Research on Emergency Distribution Route Planning Based on the Ant Colony Algorithm

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Abstract: Emergency Distribution Refers to Provision of Necessary Emergency Supply Ant Colony Algorithm; Emergency Distribution; Path Planninges for Emergent Events. This Paper Analyzes the Objective Function and Boundary Condition for the Emergency Distribution Route Based on the Ant Colony Algorithm, and Also Solves the Optimal Route Based on the Pheromone Content of Each Route. the Emergency Distribution Route Based on the Ant Colony Algorithm Can Achieve Materials Delivery by the Optimal Vehicle and At the Shortest Time in the Event of Shortage of Vehicle, and Solves the Model Properties According to the Characteristics of the Model.

1. Introduction

With Frequent Geological Disasters in China, the Economic Losses Caused by the Geological Disasters Are Serious. Therefore, Timely Delivery of Emergency Resources is a Major Route to Save Life and Property Losses. the Emergency Logistics Research for Most Scholars is Mainly Focused on Logistics Efficiency and Logistics Costs and So on. from the Point of View of Realizing Efficient Emergency Distribution, the Research of Distribution Route Planning Can Respond the Emergencies More Quickly. This Paper Researches the Optimization Problem of Emergency Distribution Route Based on the Variable Neighborhood Ant Colony Algorithm, and Analyzes It by the Establishment of the Mathematical Model.

In the Research of Emergency Route Planning, It Involves in Materials Distribution under the Material Shortage Condition and Materials Distribution under the Material Abundance Condition. in the Selection of Routes, the More Pheromones Transmitted by Each Route, the Higher the Possibility to Select Such Route. in the Scheduling Ar-Rangement, Due to the Uncertainty of the Smooth Route in the Disaster-Stricken Areas, in Order to Dynamically Adjust the Development of the Route, the Variable Neighbor-Hood Search Algorithm is Used for Arrangement. the Principle of the Variable Neighborhood Algorithm is Based on the Following Condition: the Optimal Solution Obtained under a Certain Neighborhood is Not the Optimal Solution under Another Neighborhood, But the Optimal Solution Obtained under All Neighborhoods is the Global Optimal Solution.

2. Ant Colony Algorithm

In the natural world, ant is one of the most common reptiles, and its crawling route has certain characteristics. Ant is a compound animal. In the motor process, each ant has a certain link, and the ant can find a feeding rout through the biologi-cal information released by another ant, which is the shortest one in all routes. Thus, due to biological inspiration, such rule is evolved into mathematics. After finding food, the ant will arrive at the destination along different routes, but after a certain period of time, the crawling route of the ant will be as shown in Figure (b). That is, almost all ants will crawl along the shortest path to the destination. In our real life, such rule is usually applied to solve a lot of optimal solutions.

3. Symbol Description

m - Collection of transport vehicles;

d_{ij} - Distance between the transport location i and j;

q_i - Number of population at i;

t_i - Waiting time at i;

Q - Total number of vehicles.

4. Mathematical Model

Let $m = \sum_{i=1}^{n} b_t(t)$. $\tau_{ij}(t)$ is the trajectory strength of the edge arc (i, j) at the moment of t (namely, amount of information remaining on the line of (i, j), and assuming that $\tau_{ij}(0) = c$ (c is a constant), $i, j = 1, 2, \cdots, n, i \neq j$; $\eta_{ij}(t)$ is the transportable degree of the edge arc (i, j) at the moment of t, representing the desired degree from the transport location i to the transport location j. Based on the above principle, the ant $k(k = 1, 2, \cdots, m)$ transfers direction in the motor process according to the amount of information on each route. Unlike the ant colonies crawling in the natural world, the artificial ant colony system built now can record crawling data. After a period of time, that is, after n moment, the mark on the crawling route, namely, the information left by ants will recede. After completion of each cycle, the marks will be readjusted.

Assuming that the artificial ant colonies search the solution to the emergency distribution path in parallel, and communicate with each other, in each node, and at the edge connected with this node, the specific media can be as a basis for finding the next node until finding the optimal solution transmitted by the data network.

