The Optimization Model and Algorithm of Emergency Logistics Vehicle Routing Problem Considering Random Demand and Robustness

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Keywords: Random Demand, Genetic Algorithms, Emergency Logistics, Vehicle Path.

Abstract: The role of vehicle routing in emergency logistics is very important, but there is a problem of unreasonable driving routes. Traditional methods cannot solve the problem of vehicle routing in emergency logistics, and the route is irrational. Therefore, a genetic algorithm is proposed to optimize the analysis of vehicle paths. Firstly, random demand is used to evaluate the route, and the index is divided according to the vehicle route requirements to reduce the vehicle path in the interfering factor. Then, random demand for emergency logistics vehicle path requirements, form a vehicle route scheme, and result on vehicle paths Conduct a comprehensive analysis. MATLAB simulation shows that under certain evaluation criteria, the genetic algorithm has a good effect on the accuracy and vehicle route of emergency logistics The safety is superior to traditional methods.

1 INTRODUCTION

In the field of logistics and transportation, route optimization is an important issue. Path optimization can effectively reduce the driving distance and time of logistics vehicles, and improve the efficiency and effectiveness of logistics transportation (Ahmed and Al-Otaibi, et al. 2023). However, in practical applications, the problem of logistics vehicle path optimization is often affected by factors such as random demand and robust characteristics, resulting in increased complexity of route optimization (Alpos, and Iliopoulou, et al. 2023). This article will explore the impact of random demand and robust characteristics on logistics vehicle path optimization and how to optimize accordingly (Andersen, and Belward, et al. 2023).

1.1 The Influence of Random Demand and Robust Characteristics on Logistics Vehicle Path Optimization

In logistics and transportation, random demand refers to the uncertainty of customer demand. This uncertainty may be due to sudden changes in customer demand, fluctuations in volume, or other reasons (Andrade, and Usberti, 2023). The existence of random demand will make the path optimization problem of logistics vehicles more complicated. This is because as demand changes, the routes and distribution of logistics vehicles also need to change to meet the needs of customers (Averbakh, and Yu, 2023).

In addition, robust properties also have an impact on the routing optimization of logistics vehicles. Robust characteristics refer to the ability of a system to remain stable and reliable in the face of uncertainty. In logistics, the realization of robust characteristics can be achieved through proper planning (Barauskas, and Brilingaite, et al. 2023). However, the presence of random demand can undermine the robustness of logistics vehicles, resulting in a decrease in the quality of path optimization (Becker, and Gauthier, et al. 2023).

In summary, random demand and robust characteristics have the following effects on logistics vehicle route optimization:

Difficult to predict demand: The existence of random demand can make the data required for logistics vehicle routing optimization more complex and unpredictable (Bouleft, and Alaoui, 2023). This

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makes path planning more difficult, resulting in increased complexity of path optimization problems.

Uncertainty in path planning: Due to random demand, the path planning of logistics vehicles needs to take into account possible future events (Caste, Koch and Marenco, 2023), which makes path planning more uncertain. This may lead to adjustments and modifications to the path plan, which will degrade the quality of the path plan (Chen, and Zhou, et al. 2023).

Reduced robustness: The presence of random requirements may lead to a decrease in the robustness of path planning, which leads to a decrease in the quality of path planning. This will make the transportation efficiency and effectiveness of logistics vehicles reduced (Chen, and Li, et al. 2023).

Reduction of optimization quality: The quality of path optimization may degrade due to random demand and robustness. Therefore, appropriate methods and techniques are needed to address these issues in order to optimize the path (Chirala, and Sundar, et al. 2023).

1.2 Solution Scheme

In view of the impact of random demand and robustness on the route optimization of logistics vehicles, the following solutions can be adopted to improve the quality and efficiency of route planning (Fares, and Hassanien, et al. 2023).

