

Algorithm of vehicle emergency evacuation in urban large-scale activities

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ABSTRACT: This article studies the problem of vehicle emergency evacuation in urban large-scale activities. Genetic algorithm and ant colony genetic algorithm are applied to the vehicle emergency evacuation separately. Finally, we choose the Shenyang Olympic Sports Center as an example, and the simulation results verify the feasibility of vehicle emergency evacuation optimization algorithm in this paper.

INTRODUCTION

In recent years, with the continuously development of economic construction and the gradually improvement of people's living standards, More and more large-scale activities are held in the cities. It's a huge challenge for those cities which are in a state of traffic tension. There will be a large number of people and traffic flows distribute in a short period of time during the large-scale activities. If some unexpected events occurred at this time, it will have an immeasurable impact on urban traffic. At this point, the traffic emergency evacuation is particularly important. It can not only help traffic managers to evacuate the traffic flow in a short time quickly and effectively, but also provide protection for people's lives and property. The reasonable plans of traffic emergency evacuation, not only improve the ability to deal with large events, but also ensure the safety and order of the traffic emergency evacuation process. It also has a positive effect on relieving traffic pressure and reducing the occurrence of secondary events. The ultimate goal of this paper is to study how to make effective and reasonable traffic emergency evacuation plans.

This paper takes the urban traffic emergency evacuation as the research object. First of all, we introduce the traffic emergency evacuation models at home and abroad. And then, we plan for the road networks, which surrounding area of the site of large-scale activities on the basis of analyzing the traffic flow, and its characteristics under the condition of emergency evacuation. Based on the investigation of the field data and references, the network model for the selection of the evacuation network is established. We choose Shenyang Olympic Sports Center as an example. It is simulated and analyzed to verify the feasibility of the algorithm.

VEHICLE EMERGENCY EVACUATION MODEL

The best purpose of the vehicle emergency evacuation is to evacuate all vehicles in the shortest time. In this process, the shortest path strategy seems to be the optimal evacuation plan. Since in the same evacuation speed case, the shorter distance, the shorter time to reach the destination. If all evacuated objects choose the shortest path to its destination, it will cause congestion in some way, so that the traffic flow will occur uneven distribution during the evacuation. Therefore, in order to avoid the drawbacks of the above vehicle emergency evacuation model based on the shortest path, emergency evacuation vehicle model based on the shortest time is presented in this paper.

The vehicle emergency evacuation model based on the shortest time of is applicable to large-scale emergency evacuation. The model is not a single evacuation object, but a combination of various factors to optimize overall by the evacuation process. It is more practical significance. The emergency evacuation model target based on the shortest time in urban large-scale activities is the

shortest time for evacuation. By optimizing the evacuation route and reducing the residence time of vehicles, the overall purpose of the shortest evacuation time is achieved. The model can establish the dynamic evacuation plan by considering the evacuation speed and the load of the road network dynamically. The model can improve the feasibility and effectiveness of the evacuation plan.

The emergency evacuation model based on the shortest time takes into account not only the evacuation routes but also the evacuation speed. It is proposed to shorten the evacuation time by optimal control to the number of the target in each evacuation time. There are many evacuation time indexes. The evacuation time mentioned in this article refers to the over time from the first evacuation object into the evacuation network to the last evacuation object into destination.

The vehicle emergency evacuation model based on the shortest time as follows:

$$\min T = \sum_{n=1}^N \sum_{i=1}^V \sum_{j=1}^V \frac{d_{ij} x_{n_i}}{v_{n_i}} \quad (1)$$

s.t. \forall

$$\sum_{j=1}^V \sum_{n=1}^N x_{n_i} = N \quad (2)$$

$$\sum_{n=1}^N \sum_{i=1}^V x_{n_i} = N_j \quad (3)$$

$$\sum_{j=1}^q N_j = N \quad (4)$$

$$\sum_{n=1}^N \sum_{i=1}^V \sum_{j=1}^q x_{n_i} = N \quad (5)$$

where V_{n_i} is the speed of the vehicle through the road (V_i, V_j) , N is the total number of evacuation roads, N_j is the number of roads to reach the j -th destination, V is the total number of nodes, q is the number of destinations, k_j is the j -th destination.

