Improved ant colony optimization for emergency rescue VRP based on matlab

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Abstract-**Ant colony algorithm offers us a effective method to look for shortest routing. This article aims at two goals, namely shortest rescue routing and shortest rescue time, and it sets up a multiple-objective vehicle routing problem(VRP) model. In order to increase speed of convergence, the article presents a new style of pheromone update---rank-based ant colony algorithm based on elite ant and improves visibility. The results of simulation experiments show that the improved algorithm surpasses existing algorithm in the performance and has better convergence.**

Keyword—semergency rescue; ant colony algorithm; VRP; matlab

I. INTRODUCTION

With the increasing of natural disaster, more and more scholars have paid attention to such kind of field as emergency management. In such a field, how emergency rescue vehicles search optimal routing and how to deliver relief supplies to spots of accident are cores of emergency work. Emergency rescue VRP mainly discusses how to calculate optimal routing in shortest time with the aid of intellectualized computer-aided decision making system. Emergency rescue VRP discussed in the paper is of shortest routing problem in Graph Theory.

The Ant Colony Optimization (ACO) method is a population-based heuristic method that has been successfully applied to solve several NP-hard combinatorial optimization problems.[1] This algorithm have been applied to many combinatorial optimization problems. Many scholars have studied on VRP from different respective. Cui xuli, Ma Liang, Fan Bingquan[2] studied on vehicle routing problems. Liu Yongqiang, Chang Qing, Xiong Huagang[3] proposed a new pheromone update method suitable for time-varying network and an improved ant colony algorithm for time-varying network. Lin WeiDong[4] combined 2-opt, λ exchange with ACO to put forward new hybrid algorithm. Li Bing[5] presented a novel vehicle routing scheduling method based on dynamic variation of customers' needs. Wu Yunzhi etc[6] used shortest routing method and user-defined price method to get optimal logistic distribution, avoiding local solution by the application of parameters optimization improving ant colony algorithm. John E. Bell, Patrick R. McMullen[7] used candidate list and local exchange to deal with multiple-ant colony problem.

At present, many researches mainly focused on single-objective function optimization, and seldom paid attention to multiple-objective function optimization with the ant colony algorithm. This paper aims at solve such practical problem as emergency rescue VRP and build an improved ant colony optimization algorithm to solve multiple-objective function optimization problem.

II. EMERGENCY RESCUE VRP DESCRIPTION

A. Problem description

In this article, emergency rescue VRP is such as follows: this VRP is a problem of finding a shortest routing and shortest time as our objective. There is only one rescue distribution depot which is the start point and also the end point. This depot has m vehicles served for n accident points, each vehicle with capacity constraint D. The vehicle returns to the depot when the capacity constraint of the vehicle is met or when all customers are visited. The ACO algorithm constructs a complete tour for the first vehicle before the second vehicle starts its tour. This continues until a predetermined number of vehicles m each construct a feasible route. It denotes a iteration when all accident points n are served.

B. Rules to be satisfied

Emergency rescue VRP has three rules to be obey:

- every vehicle must start with distribution depot, then return to distribution depot.
- each accident point is visited only once by one vehicle.
- Total demand serviced by each vehicle cannot exceed D.

C. Basic parameters

In this paper, basic parameters are input as follows:

- Each point's coordinate is $(x_i, y_i), i = 0,1,2,\cdots n$ (this point is distribution depot when $i = 0$).
- Demand of each accident point is d_i, capacity of each vehicle is D.
- Distance between two points is l_{ij}.
- Average rate of vehicle is v_a, maximum rate of vehicle is $v_{\max}$.
- Unblocked reliability of each rout is q_{ij}, maximum volume of each rout is p_{ij}.

III. IMPROVED ANT COLONY ALGORITHM DESIGN

A. Mathematical model

Based on city transportation network, we build a emergency rescue optimal model. Mathematically, this system is described as a weighted graph $G(V,E)$ where the vertices are represented by $V=\{1,2,\cdots,n\}$ and the arcs are represented by E. The distances associated with each arc are represented by the variable $l_{ij}(l_{ij}>0, l_{ii}\to\infty, i,j\in V)$.

Other variables are as follows:

$$x_{ijk}=\begin{cases}1 & vehicle\ k\ from\ i\ to\ j\\ 0 & others\end{cases}$$

$$y_{ik}=\begin{cases}1 & vehicle\ k\ serves\ i\\ 0 & others\end{cases}$$

$$v_{ij}=\begin{cases}p_{ij}q_{ij}v_a & p_{ij}q_{ij}v_a\le v_{\max}\\ v_{\max} & p_{ij}q_{ij}v_a> v_{\max}\end{cases}\qquad t_{ij}=\frac{l_{ij}}{v_{ij}}$$

The problem is solved under such constraints:

$$\min z=\left\{\sum_{k\in V}\sum_{i\in V}\sum_{j\in V} l_{ij}\cdot x_{ijk},\sum_i\sum_j\sum_k t_{ij}\cdot x_{ijk}\right\}\tag{1}$$

Subject to :

$$\sum_k y_{ik}=1\tag{2}$$

$$\sum_i d_i y_{ik}\le D\qquad \forall k\tag{3}$$

$$\sum_i x_{ijk}=y_{jk}\tag{4}$$

$$\sum_j x_{ijk}=y_{ik}\tag{5}$$

$$\sum_{i\times j\in s\times s}\sum x_{ijk}\le |s|-1\qquad s\in V \\ 2\le|s|\le n-1\tag{6}$$

- where objective function(1) is that the way and the time of transporting are shortest;
- where constraint (2) guarantees that each vehicle visits one time to each fixed point;
- where constraint (3) is vehicle capacity constraint;
- where constraint (4),(5),(6) denote that feasible looping can be formed.