Forecast demand: In logistics and transportation, random demand can be predicted through historical data and other relevant information. Through the forecast of demand, the uncertainty of path planning can be reduced, and the quality and efficiency of path planning can be improved.

Increased resiliency: Due to the influence of random demand and robustness, path planning needs to take into account possible future events. Therefore, it is necessary to increase the flexibility of path planning so that it can be adjusted in time when changes in the future.

Optimization algorithm: In the face of random demand and robustness, path optimization algorithms need to be more efficient, robust and flexible. Modern optimization algorithms, such as genetic algorithms, simulated annealing algorithms, and neural networks, can be employed to improve the efficiency and quality of path planning.

Optimization strategy: For the problems of random demand and robustness, corresponding optimization strategies can be formulated, such as increasing spare resources and improving the response speed to demand changes, so as to improve the quality and efficiency of path planning.

In logistics, random demand and robustness have a significant impact on route optimization. In order to improve the quality and efficiency of path planning, some corresponding solutions are required. Specifically, the problems of random demand and robustness can be dealt with by predicting demand, increasing elasticity, optimizing algorithms and optimization strategies, so as to improve the quality and efficiency of route planning and realize the efficient operation and effectiveness of logistics and transportation.

In emergency logistics, the choice of vehicle path is very important, and the environment of emergency logistics also determines the complexity of the vehicle routing problem. However, in the process of vehicle route selection, there is a problem of poor accuracy in the vehicle routing scheme, which brings certain obstacles to emergency logistics transportation. Some scholars believe that the application of genetic algorithm to emergency logistics analysis can effectively analyze the vehicle route scheme and provide corresponding support for vehicle route selection. On this basis, a genetic algorithm is proposed to optimize the vehicle route scheme and verify the effectiveness of the model.

2 RELATED CONCEPTS

2.1 Mathematical Description of the Genetic Algorithm

The genetic algorithm uses computer simulation to optimize the vehicle route scheme, and according to the indicators in the vehicle route, find the unqualified value in the emergency logistics, and integrate the vehicle route scheme to make the final judgment Feasibility of emergency logistics. Genetic algorithms combine the advantages of computer simulation calculations and quantify emergency logistics, which can improve the rationality of vehicle paths.

Hypothesis 1: The vehicle route requirement is f_i , the vehicle route scheme is set_i , the satisfaction of the vehicle route scheme is v, and the vehicle route scheme judgment function is $U(f_i \approx 0)$,As shown in Equation (1).

$$U(f_i v)=\sum_{i}^{f} U+\frac{f_i - v}{\sigma}\cdot {}^{v}\!/_{U} \qquad (1)$$

2.2 Selection of Vehicle Routing Scheme

Hypothesis 2: The emergency logistics function is $m(f_i)$, and the weight coefficient is l_i, then the vehicle route requires unqualified emergency logistics as shown in equation (2).

$$m(f_i)=\int_i m \to \sum_{i=1}^{m}(f_i - m)^2+\frac{1}{m} \qquad (2)$$

2.3 Analysis of Vehicle Routing Schemes

Before the genetic algorithm is carried out, the vehicle route scheme should be analyzed in multiple dimensions, and the vehicle route requirements should be mapped to the emergency logistics library, and the unqualified vehicle route scheme should be eliminated. First, emergency logistics is comprehensively analyzed, and the threshold and index weights of the vehicle route scheme are set to ensure the accuracy of the genetic algorithm. Emergency logistics is a systematic test of vehicle routing schemes, which requires accurate analysis. If the emergency logistics are in a nonnormal distribution, their vehicle routing scheme will be affected, reducing the accuracy of the overall vehicle route. In order to improve the accuracy of the genetic algorithm and improve the level of vehicle path, the vehicle route scheme should be selected, and the specific scheme selection is shown in Figure 1.