ANT COLONY GENETIC ALGORITHM

Since the vehicle emergency evacuation model need to consider many factors, including to constraints, complex degree, and the search difficulty for the optimal solution path. So in the design of algorithms, genetic algorithm is a preferentially considered algorithm. However, since the conventional genetic algorithm premature convergence can result in local optimum, which will affect the global optimum. And in large-scale evacuation, the search time will be extended. Therefore, for the above reasons, we consider the combination of traditional genetic algorithm and ant colony algorithm to improve the quality and efficiency of solving.

(1) Establishment of fitness function

$$F_i = \begin{cases} \bar{F} + k_1 C_1^{N_c} \frac{F_i - \bar{F}}{F_{\max} - \bar{F}} \bar{F} F_i \geq \bar{F} \\ \bar{F} + k_2 C_2^{N_c} \frac{\bar{F} - F_i}{\bar{F} - F_{\max}} \bar{F} F_i < \bar{F} \end{cases} \quad (6)$$

where \bar{F} is the average fitness of all individuals in the first generation; N_c is cyclic algebra; k_1, k_2, C_1, C_2 are adjusting coefficient values; F_i is fitness function value of chromosome i .

(2) Iterative pheromones

Suppose each iteration of the genetic algorithm generates K group path, the update mechanism.

$$t_{ij}(t+1) = r_{GA} \cdot t_{ij}(t) + (1 - r_{GA}) \cdot \Delta t_{ij} \quad (7)$$

$$\Delta t_{ij} = \sum_{k=1}^m \Delta t_{ij}^k \quad (8)$$

$$\Delta t_{ij}^k = \begin{cases} w/d_{ij} \\ 0 \end{cases} \quad (9)$$

$$t_G = \sum_{t=0}^{N_{CGA}} t_{ij}(t) \quad (10)$$

where r_{GA} is the residual factor $0 \leq r_{GA} < 1$; $1 - r_{GA}$ is the volatile degree of pheromone; w is the custom coefficient; N_{CGA} is the number of iterations in the process of genetic algorithm.

(3) Options

Individual probability is selected as follows:

$$P_i = \frac{t_i^k F_i^l}{\sum_{i=1}^n t_i^k F_i^l} \quad (11)$$

where n is the number of paths; k is an important factor of the pheromone; l is an important factor of the fitness; F_i is the fitness value of the path i .

(4) Selection of the crossover mutation point

We use pheromone content between node i and node j and its length s to establish the Select mechanism as follows:

$$s = \begin{cases} S_1 = \arg \max(d_s^q / d_s^d) \\ S_2, \text{ random selection} \end{cases} \quad (12)$$

where d_s is the length of s ; q, d are the two parameters, which reflect the relative importance of the pheromone and the length of the side s on the point of crossover and mutation selection.

NUMERICAL SIMULATIONS

Shenyang Olympic Sports Center has Wulihe Stadium, gymnasium, swimming pool and tennis court. Stadium provided 450 parking spaces, in which one layer Huanlang stadium parking for 238 vehicles; the northwest side of the stadium, the northeastern part of parking for 212 vehicles. The article focused on the evacuation of 450 vehicles in Wuli stadium.