At the moment of t, the probability of artificial ant k moving from the transport location i to the transport location j is:

$$p_{ij}^{k}(t) = \begin{cases} \dfrac{\tau_{iv}^{a}(t)\eta_{iv}^{\beta}(t)}{\sum\limits_{v \in s}\tau_{iv}^{a}(t)\eta_{iv}^{\beta}(t)}, & j \in s \\ 0 & , j \notin s \end{cases}, \tag{1}$$

where α is the relative importance of trajectories ($\alpha \geq 0$); β is the relative importance of transportable degree ($\beta \geq 0$); s is a feasible point set, namely, the transport location that the artificial ant k can select next. When m artificial ant(s) (emergency distribution vehicle) finds the optimal feasible solution to the transport route according to the formula, the amount of data on each side can be modified by the following formula, that is, the equation is:

$$\tau_{ij}(t+1) = \rho\tau_{ij}(t) + \Delta\tau_{ij}, \rho \in (0,1)$$
$$\Delta\tau_{ij} = \sum_{k=1}^{m}\Delta\tau_{ij}^{k} \tag{2}$$

Thus, for the solution to the modeling of the ant colony system for emergency distribution route planning, the method of artificial ant colony can be used to solve as follows:

(1) $NC \leftarrow 0$ (NC is the number of iterations or number of search times); initialization of τ_{ij} and $\Delta\tau_{ij}$; to place m ant(s) on n vertex.

(2) The starting point of all ants must be at the same level; the ant $k(k = 1, 2, \cdots, m)$ crawls to the next location j, and the transition probability is p_{ij}^{k}.

(3) To calculate z_k ($k = 0, 1, 2, \cdots, m$), write down the current optimal solution;

(4) To modify the trajectory strength according to the equation in (3);

(5) $NC \leftarrow NC + 1$, if the same solution is found, return to Step 2.

When the route transmitted by the network data is relatively complex, its calculation process is

also very troublesome, so the improved formula is:

$$\tau_{ij}(t+1) = \rho\tau_{ij}(t) + (1-\rho)\Delta\tau_{ij} \quad \rho \in (01)$$

$$\Delta\tau_{ij}^{k} = \begin{cases} \dfrac{1}{d_{ij}}, & ij \in BE \\ 0, & \text{others} \end{cases} \tag{3}$$

The above is a process to build a wireless sensor network data transmission sys-tem based on the ant colony optimization algorithm. Based on this process, the shortest data aggregation route can be calculated in the process of development of the data aggregation protocol, in order to clarify the actual problem.

Objective function in the variable neighborhood is:

$$minf = \sum_{k}\sum_{i}\frac{q_i}{d_{0,i}}t_i$$

$$s.t.\begin{cases} t_i + d_{i,j}x_{ij}^{k} - t_j \le (1-x_{i,j}^{k})M \\ level_i + x_{i,j}^{k} - n(1-x_{i,j}^{k}) + (n-1)x_{i,j}^{k} \le level_j \\ \sum_{k}\sum_{i}x_{i,j}^{k} = 1 \\ \sum_{i}\sum_{j}d_{i,j}x_{ij}^{k} \le Q \end{cases} \tag{4}$$

where, $x_{i,i}^{k} = 0$, $x_{0,n+1}^{k} = 0$, $\sum_{i}x_{i,0}^{k} = 0$, $\sum x_{0,n+1}^{k} = 0$, $t_i \ge 0$.

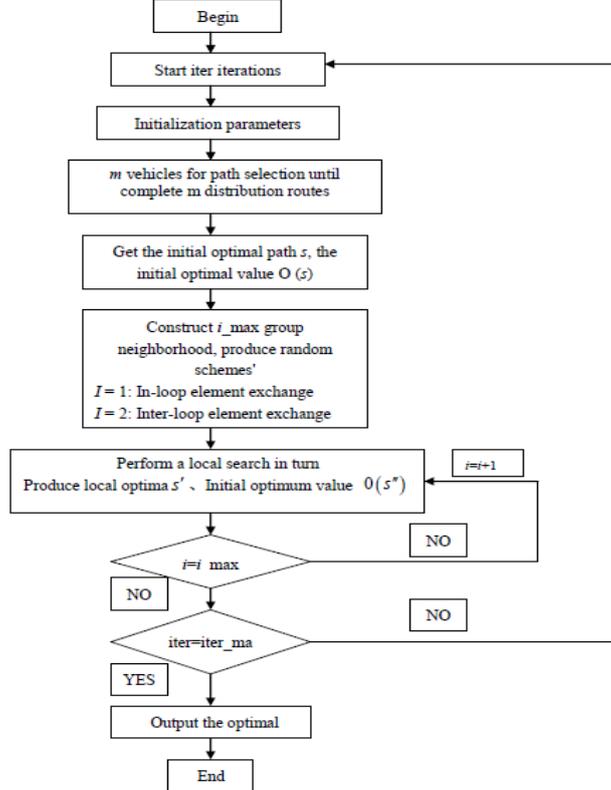The flow chart of the variable neighborhood ant colony algorithm is shown in Figure 1.

