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Emergency Evacuation Model Based on Improved Adaptive ant Colony Algorithm

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ABSTRACT. *As one of the largest museums in the world, the Louvre Museum has a large number of tourists every day.Solutions to safe evacuation issues are becoming more and more needed.This paper mainly constructs a simple emergency evacuation model based on improved adaptive ant colony algorithm for the Louvre.In the process of evacuation, people can be regarded as clusters with common characteristics due to the interaction of people. This paper uses cellular automata and real-time information to determine people's evacuation behavior.The model can be used to predict and analyze the evacuation characteristics of buildings, and the results are in line with the actual situation, with good reliability and stability.*

KEYWORDS: *ant colony algorithm, cellular automata, crowd evacuation*

1. Introduction

In recent years, France has been caught in persistent social unrest and terrorist attacks.According to news reports, since 2012, there have been at least 12 major terrorism-related incidents in France, including the Louvre Museum, which was attacked by terrorists in 2017.Therefore, tourists and those responsible for this matter are very concerned about this incident.As one of the four major museums in the world, the Louvre Museum in Paris, France is known for its magnificent architecture and exquisite exhibits.The Louvre Museum attracts visitors from all over the world with its magnificent architecture and ingenious structure, so evacuating people in dangerous situations is a huge challenge.

2. Ant colony model establishment

First, assume that the pheromone concentration is the same in each path and is set to a constant S.The best path selection based on the ant colony algorithm is to find nodes in the node set. When the tourist k is active, the topology table is used to record the nodes through which the tourists pass.Second, during the path change, the

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path set is adaptable.$\pi_{i,j}^{k}(t)$ For the ant to start from node i to node j.The relevant equation is as follows:

$$\pi_{i,j}^{k}(t)=\begin{cases}\dfrac{\tau_{ij}^{\gamma}(t)\varphi_{ij}^{\delta}(t)(\mu_{ij}^{\varepsilon}(t))^{-1}}{\sum\tau_{ij}^{\gamma}(t)\varphi_{ij}^{\delta}(t)\,(\mu_{ij}^{\varepsilon}(t))^{-1}}, & if\ j\ \in nodes\ that\ tourist\ k\ can\ choose\\ 0 & ,otherwise\end{cases}$$

Slave nodei Departure to nodej Expectation level:

$$\varphi_{ij}(t)=\frac{1}{\omega_{ij}}$$

Visitors will focus on choosing when they decide on the next node and the likelihood of stagnation increases.So you need to choose the connected noden_i Disperse.Since the pheromone residue will decrease over time, the pheromone data must be updated. The update method is as follows:

$$\tau_{n_i,n_j}(t+1)=\begin{cases}\tau_{n_i,n_j}(t)-10/\omega_{n_i,n_j}(t)\\ \tau_{n_i,n_j}(t)+1/\omega_{n_i,n_j}(t)\end{cases}$$

3. Optimization model

The optimization model is an improvement of the emergency evacuation model. Because of the large number of people and the multiple choice of portals, this paper uses cellular automata to simulate more complex situations.After setting the evacuation time, compare the escape time and prime time to determine which entrances should be open to visitors to escape the Louvre Museum.

The model uses the shortest distance between the cell and the entrance to indicate the different degrees of attraction to people in different locations in the building.When there are multiple entrances in a building, the shortest distance between the cell and the entrance closest to the cell is consideredS_{xy}.Calculated as follows:

$$S_{xy}=\begin{cases}\underset{m}{\text{Minute}}(\underset{m}{\text{Minute}}(\sqrt{(x-x_n^m)^2+(y-y_n^m)^2}))\,, & if\ cell(x,y)\ is\ empty\\ M, & cell\ (x,y)\ is\ wall\end{cases}$$

S_{xy} Representing the shortest distance between cells, (x, y)Is the coordinates of the cells in the evacuation model.

D_{ij}Calculated as follows:

$$D_{ij}=\begin{cases}\dfrac{\mathrm{S_{00}-S_{he}}}{1}, & move\ vertially\ or\ horizontally,\ i+j=1,-1;\\ \dfrac{\mathrm{S_{00}-S_{he}}}{\sqrt{2}}, & move\ diagonally,\ i+j=0,-2,2;\end{cases}$$

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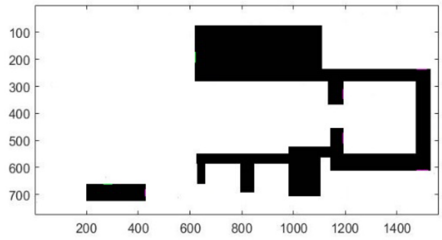
In each step, a person can only move one unit length, so a person has nine positions to choose to move.P_i Represents the sum of the direction parameters and sets the parameter indicating whether the cell is occupied (E_{ij}).Calculated as follows:

$$P_i = D_{ij} + E_{ij}$$

Based on the above formula, the direction of movement of the cells can be determined.

4. Model simulation

First, create a l * l simple matrix model to simulate the evacuation of people with multiple entries.Each empty unit can accommodate one person, and draws the Louvre Museum according to the scale. Take the first floor and the second floor of the Louvre as an example. The exhibition area of the display floor is shown in Figure 1-2.



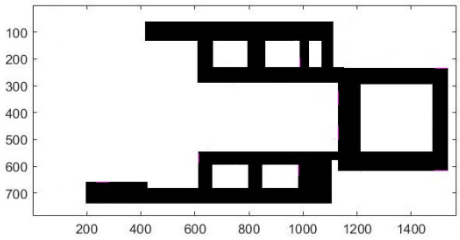


Figure. 1 1st floor of the Louvre Museum Figure 2 2nd floor of the Louvre Museum

Since the moving speed of the flow is not constant, this paper uses the dynamic bottleneck recognition method based on fuzzy set theory to judge the current state, and then establishes the membership function according to the flow of people.Use u's description of fuzzy math to set u to the degree of congestion.The set u consists of two fuzzy sets, the fuzzy set$A_i (i = 1,2)$ Is a set of fuzzy vectors, where each fuzzy vector set is determined by speed and density.A_i Can be expressed as follows:

$$A_{ij}(x) = \begin{cases} 1, & x < a_{ij} \\ \dfrac{b_{ij} - x}{b_{ij} - a_{ij}}, & a_{ij} \le x < b_{ij} \\ 0, & x > b_{ij} \end{cases}$$

According to the research data of the movement speed and density of the crowd during the evacuation process, the following table is obtained by substituting the data into the formula:

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Table 1 Parameter values of membership functions

Death accident	j / i	1		2	
		a_{ij}	b_{ij}	a_{ij}	b_{ij}
Entrance	1	1.71	1.98	0.37	0.83
	2	0.27	0.62	1.97	3.17

5. Conclusion

The model in this paper is based on an improved adaptive ant colony algorithm and a cellular automaton.At the same time, the design of the Louvre Museum and the movement characteristics of people in emergencies are referenced, which improves the freedom of the model and the accuracy of the calculation.The model can be used to predict and analyze the evacuation characteristics of buildings, and the results are in line with the actual situation, with good reliability and stability.

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