Evacuation networks as shown in Figure 1:

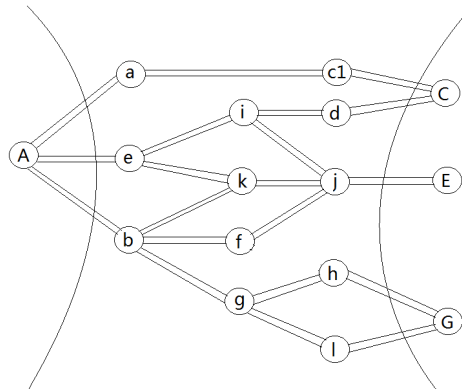


Figure1. Diagrammatic Sketch of the Evacuation Road Network

From Figure 1 can be learned, there are 12 evacuate nodes, including to three safe evacuation point. According to some information and the actual survey data, various sections are shown in Table 1.

Table 1 Basic Information of Road Sections

No. Sections		Capacity	Length	ULN	MS	AVAR
		veh / h	km		km / h	veh / s
1	A-a	158	0.217	2	40	2
2	A-b	140	0.201	2	40	2
3	a-b	80	0.103	2	40	2
4	b-c1	302	0.409	2	40	2
5	c1-C	275	0.385	2	40	2
6	d-C	265	0.370	2	40	2
7	c1-d	52	0.075	2	40	2
8	d-e	158	0.222	2	40	2
9	d-i	172	0.258	2	40	2
10	A-f	182	0.267	2	40	2
11	f-j	60	0.080	2	40	2
12	j-E	62	0.085	2	40	2
13	A-g	63	0.088	2	40	2
14	g-k	85	0.123	2	40	2
15	f-g	172	0.235	2	40	2
16	g-h	180	0.240	2	40	2
17	j-k	238	0.398	2	40	2
18	k-h	225	0.370	2	40	2
19	h-G	175	0.242	2	40	2
20	l-G	150	0.203	2	40	2

ULN : Unidirectional lane number.

MS: Max speed.

AVAR: Average vehicle arrival rate.

Using the basic information of each path, we separately use separate genetic algorithm and hybrid ant colony genetic algorithm, the optimization path and the evacuation time as shown in table 2 and 3.

Table 2 Optimal Evacuation Routes of Genetic Algorithm

TSAEP	ER	PL	EF	ET
		km	veh	h
A-C	A-a-c1-C	1.2	[68-73]	[0.25-0.28]
A-C	A-e-d-C	1.8	[87-95]	[0.35-0.38]
A-E	A-e-f-j-E	2.2	[118-126]	[0.45-0.50]
A-G	A-g-k-h-G	2.8	[137-146]	[0.50-0.55]
A-G	A-b-a-l-G	1.4	[78-83]	[0.30-0.33]

TSAEP: the starting and ending points.

ER: evacuation route.

PL: path length.

EF: evacuation flow.

ET: evacuation time.

Table 3 Optimal Evacuation Routes of Ant Colony and Genetic Algorithm

TSAEP	ER	PL	EF	ET
		km	veh	h
A-C	A-b-c1-C	1.1	[68-73]	[0.24-0.27]
A-C	A-e-k-j-i-d-C	2.3	[87-95]	[0.30-0.35]
A-E	A-f-j-E	0.8	[118-126]	[0.25-0.35]
A-G	A-a-l-G	1.4	[137-146]	[0.35-0.40]
A-G	A-g-h-G	1.2	[78-83]	[0.28-0.33]

TSAEP: the starting and ending points.

ER: evacuation route.

P L: path length.

EF: evacuation flow.

ET: evacuation time.

The vehicle evacuation simulation is operated through Matlab for the above two algorithms. Comparison two algorithms, the evacuation time for using ant colony genetic algorithm is significantly lower than separate genetic algorithm through three vehicle evacuation. The simulation results verify the feasibility of vehicle emergency evacuation optimization algorithm in this paper.

CONCLUSION

The intention of the emergency evacuation is to transfer evacuated object to safe destination in the shortest possible time, not just confined to ensure the safety of persons, but also to ensure the security of personal property. With the improvement of living standards, more and more people pay attention to research the vehicle emergency evacuation. Though there are many details to be explored and research, we hope this research can play a little help to the emergency evacuation problem.

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