SUPPLIERS

Supplier code	*S*1	*S*2	*S*3	*S*4	*S*5
Supply quantity （piece/month）	200	208	120	250	72

The departments for connector's sale and use include: China Information and Electronics Development Inc. Ltd. headquarters, Beijing liaison offices, Xiamen liaison offices, Chengdu business department, Shenzhen liaison offices and Xinjiang liaison offices. They are represented respectively by the following symbols: *D*1, *D*2, *D*3, *D*4, and *D*5.

The departments' demand quantities of the connector are listed in the following table (TABLEⅡ):

TABLE Ⅱ

DEMAND QUANTITIES OF SALE DEPARTMENTS

Sale department code	*D*1	*D*2	*D*3	*D*4	*D*5	*D*6
Demand quantity （piece/month）	210	220	85	180	65	90

The average transportation cost and time from suppliers to sale departments are listed in the following table (TABLEⅢ):

C. Optimization Target

It needs us to figure out the optimal transportation scheme from suppliers to sale departments. In the scheme, the transportation time and cost in total should meet the minimum value simultaneously.

TABLE Ⅲ

TRANSPORTATION COST AND TIME

Supplier code	Average transportation cost c_{ij}^1 （yuan/piece）						Supply quantity a_i (piece)
*S*1	10	20	15	25	6	32	200
*S*2	11	8	21	7	5	28	208
*S*3	9	3	14	16	19	27	120
*S*4	10	12	14	15	18	20	250
*S*5	12	20	22	16	2	35	72
	Average transportation time c_{ij}^2 （hour/piece）						
*S*1	8.5	6	12	18	4	16	200
*S*2	13	11	17	7	16	8	208
*S*3	9	3	16	14	19	19.5	120
*S*4	6	7	13	9	22	29	250
*S*5	9.5	20	19	18	1.5	30	72
Demand quantity b_j (piece)	210	220	85	180	65	90	850

III. SOLUTION PROCESS

A. Solution Method

The transportation problem is expressed in mathematical language [1] as follows:

$$\min\ z_q = \sum_{i=1}^{5}\sum_{j=1}^{6} c_{ij}^q x_{ij},\ q = 1, 2$$

$$\text{s.t.}\ \sum_{j=1}^{6} x_{ij} = a_i,\ i = 1, 2, \cdots, 5$$

$$\sum_{i=1}^{5} x_{ij} = b_j,\ j = 1, 2, \cdots, 6$$

$$x_{ij} \geq 0, \qquad \forall i, j$$

It is a multi-objective transportation problem of NP-hard [2]. We may adopt adaptive weight [3] multiple-objective genetic algorithm [4] to solve the optimization problem.

B. Genetic Algorithm Program Flow

For solving the problem, we adopt a coding method based on prüfer numbers of spanning tree, and design a adaptive weight multiple-objective genetic algorithm program with MATLAB. The main program flow chart is showed as follows:

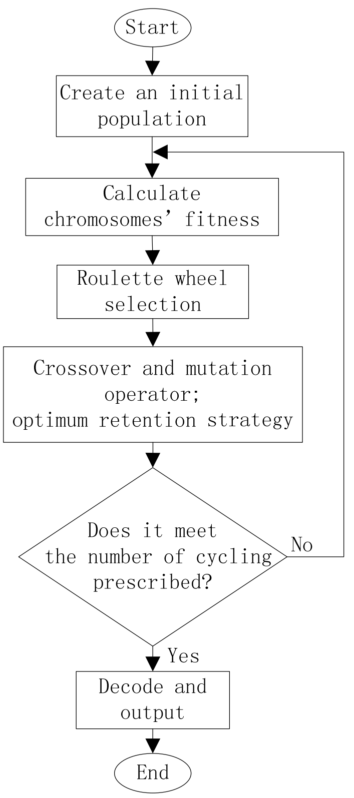

Fig. 1. Genetic algorithm program flow chart

C. Method Based on Spanning Tree

The genetic algorithm uses a prüfer numbers coding based on spanning tree [5]. It can represent all possible trees. With the genetic algorithm based on spanning tree, we can find out the optimal solutions or the approximate optimal solutions of transportation problem in the total solution space.

