Research on Postal Dispatching System at Multiple Transfer Points of Postal Containers Based on Genetic Algorithm

Min Liu, Jie Meng, Guangping Li
College of Mechanical and Power Engineering
Chongqing University of Science and Technology
Chongqing, China
*Corresponding author’s e-mail: 1liuyijunpp2007@163.com

Abstract. In this paper, a new comprehensive algorithm is proposed to solve the problem of postal dispatching at multiple transfer points of postal containers, and based on this, a postal dispatching system of postal transfers at multiple transfer points is established. In this system, Floyd algorithm combined with fuzzy judgment to find each key route, and to combine linear programming to set a small step size for the far three points on each key route, so as to realize the area planning and design of key points. Finally, the genetic algorithm is used to solve the postal planning of the remaining points in the area. To optimize the system, the compensation principle is used to carry out post and mail planning at nearly three points in the area and complete the post and mail planning for the entire area.

1. Introduction
Postal containers are conducive to improving the quality and efficiency of postal communications production, and enhancing the market competitiveness of postal communications. The use of postal containers and letter boxes to replace flexible containers such as pouches to encapsulate mail is the development tendency of postal communications. Practice in recent years has proved that there are many problems required to be solved in the promotion and application of postal containers, especially the problem of postal dispatching at multiple transfer points of postal container. Due to the complex and changeable interrelationships, it is particularly difficult to solve this problem[1]. Only by solving this problem, using postal containers on the vehicle mail road from central office to the city of each branch office and the secondary trunk line can be realized.

The postal dispatching system at multiple transfer points of postal containers is to provide the entire network of mail and post production scheduling information for each batch of intra-city transfers and secondary trunk lines. The information include the reference time for handover of the import and export containers (mail) at the branch office, the type of vehicle implementation, the delivery method, the arrangement of specific vehicle driving routes and specific tasks for the vehicles that can be controlled within this period. Under the premise of collecting the number of import and export containers of the central office and each junction within a certain time limit, combining all kinds of conditions and constraint conditions, according to the principle of minimum labor consumption, the best postal organization scheme of the day is calculated to determine the running schedule of the vehicle and the equipment of the vehicle. The number of containers in each batch of the
central office and each junction is changing, so the choice of mail route and the dispatch of mail vehicles should be changed according to the specific situation, which is the key problem to be solved in the dispatching system[2].

2. The system description

The vehicle mail dispatching system is a system that is based on hundreds of contact points (branch offices), a variety of paths to each junction point and a number of import / export containers (mail) randomly generated by each batch, etc., which can not be planned and scheduled manually. Therefore, it is necessary to establish a postal dispatching system at multiple transfer points of postal containers, which requires a feasible mail scheduling for a city multi-point handover problem with more comprehensive historical data.

For the sake of analysis, note a central office as \( V_0 \) points, each branch is recorded as \( V_1, V_2, V_3, \ldots, V_n \) (n is the number of branch offices). Assume that the time distance between each post office is \( l_{ij} \) (The time that takes for a vehicle to travel between two branch offices under normal traffic conditions, where i and j respectively represents the serial number of the corresponding branch office), the probability of traffic congestion on this road section is \( \alpha_{ij} \). In addition, the number of sent and received mail of any branch \( V_i \) is: \( F_i \) and \( J_i \), respectively.

The problems to be solved by the system: firstly, according to the historical accumulation and the necessary supplementary investigation data, the basic operation route of the postal vehicle is put forward. Secondly, on the basis of the completion of the first step, the basic route is supplemented and the complete operation route of the mail vehicle is made. Thirdly, a mathematical model is developed to simulate the running process of each line (with one as the object). Fourthly, on the basis of solving the above three problems, propose a normal vehicle operation schedule for each line.

Specific tasks include two parts: designing driving routes and designing all-day mail dispatching vehicle schemes which are easy to operate and determine for working days. For the design of driving routes, taking into account the operating efficiency of the mail cars, there are always a number of routes that are more frequent in the shipping process of each batch, which are noted as the key routes. The determination of dispatching routes can be topological on the key routes. For the second task, it is required to determine departure schedule of the route, in which the total running time is the shortest. Therefore, the dispatching problem is abstracted into a clear mathematical model, and the specific method of solving the model is given.

3. System solving method

In order to solve the above problems, the solution process shown in Figure 1 can be used.

3.1. Use the improved FLOYD algorithm combined with fuzzy judgment to seek each key route

Set the central office as the starting point of the key route.

Determination of the end points of the key routes: the traffic map is traversed, and all points in the figure are divided. The central office is classified into the first stage. The points which are directly connected with the central office are classified into the second stage; the other points which are directly connected with the points of the second stage are in the third stage, and so on... all the point division phases are classified like this way. The point in the last stage, and all the points that are not directly connected to the point in the next stage from this stage are the end points for each key route.

Determination of the rest points for the key route: (take the \( V_i \) end route as an example.) With fuzzy judgment, the traffic condition of the route is converted into a time path, and the actual time path is the product of the general time path and the fuzzy function of the traffic condition. If there is an arc from \( V_i \) to \( V_j \), then there is a path of length arcs \( [a] [i] \). A huge number of trials are required since this
Whether the path \((V_d, V_i, V_f)\) exists needed to be considered first. If it exists, the path length of \((V_d, V_i)\) and \((V_d, V_i, V_f)\) need to be compared. The shorter path is the key path where middle vertex sequence number from \(V_d\) to \(V_f\) is not greater than 1. Assume that one more vertex \(V_2\) is added to the path, that is, if \((V_d, ..., V_i)\) and \((V_i, ..., V_f)\) are the key routes where the middle vertex sequence number from \(V_d\) to \(V_f\) is not greater than 1, then \((V_d, ..., V_2, ..., V_f)\) may be the shortest path where the middle vertex sequence number from \(V_d\) to \(V_f\) is not greater than 2. Compared with the shortest path that has been obtained where middle vertex sequence number from \(V_d\) to \(V_f\) not greater than 1, the shorter path of them can be selected. And then add into one more vertex \(V_3\), continue testing, and so on.

