THE PASSENGER VEHICLE’S LOGISTICS TRANSPORTATION PLANNING PROBLEM BASED ON THE QUANTUM INSPIRED GENETIC ALGORITHM

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ABSTRACT

In order to solve the heterogeneous vehicle routing problem with two-dimensional loading constraint, an integer programming model of the heterogeneous vehicle’s routing problem has been founded. To optimize the loading way of the 45 kind of passenger car by quantum genetic algorithm (QGA), firstly the QGA is adopted to get the assemble of each passenger car, then analysis the routing problem of the each car-carrier. The optimization of integer programming problems and the simulation and application of QGA are discussed specifically.

KEYWORDS

loading constraint; vehicle scheduling; integer programming model; quantum genetic algorithm.

1. INTRODUCTION

Automobile enterprises pay more and more attention to the problem of the logistics transportation and the routing optimizing, the logistic transportation of the passenger car involve varieties of optimization decision problem[5], the choice of transportation routes was one of them. When choosing transport routes, should not only consider the transport distance, transport link, and also should consider the means of transport, transportation time and cost of transport and so on. Therefore, the choice of transportation routes is also the choice of transport routes in fact[3]. The premise of ensuring accomplishing the transportation duty, the logistics company is chasing to reduce transportation costs, but because of the car carrier and passenger car have multiple standard, at present many logistics company make the transportation planning main rely on the experience of the Crew Schedulers, when face the complex transportation duty, they are often inefficient, and the transportation cost is not ideal[4].
In this paper, the problem that the heterogeneous vehicle routing problem with two-dimensional loading constraint has been solved, modeling the heterogeneous vehicle's integer programming[2]. To optimize the loading way of the 45 kind of passenger car by Quantum Inspired Genetic Algorithm, on the basic of the initial assembly, to analysis the routing problem of the each car-carrier, discussed how to optimize the integer programming model and the modeling and simulation of the Quantum Inspired Genetic Algorithm[9].

2. RAISE QUESTION

The transportation cost calculation of the vehicle logistics is complicated and overloaded, we should to simplify it. At first, influence the cost of high and low is the usage quantity of the car carrier. The second, under the condition of the same number of the car carrier to use, 1-1 car carrier of low use cost, but the 2-2 are higher, 1-2 slightly lower than its average of the first two, but logistics company's 1-2 car carrier ownership is small, In order to facilitate subsequent task arrangement, every 1-2 car transport vehicles use no more than 1-1 car transport vehicle usage of 20% . Once again, under the condition of the same number and the type of the car carrier to use, the cost of the short mileage is low, we should pay more attention because of the logistics company is a national company, in all parts have the vehicle logistics business, so after arriving at our destination, the car put on standby, don't need to return empty[2].

Raise question: the table1 in the appendix give the types and size dimension and quantity and the destination of passenger vehicles to transport, the table2 in the appendix give the types and quantity and the loading area size of passenger vehicles to transfer (the table data is lower loading zone length and width, the 1-1 type and 2-2 type car carrier's upper and lower area is in the same area; the 1-2 car carrier's upper and lower area is in the same length, but the upper is widen 0.8 meters than the lower. Besides, because the 2-2 car carrier has the lower level, the upper and the lower level neither can't load the passenger car that the height is more than 1.7 meter. Make the detail planning for the logistics company, containing the quantity of the varieties type of car carrier what we need, the passenger car's loading program and the route planning of each car carrier.

3. THE ANALYSIS OF THE QUESTION

The car carrier starting from the logistics center, full loaded with cargo to arrive the destination, by unloading along the way to complete the task, the car goods can according to the actual situation of unloading and loading of good position to adjust the situation, the delivery demand of every destination can be broken up, performed by different or the same vehicles, loading the configuration of the car carrier reasonably, and arrange the driving route of the vehicles, make the total amount of car carrier minimum, and the minimizing the sum of distance.