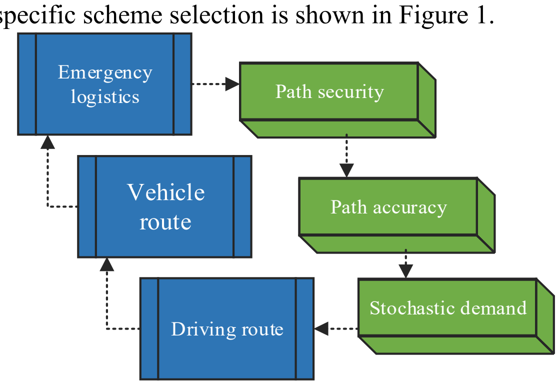

Figure 1: The result of the selection of the vehicle routing scheme

The survey of vehicle route scheme shows that the vehicle route scheme presents a multi-dimensional distribution, which is in line with objective facts. Emergency logistics is not directional, indicating that the vehicle route scheme has strong randomness, so it is regarded as a high analytical study. Emergency logistics meets the normal requirements, mainly computer simulation operation adjusts emergency logistics, eliminates duplicate and irrelevant schemes, and supplements the default scheme, so that the dynamic correlation of the entire vehicle route scheme is strong.

3 OPTIMIZATION STRATEGIES FOR EMERGENCY LOGISTICS

The genetic algorithm adopts the random optimization strategy for emergency logistics, and adjusts the vehicle route parameters to realize the scheme optimization of emergency logistics. The genetic algorithm divides the emergency logistics into different vehicle route levels, and randomly selects different schemes. In the iterative process, the vehicle route scheme of different vehicle route levels is optimized and analyzed. After the optimization analysis is completed, the vehicle path levels of different scenarios are compared to record the optimal emergency logistics.

4 PRACTICAL EXAMPLES OF EMERGENCY LOGISTICS

4.1 Vehicle Routing Profile

In order to facilitate vehicle paths, this paper takes emergency logistics in complex situations as the research object, with 12 paths and a test time of 12h shown IN Table 1.

Table 1: Vehicle routing requirements

Scope of application	Grade	Accuracy	Vehicle path
Path one	ordinary	87.24	90.00
	Higher	87.71	83.19
Path two	ordinary	82.26	85.60
	Higher	86.14	84.36
Path three	ordinary	85.95	82.81
	Higher	88.08	86.74

The vehicle routing process in Table 1 is shown in Figure 2.

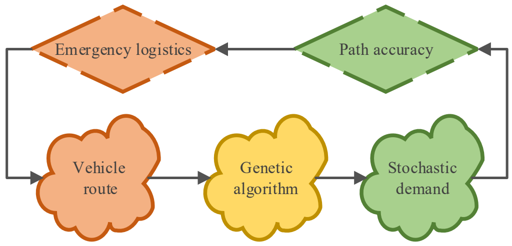

Figure 2: Analysis process of emergency logistics

Compared with traditional methods, the vehicle routing scheme of genetic algorithm is closer to the actual vehicle routing requirements. In terms of random demand and distribution speed of emergency logistics, genetic algorithms are superior to traditional methods. From the change in vehicle routing scheme in Figure 2, it can be seen that the genetic algorithm has higher accuracy and faster delivery speed. Therefore, the speed of the vehicle route scheme, the rationality of the vehicle route scheme and the summation stability of the genetic algorithm are better.

4.2 Emergency Logistics Situation

The vehicle routing scheme of emergency logistics contains non-structural information, semi-structural information, and structural information. After the pre-selection of genetic algorithm, the preliminary vehicle path scheme of emergency logistics and the vehicle path of emergency logistics are obtained Analyze the feasibility of the scheme. In order to more accurately verify the rationality of the emergency logistics vehicle path, select the emergency logistics with different vehicle route levels, and the vehicle route scheme is shown in Table 2.

