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A Study on Emergency Logistics Vehicle Routing Problem Based on Improved Ant Colony Algorithm

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ABSTRACT

A mathematical model with the shortest distribution path is established as the objective, using the distribution of emergency supplies following natural disasters as baseline information. The ant colony algorithm is used to solve the model, and the C-W algorithm and the 2-opt method are used to optimize the algorithm while simultaneously optimizing the ant path transfer and pheromone evaporation factor. The case study demonstrates the efficacy of the enhanced ant colony algorithm in solving the emergency logistics vehicle routing issue.

Key Words: ACA, Connection based, Service Oriented

1. INTRODUCTION

Since natural disasters in the real world are unpredictable and cannot be stopped, we must act swiftly to contain their effects and complete any necessary rescue operations as soon as possible to minimize casualties and financial losses. Natural catastrophes such as the Wenchuan earthquake in 2008 and the June 2018 earthquake in Japan have alerted people to the importance of rescue operations in minimizing casualties and financial damages. Emergency rescue relies heavily on the deployment of emergency materials. Consequently, the subject of emergency logistics vehicle routing is of great theoretical and practical importance.

Several academics have looked at the emergency logistics vehicle routing issue from a model perspective: A multi-objective mixed integer nonlinear optimization model was developed by Zhang Wei et al. with the goals of minimizing path complexity, minimizing transportation distance, and shortest transportation time. Liu Yang creates a model for the anticipated time and a minimum of the last called car to reach the disaster spot, taking into account the probability of traffic jams and road damage. Zhiyu Xu and others. A Split Delivery Vehicle Routing Problem (SDVRP) model with the lowest degree of imbalances and the shortest overall delivery time was established by Xu Zhiyu .

Several academics have conducted pertinent studies on the emergency logistics vehicle path problem from the standpoint of model algorithm solving: Tang Chong demonstrates the algorithm's efficacy by applying the simulated annealing technique to the VRP problem of single time windows.

Gong Yawei concentrated on path optimization using the traditional shortest path algorithm, or Dijkstra algorithm. Zhang Bin demonstrated that the immune algorithm outperformed the genetic algorithm by studying the optimization of emergency logistics vehicle scheduling using the saving algorithm and immune algorithm . Xu Haoqin used a hybrid optimization approach that included tabu search and evolutionary algorithms to study vehicle scheduling. An improvement analysis was conducted by Zhang Yuhua using the ant colony algorithm to solve the vehicle delivery path model with time window.

This study establishes a mathematical model that uses an ant colony method to tackle the problem of finding the shortest vehicle path. To demonstrate the efficacy of the algorithm optimization, a correlation optimization based on the ant colony algorithm was conducted and compared with the unfertilized algorithm.

2. PROBLEM DESCRIPTION

Relief supplies must be delivered from the emergency logistics center to each catastrophe site as quickly as possible in order to conduct rescue operations and minimize losses. The vehicle leaves from the emergency logistics center and makes many delivery stops to disaster sites, meaning that each vehicle must be in charge of distribution. There is knowledge about the locations and coverage of emergency logistics centers. Every emergency logistics center has a set amount of vehicles of the same kind, and every disaster site has a known demand for supplies. This article's challenge is to figure out how to logically set up the distribution path so that supplies can reach each crisis site as quickly as feasible.

ESTABLISHMENT of MODEL

Assumptions

1. An emergency logistics hub to provide all disaster sites with supplies.
2. Every vehicle only serves a distribution path from each vehicle emergency logistics center.
3. A single vehicle service is available for each impacted site, but each vehicle can be dispatched for several disaster points.
4. The road conditions are the same both to and from each demand location and the logistics center.

MODEL SOLUTION

The Ant Colony Algorithm (ACA) is used to solve the path optimization problem's fundamental idea: the problem's feasible solution is represented by the ant's walking path, and the problem's solution space is made up of all the paths taken by the ant group as a whole.

More pheromones are emitted by ants with shorter pathways. The concentration of pheromone that builds up on shorter paths progressively rises with time, and more ants will opt to travel along that path. When positive feedback is present, the ant as a whole will ultimately focus on the ideal path, and the corresponding solution is the one that has to be optimized.

First off, this paper enhances the transition probability by including a C-W algorithm into the ant colony method.

Second, there were several phases of adjustment made to the pheromone evaporation factor scaling. Ultimately, the 2-opt algorithm optimizes the best possible answer.

A. C-W Algorithgm

The Clarke-Wright algorithm, also known as the C-W algorithm, is a straightforward and workable heuristic algorithm that was proposed by Clarke and Wright in 1964. It calculates the total number of kilometers (or time or cost) for all vehicle transportation by taking into account the distribution center's capacity, the distance between each distribution demand point, and the distribution center.

The distribution center supplies materials to two demand locations, and the distances between the distribution center and the demand points i and j are di0 and dj0, respectively. This is the fundamental procedure of the saving method.

B. Transition Probability Improvement

It is determined via the C-W algorithm what the savings factor is. A higher savings factor leads to a shorter total path length and a higher likelihood of (i, j) selection, both of which are better for global optimization.

C. Pheromone Evaporation Factor Scaling

The ant colony method relies heavily on the pheromone evaporation factor $\rho(0<\rho<1)$, whose magnitude directly affects the algorithm's capacity for search and rate of convergence. Consequently, great consideration must be given to the precise value of ρ. An excessively large ρ has the drawback of making it simple to create specific pheromones on unexplored paths or of having ants quickly disappear. The diversity of the solution is still unfavorable in the early stages of optimization, and the algorithm is readily caught in a local optimum.

One benefit is that the method converges quickly. One advantage of having a small enough ρ is that the pheromone will evaporate more slowly, which will help with global search performance, multiple solution generation, and avoiding the local convergence issue.

The sluggish convergence speed is the drawback.

Consequently, the approach of segmentally altering ρ is used in this paper, and the algorithm is adjusted based on the size of ρ and the circumstances at different times. A lower value for ρ is used in the early stages. Even though the algorithm's convergence speed is slower, its global search capability has been enhanced, which is helpful for finding the best answer. Later on, when the number of iterations rises, there's a greater chance that the ideal solution will be found, thus ρ is set to a higher value, which accelerates convergence.

D. 2-opt algorithm

The 2-opt algorithm is a local search technique that was first put forth by Croes. The 2-opt algorithm can be used in conjunction with other algorithms to further optimize the initial answer while addressing path optimization problems, which helps to increase the algorithm's efficiency.

The 2-opt algorithm's core idea is to identify an original solution, choose two demand points at random, flip the path between the two locations, and leave the other demand points untouched. Then, the new solution will be obtained.

After the new solution is evaluated against the original, it is either kept or abandoned depending on how well it fits the needs of both parties.

3. CONCLUSION

The problem of emergency logistics vehicle routing is solved using the enhanced ant colony method in this study. Better results are produced, demonstrating the effectiveness of the algorithm enhancement. The model with time limitations, road connection gaps, and parameter selection in the ant colony method should all be taken into account in the subsequent investigation. Consequently, certain concepts and guidelines for the investigation of emergency logistics distribution routes are provided by the research and results in this work.

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