4. MODELING AND SOLVING

4.1. Modeling And Solving

Using SPSS software to the table 2 in the appendix for cluster analysis, according to the passenger car's height, width to cluster 5 classes. We use all passenger cars as object, according to the number named a 45-dimensional vector, the element values represent numbers i passenger car that will use the corresponding vehicle load, after the following by using the quantum genetic algorithm can solve the optimal individual, when loading the carriage, choose the models in the same type priority.
step 1:
Use appropriate vehicles to accomplish the car quota that each destination need full height more than 1.7 meters and width more than 1.7 meters;

step 2:
Use the bottom of the 1-2 car and 1-1 car carrier to accomplish the rest of the task, to supplement the destination's delivery requirements;

step 3:
To solve the car carrier's total amount, the summarize of the shortest distance between destination and logistics center. At each step in the process of operation, need to updated the demand of delivery constantly.

Set adopt load method that according to the car carrier's type number is 1,...,12, As shown in table, the number 5 and 10 of the 1-2 type can breaking down the bottom of the 1-2 type, the top of the 1-2 type. The number i(i=1,2,...,12) car carrier type can identified with 3 dimension array \( o_i(l_i,w_i,p_i) \) therefore, \( l_i \), \( w_i \) represent the length and the width, \( p_i \) represent the holding quantity.(As shown in table 1)

<table>
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<th>Type</th>
<th>Length</th>
<th>Width</th>
<th>Height</th>
<th>Holding quantity</th>
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</tbody>
</table>
4.1.1. Modeling

In order to simplify, in this paper, reference the vehicle classification, agreed the passenger car that height more than 1.7 meter can only set in the bottom of the 1-2 and the 1-1 car carrier; the passenger car that width under the 1.7 meters can only put into the top of the 1-2 or 2-2 car carrier.

In this way, corresponding to every single model number, there have a 3 dimension $R_i = (L_i, W_i, D_i)$, $L_i$, $W_i$ represent the length, width, $D_i$ represent the car’s total demand for shipping, the 45 row vector consist the matrix $R_{45x3}$, set a chromosome coding that for output by a genetic algorithm $x$, so the packing problem is to solve the following optimization problem.

$$SC = \min \left( \sum_{i=1}^{12} \sum_{j(I \neq j)} \left[ \frac{L_i D_i}{l_j} \right] \right)$$  \hspace{1cm} (4.1-1)

$$\text{s.t.} \sum_{s(I \neq j)} \left[ \frac{L_i D_i}{l_j} \right] \leq p_j, \quad j = 1, 2, \cdots, 12$$  \hspace{1cm} (4.1-2)

$$\sum_{s(I \neq j)} \left[ \frac{L_i D_i}{l_j} \right] = \sum_{s(I \neq j)} \left[ \frac{L_i D_i}{l_{j+1}} \right], \quad k = 5, 11$$  \hspace{1cm} (4.1-3)

$$\sum_{s(I \neq j)} \left[ \frac{L_i D_i}{l_j} \right] \leq 0.2 \times \sum_{s(I \neq j)} \left[ \frac{L_i D_i}{l_j} \right] I = \{5, 6, 11, 12\} J = \{1, \cdots, 12\} - \{5, 6, 10, 11, 12\}$$  \hspace{1cm} (4.1-4)

In the process of passenger car loading, loaded into the quantum genetic algorithm, Quantum genetic algorithm is a genetic algorithm based on the principles of quantum computing, introducing quantum state vector expression into the genetic code, by using quantum logic gates to achieve the evolution of the chromosome, can achieve better results than traditional genetic algorithm.

4.1.2. Quantum Gate Update

Quantum gate as evolution operation of actuators, can according to the specific problems to undertake choosing, according to the calculation of quantum genetic algorithm, choose quantum revolving door relatively appropriate[7]. The adjustment of quantum revolving door can operate:

$$U(\theta) = \begin{bmatrix} \cos(\theta_i) & -\sin(\theta_i) \\ \sin(\theta_i) & \cos(\theta_i) \end{bmatrix}$$  \hspace{1cm} (4.1-5)

The update process is as follows:

$$\begin{bmatrix} \alpha_i' \\ \beta_i' \end{bmatrix} = U(\theta) \begin{bmatrix} \alpha_i \\ \beta_i \end{bmatrix} = \begin{bmatrix} \cos(\theta_i) & -\sin(\theta_i) \\ \sin(\theta_i) & \cos(\theta_i) \end{bmatrix} \begin{bmatrix} \alpha_i \\ \beta_i \end{bmatrix}$$  \hspace{1cm} (4.1-6)
At the same time, represent the chromosome's $i$th quantum bit probability amplitude that after updating, $\theta_i$ represent the rotation angle, its size and symbol determine by advance design adjustment[3].