Suppliers S1、S2、S3、S4、S5 are defined as elements of the set S ={1，2 ，3，4，5}; sale or use departments D1、D2、D3、D4、D5、D6 are defined as elements of the set D={5+1，5+2，5+3，5+4，5+5，5+6}={6，7，8，9，10，11}. The transportation problem has 5+6=11 nodes in its spanning tree. It may have 5×6=30 different edges. For a complete graph of p nodes, it may have pp-2 trees of different node label permutations. The node that only connects one edge is called leaf of the tree. Any tree has at least 2 leaves.

Coding Method

As a coding manner of spanning tree, prüfer numbers can be used to code transportation tree. First record a non-leaf node that directly connects a minimum leaf node, and then remove the minimum leaf node from transportation tree. Do it every time until only two nodes left in the tree to complete constructing prüfer numbers $P(T)$ gradually. Leaf nodes are marking out with dotted line circles in the below chart. Overall process of constructing prüfer numbers is showed as follows:

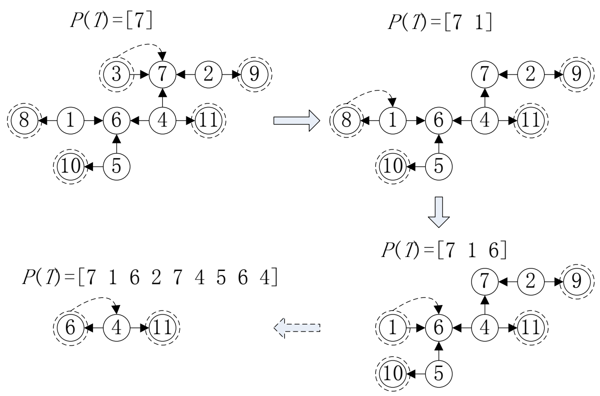

Fig. 2. Process of constructing prüfer numbers

Decoding Method

First connect the minimum considering node in the set $\overline{P}(T) = S \cup D - P(T)$ to the leftmost number of $P(T)$, and then remove the leftmost number of $P(T)$. Do it every time to construct transportation tree gradually. In the following chart, the numbers underlined in $\overline{P}(T)$ are the nodes that have been added to the tree. They belong among unconsidering nodes. When $P(T) = \varnothing$, directly connect two considering nodes in $\overline{P}(T)$ to complete constructing transportation tree. The process of converting prüfer numbers into transportation tree is showed as follows:

ISBN: 978-988-19251-9-0
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

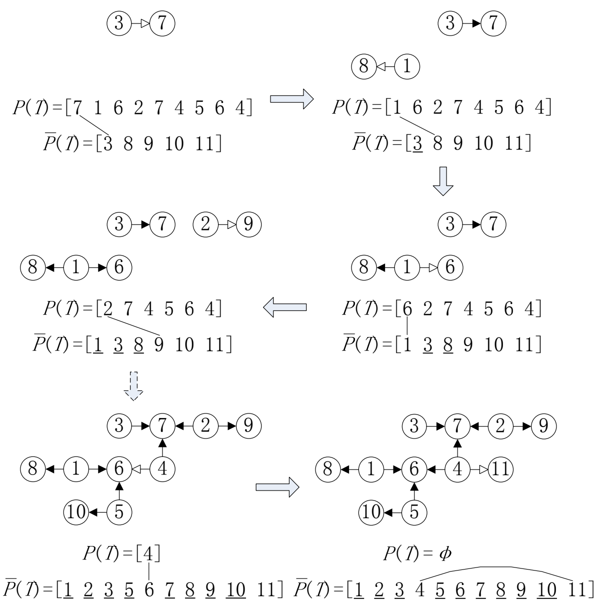

Fig. 3. Process of converting prüfer numbers into transportation tree

D. Setting Genetic Algorithm Parameters

The size is set to contain 20 chromosomes in each population. The number of iteration is set to 600 genetic operations. We combine manual weight $w_1 = 0.6, w_2 = 0.4$ with adaptive weight $(w_a)_q = \frac{1}{z_q^{\max} - z_q^{\min}}, (q = 1, 2)$ to form the last weight value.