B. Improved ant colony algorithm

1) Route construction

Initially, m ants are randomly put on chosen cities, the number of which is n. Suppose ant k in city i, the probability of visiting next point j depends on the following formula:

$$p_{ij}^k=\frac{\left[\tau_{ij}\right]^\alpha\cdot\left[\eta_{ij}\right]^\beta}{\sum_{l\in N_i^k}\left[\tau_{il}\right]^\alpha\left[\eta_{il}\right]^\beta}\qquad j\in N_i^k\tag{7}$$

Where $\tau_{ij}(t)$ is pheromone trail value, η_{ij} is visibility between routing i,j. η_{ij} can be defined as the inverse of distance and time[8]: $\eta_{ij}=\frac{1}{l_{ij}t_{ij}}$. α,β are two parameters which determine the relative importance of pheromone trail and visibility. N_i^k denotes cities ant i has not visited.

2) Pheromone trail updating

Once all ants completed a tour, pheromone trails are updated according to ant-cycle rules. Local updating: after m ants move one step, local updating is needed. $\tau_{ij}(t+1)=\rho\tau_{ij}(t)+\Delta\tau_{ij}(t,t+1)$ .Global updating: after m ants have visit n cities, global updating is needed.

$\tau_{ij}(t+n)=\rho\tau_{ij}(t)+\Delta\tau_{ij}(t,t+n)$ .Where $\rho(0<\rho<1)$ is pheromone hold capacity, $\Delta\tau_{ij}$ is the pheromone increasing volume.

In order to speed up convergence, this article improves the algorithm using elite ant rank-based pheromone update method. We need only the best r ants to update pheromone and use weight ω to update pheromone. To make global update rule reasonable, this article uses the best r^{th} ant to update its pheromone with weight $\omega-r$ .so global updating rule is as follows:

$$\tau_{ij}(t+n)=\rho_2\tau_{ij}(t)+\sum_{r=1}^{\sigma-1}(\omega-r)\Delta\tau_{ij}^r+\omega\Delta\tau_{ij}^{bs}\tag{8}$$

σ is the number of elite ants.

$$\Delta\tau_{ij}^{bs}=\frac{1}{l^{bs}},\qquad \Delta\tau_{ij}^r=\frac{1}{l^r}$$

During calculating, pheromone is controlled between $[\tau_{\min},\tau_{\max}]$.

C. Simulation Experiment

The proposed algorithm is simulated under matlab2008a,using VC++ compiler, and calls dynamic interlinking database to realize the goals of minimum routing and minimum time.

In the experiment, parameters are setup as follows m =6, $n = 26$, D =20, $\alpha = 1, \beta = 3, \rho = 0.7, NC_{\max} = 20$.

Result of this simulation experiment is as follows:

TABLE I. RESULT OF THIS EXPERIMENT

sequence	distance	time	sequence	distance	time
1	210.5	2.87	11	208.1	2.76
2	205.6	2.54	12	207.6	2.73
3	207.4	2.68	13	209.4	2.82
4	210.0	2.85	14	208.9	2.80
5	209.7	2.84	15	209.0	2.80
6	206.3	2.61	16	205.0	2.51
7	207.5	2.70	17	204.9	2.50
8	208.4	2.77	18	205.8	2.55
9	206.8	2.62	19	206.2	2.60
10	207.8	2.74	20	206.5	2.62

In the simulated experiment, the most optimal rout is 204.9, and its optimal graph is as follows:

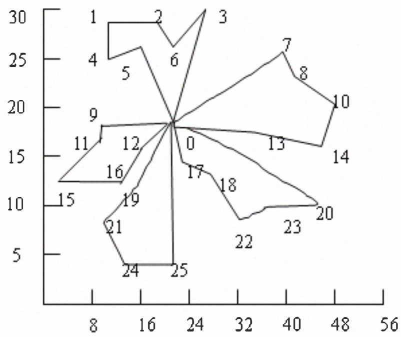

Figure 1. optimal graph

Its routing is as follow:

The first rout: 0→3→6→2→1→4→5→0

The second rout:0→7→8→10→14→13→0

The third rout:0→20→23→22→18→17→0

The fourth rout:0→25→24→21→19→0

The fifth rout:0→12→16→15→11→9→0

IV. CONCLUSION

This paper improves ant colony algorithm on the application of emergency rescue VRP and builds multiple-objective function, which aims at minimize routing and time. While calculating , we transfer multiple-objective function into single-objective function, by the use of corresponding weight. The simulation experiment achieves better result and at the same time proves the feasibility of improved ant colony algorithm on the application of emergency rescue.

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