Fig.1 Flow Chart of Ant Colony Algorithm

5. Odel Properties

The objective function is a sum of the fairness waiting time of all disaster-stricken areas. The

constraint conditions are as follows: vehicles are not allowed to stay in the disaster-stricken areas; only one vehicle distributes in each disaster-stricken area. The traditional vehicle distribution is in order. In case of shortage of vehicles in the ant colony algorithm, one vehicle distributes in a route. The number of vehicles that have achieved the optimal solution is $min(K,n)$, as shown in Figure 2.
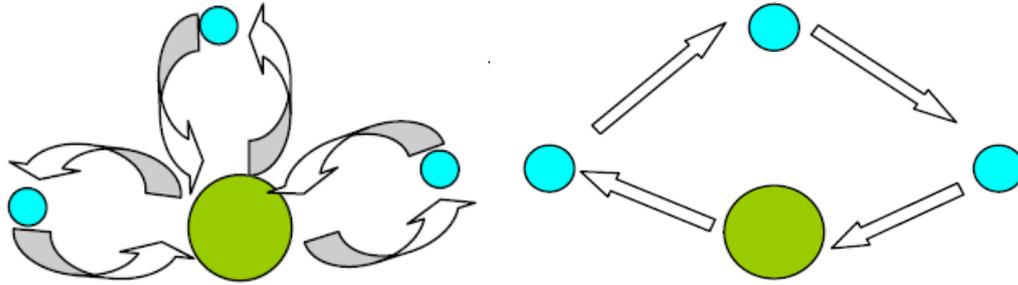
(a) Common emergency distribution path   (b) Emergency distribution route in the ant colony algorithm

Fig.2 Comparison with the Common Distribution and Distribution Mode in the Ant Colony Algorithm

From the point of view of distribution time, in the two-way distribution time under the ant colony algorithm, there are differences in the target values of reverse distribution time, of which n_k represents that k vehicles distribute in n disaster-stricken areas, and the waiting time t_i is:

$$t_i = t_{i-1} + d_{i-1,i} , \tag{5}$$

where $t_0 = 0$ is the distribution time of the distribution center, then the time T_k for the k vehicle to run the entire path is:

$$T_k = \sum_{i=1}^{n_k} \frac{q_i}{d_{0,i}} t_i . \tag{6}$$

The lower bound of the objective function is:

$$LB = \sum_{e=1}^{K} \left(\frac{n - e - (n - \text{mod}|K| + |K|)}{|K|} \right) \frac{q_e}{d_{0,e}} d_e' + \sum_{e=1}^{K} \left(\frac{n - e - (n - \text{mod}|K| + |K|)}{|K|} \right) \frac{q_e}{d_{0,e}} d_e'' . \tag{7}$$

Compared with COLEX optimization software and ant colony algorithm, the comparison with calculation results with these two methods are shown in Table 1.

Table 1 Comparison with Calculation Results of Colex and Ant Colony Algorithm.

M	K	COLEX		Ant colony algorithm	
		Solution	Time	Solution	Time
5	2	2.75e+04	1.34	2.75e+04	1.76
6	2	3.41e+04	2.76	3.41e+04	2.65
7	2	3.54e+04	9.95	3.54e+04	10.21
5	3	2.12e+04	1.63	2.12e+04	1.98
6	3	1.94e+04	4.96	1.94e+04	5.56
7	3	2.43e+04	36.46	2.43e+04	5.23
8	3	3.685e+04	368.52	3.685e+04	8.45
9	3	4.645e+04	2345.67	4.645e+04	6.93

6. Conclusion

General logistics considers the cost of logistics. When the disaster occurs, the failure and comprehensiveness of logistics are more concerned. According to the characteristics of emergency distribution, this paper considers the fairness of dis-tribution, and puts forward the logistics emergency distribution path under the ant colony algorithm under the material abundance condition.

The ant colony algorithm has the advantages to solve the problem of optimal selection for complex problems, especially in the arrangement of complex network structure.

Acknowledgement

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