In general, if \((V_d, ..., V_k)\) and \((V_k, ..., V_f)\) are the key routes where the middle vertex sequence number from \(V_d\) to \(V_k\) and from \(V_k\) to \(V_f\), respectively, not greater than \(k\), then \((V_d, ..., V_k, ..., V_f)\) and the already obtained shortest path where the middle vertex number from \(V_d\) to \(V_f\) not greater than \(k\) have been compared, the shorter one is the key route where the middle vertex sequence number from \(V_d\) to \(V_f\) is not greater than \(k\).

In this way, after \(n\) comparisons, the final result must be the key route from \(V_d\) to \(V_f\). Based on this method, the key paths of each pair of determined end points can be obtained at the same time (fig.1).

A sequence of \(n\)-order square matrices is defined:
\[ D(-1), D(0), D(1), ..., D(k), ..., D(n-1) \]
where
\[
\begin{align*}
D(-1)[i][j] & = \text{arcs}[i][j] \\
D(k)[i][j] & = \text{Min}\{D(k-1)[i][j]\} \\
D(k-1)[i][k]+D(k-1)[k][j] & \quad 0 \leq k \leq n-1
\end{align*}
\]
It can be seen from the above calculation formula that \(D(k)\) (i) (j) is the length of the key path where the middle sequence number from \(V_i\) to \(V_j\) is not greater than \(k\). The Floyd algorithm is modified, and a path matrix \(P\) is added based on the original weight \(C\) and the minimum weight matrix \(A\), initialized to 0. That is, suppose the shortest distance between any two points is a direct arc of two points, without passing through other points. When \(A[i][j]\) is obtained by the FLOYD algorithm, let \(P[i][j]\) be the point passing in the middle. In this way, the Floyd algorithm finally produces two matrices: the minimum weight matrix \(A\) and the path matrix \(P\). For the path matrix \(P\), the critical path of any two points can be obtained recursively.

3.2 Linear programming is used to set the step size of the far three points on each key route in a small range
By using the capacity principle of the car, a linear programming model is established based on the maximum useful box kilometers and the minimum useless box kilometers as follows:

1) In order to meet the capacity of the vehicle, consider the number of mail sent and received by the mail car at each transfer point and the quantity of the mail carried by the post-mail vehicle, the sum of them is not greater than the capacity of the vehicle.

2) The principle of early departure and late return is met, and the corresponding constraint relationship is established.

The so-called early departure and late return principle means that during a postal shipment, the export
container (mail) is required to be delivered to each branch office as soon as possible, and the imported container (mail) is required to recover the central office as late as possible within a certain period of time.

3) Establish the useless box kilometers discrimination function as the target for discrimination

An export or import container (mail) of a transfer point (branch office), the container (mail) of
which is loaded into a mail car. If the same batch of mail is being sent, the post car must also pass through the transfer point (branch office), then during the course of the mail car passing through the transfer point twice, one kilometer of container (mail) received from the transfer point (branch office) is called a unit of useless container kilometers.

Solved this simple linear planning problem by computer, the postal planning of far three points on each key route can be got.

### 3.3 Using genetic algorithm to solve the postal planning of other points in the area

The specific steps of the genetic algorithm are as follows:

1) **Parameter encoding**
   The data of the traffic map are represented as the genetic structure data of the genetic space. It is planned to traverse the branches and use the sequence as the coding of the genetic algorithm.

2) **Generation of initial population**
   Prepare an initial population for genetic algorithms (with historical data as the initial population) consisting of several initial solutions, that is, the first generation of evolution[3].

3) **Fitness evaluation and detection:** this test is used to measure the pros and cons of the offspring during the search process, that is, the objective function[4].

\[
    f = \left\{ \begin{array}{l}
    a \left[ \max\{L(\phi_{TSP}^k)} - \min\{L(\phi_{TSP}^k)\} \right] + 1 \\
    (1 - a) \sum_{k=1}^{m} L(\phi_{TSP}^k) 
    \end{array} \right. 
\]  

Where, \( \phi_{TSP}^k \) represents the initial, and \( k \) represents the \( k \)th. \( L(\phi_{TSP}^k) \) represents the total time course, \( a \) as the adjustment factor.

4) **Design of genetic operations:** selection, crossover, mutation.

5) **Setting control parameters:** The setting of control parameters can control the running time of the program and the accuracy of the results[5].

### 3.4 Use the compensation principle to plan the shipping of nearly three points in the area

In the postal planning process, in order to avoid a small number of transfer points (branch offices) that are not conducive to optimization of the transfer conflict, arrange the shipping of their containers (mails) to the remaining capacity on other paths passing this transfer point (branch offices).

### 4. Conclusion

Aiming at the difficulty of the multi-junction postal container transportation dispatching problem, it is proposed to use Floyd algorithm combined with fuzzy judgment to find each key route, and to combine linear programming to set a small step size for the far three points on each key route, so as to realize the area planning and design of key points. In addition, the genetic algorithms is used to solve the postal planning of the remaining points in the area. On this basis, a postal dispatching system of postal transfers at multiple transfer points is established. The test result show that this method is highly practical and can significantly improve the efficiency of postal transportation.

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