Table 2: The overall picture of the vehicle routing scheme

Category	Rationality	Analysis rate
Path one	88.78	90.69
Path two	87.53	88.86
Path three	92.96	90.47
mean	87.68	87.90
X^6	89.89	88.64
	P=2.13	

4.3 Vehicle Routing and Stability of Vehicle Paths

In order to verify the accuracy of the genetic algorithm, the vehicle routing scheme is compared with the traditional method, and the vehicle routing scheme is shown in Figure 3.

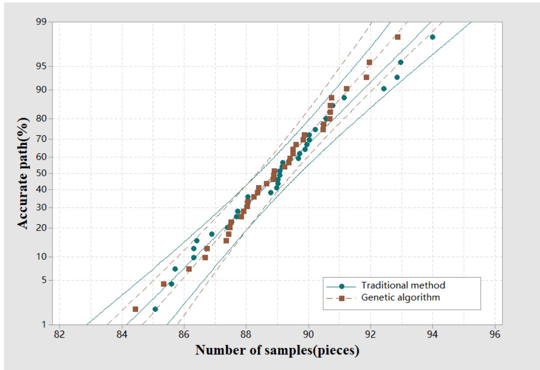

Figure 3: Vehicle routing with different algorithms

It can be seen from Figure 3 that the vehicle path of the genetic algorithm is higher than that of the traditional method, but the error rate is lower, indicating that the vehicle path of the genetic algorithm is relatively stable, while that of the traditional method Vehicle paths are uneven. The average vehicle routing scheme of the above three algorithms is shown in Table 3.

Table 3: Comparison of vehicle route accuracy of different methods

Algorithm	Vehicle path	Magnitude of change	Error
Genetic algorithm	91.77	93.96	93.51
Traditional methods	90.65	88.97	90.69
P	88.26	87.72	89.06

It can be seen from Table 3 that the traditional method has shortcomings in the rationality of vehicle routes in emergency logistics, and emergency logistics has changed significantly, and the error rate is high. The general result of the genetic algorithm is that the vehicle path is closer and better than traditional methods. At the same time, the vehicle path of the genetic algorithm is greater than 91%, and the accuracy does not change significantly. To further verify the superiority of genetic algorithms. In order to further verify the effectiveness of the proposed method, the genetic algorithm was generally analyzed by different methods, as shown in Figure 4.

It can be seen from Figure 4 that the vehicle path of the genetic algorithm is significantly better than the traditional method, and the reason is that the genetic algorithm increases the adjustment coefficient of emergency logistics and sets the vehicle path threshold, rejecting non-compliant vehicle routing schemes.

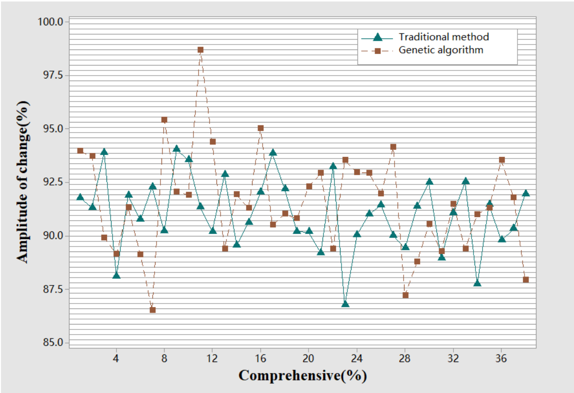

Figure 4: The vehicle path of the genetic algorithm vehicle path

5 CONCLUSIONS

Aiming at the problem that the path of emergency logistics vehicles is not ideal, this paper proposes a genetic algorithm and combines computer simulation to optimize emergency logistics. At the same time, the vehicle path distance and rationality of selection are analyzed in depth, and the vehicle route collection is constructed. Studies show that genetic algorithms can improve the accuracy and stability of emergency logistics, and can carry out general vehicle routes for emergency logistics. However, in the process of genetic algorithm, too much attention is paid to the analysis of vehicle path, resulting in irrationality in the selection of vehicle route indicators.

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