The regret value calculation of double-objective genetic algorithm in this case adopts formula as follows:

$$r(z;p,w) = \| z - z^* \|_{p,w}$$
$$= [\sum_{q=1}^{2} w_q^p (w_a)_q^p \mid z_q - z_q^* \mid^p]^{1/p}$$
$$= [\sum_{q=1}^{2} w_q^p \mid \frac{z_q - z_q^{\min}}{z_q^{\max} - z_q^{\min}} \mid^p]^{1/p}$$

In the formula, z_q denotes objective value vector of objective (q) of a population. z_q^* denotes ideal point [6] of the objective, it represents the location of the desired objective. We use it to identify the search direction of genetic algorithm. $z_q^{\max}$ and $z_q^{\min}$ denote the maximum number and the maximum number in objective value vector z_q.

This preference parameter p is set to 3. The ability of taking both objectives into account is more power for large p.

The smaller the regret value $r(x)$ of the function is, the closer the chromosome is to the solution. Thus method of converting the regret value to fitness value $eval(x)$ is defined as follows: $eval(x) = \frac{r_{\max} - r(x) + \gamma}{r_{\max} - r_{\min} + \gamma}$. The parameter γ could be used to regulate the probability of the roulette wheel selection. When $\gamma \to 0$, the roulette probability is directly proportional to chromosome fitness value; When $\gamma \to +\infty$, the roulette wheel selection will select chromosomes at complete random. Here, we set $\gamma = 0.5$.

E. Result of Genetic Algorithm

We adopt MATLAB genetic algorithm program to solve the problem. Solution result is as follows:
Genetic algorithm effect figure was depicted.

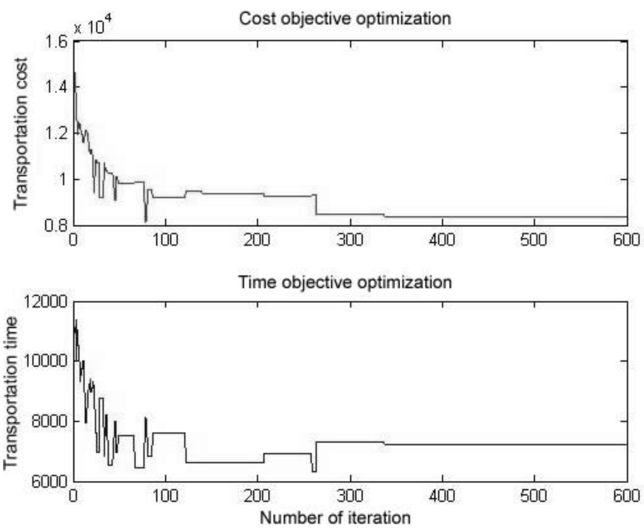

Fig. 4. Genetic algorithm effect figure

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ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

Optimal chromosome:

$$P(T) = [6 \quad 7 \quad 4 \quad 4 \quad 4 \quad 11 \quad 5 \quad 9 \quad 2]$$

Optimal transportation matrix:

$$GA = \begin{bmatrix} 200 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 173 & 0 & 35 \\ 0 & 120 & 0 & 0 & 0 & 0 \\ 10 & 100 & 85 & 0 & 0 & 55 \\ 0 & 0 & 0 & 7 & 65 & 0 \end{bmatrix}$$

Optimal transportation routing chart (Automatic program generator in MATLAB):

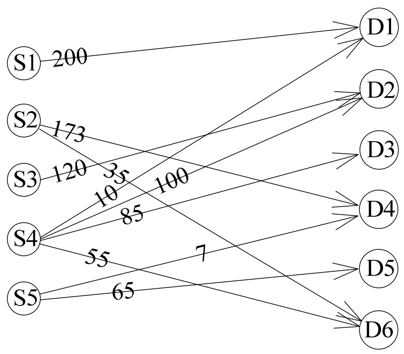

Fig. 5. Optimal transportation routing chart

IV. Conclusion

Lack of space forbids further concrete details of the adaptive weight multiple-objective genetic algorithm solution here. But all over idea and solution are clearly expressed. The MATLAB genetic algorithm program is designed to solve the practical problems. It provides an effective way of reducing transportation cost and time for China Information and Electronics Development Inc. Ltd. From the result chart and practical application, the company could cut down retrench about RMB 4500 Yuan and save transportation time about 4000 hours at 10 routes every month on average. It avoids the blindness and reduces the difficulty of scheduling decision.

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ISBN: 978-988-19251-9-0
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)