By (4.1-7) can be obtained $\alpha'_i$ and $\beta'_i$:

$$\alpha'_i = \alpha_i \cos (\theta_i) - \beta_i \sin (\theta_i)$$

$$\beta'_i = \alpha_i \sin (\theta_i) + \beta_i \cos (\theta_i)$$

so

$$|\alpha'_i|^2 + |\beta'_i|^2 = [\alpha_i \cos (\theta_i) - \beta_i \sin (\theta_i)]^2 + [\alpha_i \sin (\theta_i) + \beta_i \cos (\theta_i)]^2 = |\alpha_i|^2 + |\beta_i|^2 = 1$$

It can be seen after the transformation, the value $|\alpha'_i|^2 + |\beta'_i|^2$ is still 1.

4.1.3. To Determine The Initial Vehicle's Loading Algorithm Progress

Using multiple quantum bit encoding gene that have $m$ parameters are as follows:

$$q'_j = \left( \begin{array}{c}
\alpha'_{11} \\
\alpha'_{12} \\
\cdot \\
\cdot \\
\cdot \\
\alpha'_{1k} \\
\cdot \\
\cdot \\
\cdot \\
\cdot \\
\alpha'_{m2} \\
\alpha'_{m2} \\
\beta'_{11} \\
\beta'_{12} \\
\cdot \\
\cdot \\
\cdot \\
\cdot \\
\cdot \\
\beta'_{1k} \\
\cdot \\
\cdot \\
\cdot \\
\cdot \\
\beta'_{m2} \\
\beta'_{m2}
\end{array} \right)$$

(4.1-9)

There into, $q'_j$ represent the $t$ for the $j$ individual chromosomes, $k$ represent for every gene's coding number of qubit; $m$ represent the number of genes in the chromosome[2].
Initialize the population $Q(t_0)$, all the genes $(\alpha', \beta')$ that on the chromosomes in a population all have been initialized $\left(\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right)$, it means that a chromosome what is expressed by the superposition of all possible states of equal probability[6]

$$\left|\psi_{i'}\right> = \sum_{k=1}^{2^m} \frac{1}{\sqrt{2^m}} |S_k\rangle$$

(4.1-10)
Among them, \( S_k \) is the \( k \) kind of state of chromosomes, what expressed a form of a binary string \((x_1, x_2, ..., x_m)\) length of \( m \), and the value of \( x_i \) is 0 or 1.

Make a measurement to the initial population of individuals, in order to obtain a set of definite solution \( P(t) = \{p'_1, p'_2, ..., p'_n\} \), among them, \( p'_j \) represent the \( j \) solution of the \( t \) populations (the individual \( j \) measurements), what express the form of a binary string in length \( m \), and based on quantum bit probability \( |\alpha|^2 \text{ or } |\beta|^2 \), \( i = 1, 2, ..., m \) to choose from and get it. In the process of measurement, generate a random number that between \([0,1]\), If it is greater than the square of the probability amplitude, then the measurement result value 1, otherwise to value 0. Then, make fitness assessment for this group solution, and record the best fitness individuals as the evolution of the next target values. Where after, the algorithm entered the stage of loop iteration, along with the iteration, the solution of the population convergence to the optimal solution gradually[7]. In each iteration, at first to measure the population, in order to obtain a set of solutions \( P(t) \), and then calculate each value of fitness, then according to the evolution of the current goal and pre-determined adjustment strategy, then using quantum revolving door to adjust the individual in the population then get the updated population, record the current optimal solution, and comparing with the current target, if it greater than the current target, then with the new optimal solution as the next-generation iteration target, otherwise keep the current target, \( x_i \) represent the first \( i \) bit for current chromosome, best represent current optimal chromosome; \( f(x) \) represent the fitness function, \( s(\alpha_i, \beta_i) \) as the direction of rotation Angle, \( \Delta \theta_i \) as the size of the rotation Angle, the individual \( q'_i \) the fitness of current measurement \( f(x) \) compared with the population of the current optimal individual fitness value \( f(\text{best}) \), if \( f(x) > f(\text{best}) \), then adjust the quantum bit in the \( q'_i \) accordingly, make the probability amplitude step into the direction of evolution, otherwise, if \( f(x) \leq f(\text{best}) \), then adjust the according quantum bit, make the probability amplitude step into the direction of best evolution[9].

Using integer coding, the length of the chromosome is equal to the passenger car's largest number, the value of the genes integer between [1, 12] said it would adopt corresponding number way of loading, such as \( (3, 5, 6, ..., 3) \) for an individual chromosome encoding, represent the NO.1 passenger cars in the NO.3 car carrier, the NO.2 passenger cars put in the bottom of the 1-2 type carrier of the NO.5. The NO.3 passenger car on the top of the NO.6 car carrier of the 1-2 type, and so on.

The decoding process is the chromosome coding transfer into feasible scheduling, then get the process of the objective function value.

To pack a chromosome transfer into passenger car after the distribution of the transport vehicle. Then get 12 kind of car carrier's assembly scheme of the passenger car, then calculated the objective function value of the chromosomes. Due to the scheduling problem is desired to minimize, and get the fitness value \( \text{fitness} = C_{\text{max}} - SC \), \( SC \) is the target function value, \( C_{\text{max}} \) is large enough positive integer. In each generation in the genetic process, select \( C_{\text{max}} \) as the biggest objective function values in the population.
4.2. Determine The Load Scheme

After get a initial optimal individual solution, for each j, if , then know the load type of the j car carrier, and choose 1-1 model from the same clustering to make full use of space.

\[ X = [7, 9, 2, 7, 7, 2, 1, 6, 1, 8, 10, 2, 8, 7, 7, 10, 8, 1, 8, 7, 10, 8, 10, 1, 7, 1, 7, 7, 2, 10, 1, 2, 7, 7, 10, 7, 7, 2, 7, 10, 2] \]

The loading plan table are shown in table 2.

<table>
<thead>
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<th>The number of the car carrier</th>
<th>The number of the passenger car</th>
<th>length</th>
<th>The delivery demand of the destination</th>
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<td>11</td>
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<td>12 3 5 0 0</td>
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<td>13</td>
<td>4500</td>
<td>15 9 5 7 6</td>
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<td></td>
<td>22</td>
<td>4531</td>
<td>4 2 0 4 3</td>
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<tr>
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<td>28</td>
<td>4865</td>
<td>12 8 4 2 6</td>
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</table>
Next, aiming at the each car carrier of the table 2, because of the load scheme has been sure, we can according to the delivery demand of the destination, to make sure the load plan of the each car carrier. The loading plan are shown in table 3.

<p>| | | | | | | |</p>
<table>
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<td>The length of the car</td>
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<td>B</td>
<td>C</td>
<td>D</td>
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### 5. CONCLUSIONS

Aiming for the problem model, we separate three steps to analyze in this paper, first we adopt the quantum genetic algorithm to get the assembly plan of each passenger car. We use the car carrier number at least for the cost function in this way. To analysis the specific steps of quantum genetic algorithm, and we realize the length of 48 chromosome encoding by matlab programming. Then, aiming at the assembly scheme of each kind of car carrier, considering the different demand for five destinations, and use the short range as the optimization goal, then studied the vehicle dispatching scheme, at last, aiming at a large number of simulation experiments in this paper, to achieve the programming by using LINGO and matlab software. The innovation point of this paper is: give the initial assembly scheme by using quantum genetic algorithm, on this basis, then reanalysis the delivery problem for each kind of car carrier.
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REFERENCES


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