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Research on Optimization Algorithm of Vehicle Distribution Path

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Abstract

With the development of logistics industry towards globalization, integration and informatization, vehicle path planning plays an increasingly xxx, xxx Universityimportant role in the whole logistics system. Transportation is a very important link in the logistics distribution process. Since the cost of transportation takes up about 50% of the total logistics cost, the transportation process is a key link to save the overall cost. Among them, the use of vehicles in the transportation process and route planning directly affect the time and cost of transportation. For example, bus route arrangement, vehicle route arrangement in logistics distribution process and garbage collection route arrangement are all vehicle route problems. Therefore, the study of vehicle path planning has profound significance. Genetic algorithm is a highly parallel, random and adaptive search algorithm. Although genetic algorithm has the characteristics of parallel algorithm and can approach the optimal solution synchronously from the initial solution, there is a big problem in genetic algorithm, that is, it does not intend to approach the optimal solution. In view of its shortcomings, a multi-population genetic algorithm is proposed, which can be divided into the main population and the auxiliary population. And in the presence of the poor local search ability, we design a local optimization algorithm, and verified the larger speeds up the convergence speed, and then, in order to make cross bring more profits, increased the number of the cross between high quality, with a higher chance of a better solution, at the same time in order to avoid too much inferior solution affects the whole population quality, set up an acceptance rate, when crossed, mutated solution is a better solution than the parent generation, is acceptable, otherwise, to reject the solution with a certain probability. Finally, the experimental results show that the improved algorithm is superior in computational efficiency and performance.

Keywords

Multi-population, genetic algorithm, local search algorithm.

1. Introduction

With the popularization of the Internet, more and more people like to shop on the Internet, which is largely because of the convenience of online shopping. Therefore, logistics has been greatly developed, and at the same time, it also brings great challenges. One is the high cost of transportation, which plays an important role. Therefore, it is very important to reduce the cost brought by the transportation process, and the role of vehicle path planning is to directly reduce the transportation cost brought by vehicle operation, thus bringing greater benefits.

At present, for the development of the logistics industry, the reasonable arrangement of vehicle route is a key issue. Vehicle Routing Problem (Vehicle Routing Problem) was first proposed by Dantzig and Ramser two people together, it refers to a certain number of customers, different customers have different demand for goods, now to the reasonable organization of Vehicle driving route, the car, both to meet the needs of Vehicle route through customer point total amount less than the load of vehicles, starting from the distribution center of each car at the same time, to return to distribution center, to achieve the total route, the shortest and shortest time goal. However, in the real world, there are many things to consider, such as the current distribution center situation, the actual road flow, congestion and weather conditions. It can be seen that the optimal choice of logistics distribution route is an extension of the VRP problem. n 1971, Eilon et al. [1]proposed a recursive algorithm and dynamic programming method for calculating the maximum number of vehicles. In 2006, Tan et al. [2], on the basis of waste recovery application, considered reverse logistics and considered three main factors: manpower workload, number of vehicles, and road compact degree, and used the hybrid heuristic algorithm of clustering memory extension insertion algorithm. In 2009, The hybrid heuristic algorithm constructed by Ostertag et al. [3]combined POPMUSIC and MA and established a large-scale path optimization system with multiple distribution centers and time Windows. In 2013, Zhou Shengwei, Jiang Tonghai, Zhang Ronghui et al. [4] adopted improved measures based on greedy random adaptive genetic algorithm to enhance its neighborhood search ability when generating initial population, and then sought the optimal chromosome from the GRASP generated initial population. In 2015, Mu Dong, Wang Chao, Wang Shengchun, Zhou Shengchuan et al. [5] used the forward insertion heuristic algorithm, the master-slave parallel simulated annealing algorithm and four neighborhood search methods to optimize the initial solution when generating the initial solution. In 2017, Dou Xun Bo, Li Li et al. [6]divided the problem into two parts: one is to use K-means clustering to solve the site selection problem; the other is to use genetic algorithm to find the path optimization problem from the delivery point to the customer point. In 2018, Ge Xianlong, Zhang Hui et al. [7] designed an improved genetic algorithm, proposed to calculate the total distribution cost across the time domain, with cost as the ultimate goal, and designed successive correction operators on both sides.

In this paper, the improved hybrid genetic algorithm is used to realize the route selection of logistics vehicle distribution and test its practical effect in logistics distribution. Therefore, the research and discussion of logistics route selection have very good application background and application value.

2. Vehicle Distribution path

2.1. Description of Vehicle Path Problem

2.1.1. Description of Vehicle Distribution Path

Vehicle routing problem is initially by Dantzig and Ramser are put forward in 1959, it is to point to in a certain number of customers, each customer has its own quantity of the goods demand, at the same time have a up to a distribution center, they are responsible for point distribution of the goods to the customers, by many car distribution, each car along the order, must have access to every customer, eventually return distribution center, planning reasonable vehicle routes, in to meet customer demand, to achieve least time, for example, recently, distance, the minimum total cost, vehicle number at least and a series of goals.

Vehicle path problem is a combinatorial optimization problem, which is to find the optimal solution among a series of solutions. It means to find the maximum or minimum value satisfying the constraints on a finite and discrete data structure. Once this question is put forward, because of its close relationship with real life, researchers have paid close attention to it and it has become a hot issue.

Vehicle path problems can also be divided into different types depending on the constraints. The following are some common types:

(1) The problem of goods delivery and collection -- that is, the vehicle distributes the goods to the customer or takes the goods from the customer.

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(2) Capacity constraint problem -- that is, the maximum load of each vehicle is limited, the customer point has a certain demand for goods, and the load of the vehicle cannot exceed the maximum load limit.

(3) Time window constraint vehicle routing problem -- that is, the service time of the customer point is fixed, and the vehicle needs to serve the customer point at the specified service time. Time window constraints are divided into two types, namely soft time window and hard time window constraints. Soft time window refers to the way in which vehicles are allowed to carry out services beyond the specified time range, but they need to be punished for being late or early. A hard time window means that services must be provided within a specified time frame, and no one should arrive early or late.

(4) Vehicle routing problem of multiple distribution centers -- there are multiple distribution centers, each of which can dispatch vehicles separately.

Due to different conditions of consideration, constraints are also different for various types of vehicle path problems mentioned above, but the essence is the same. This paper is based on vehicle path problems with load capacity constraints.

2.2. Optimization Algorithm of Vehicle Distribution Path

At present, the algorithm for solving vehicle routing problems are many, different algorithms have different advantages and disadvantages, the current algorithms for some roughly two kinds, one kind is accurate algorithm, and the other is a heuristic algorithm, and the heuristic algorithm can also be divided into two categories, namely traditional heuristic algorithm and two kinds of intelligent optimization algorithm.

Accurate algorithm refers to the method that uses a certain operational research or mathematical method to calculate the optimal solution. This method seems to be a good way to solve the optimization problem, but its computational complexity generally increases exponentially with the expansion of the computational scale, so it is not suitable for the case of large data volume. The commonly used accurate algorithms are branch and bound, integer programming, network flow and tangent plane.

Heuristic algorithm is a kind of algorithm constructed based on subjective experience or natural law and developed towards the direction of the optimal solution. Common heuristic algorithms are simulated annealing algorithm, tabu search algorithm, ant colony algorithm and genetic algorithm.

The following is the introduction of several commonly used heuristic algorithms:

(1) Simulated annealing algorithm

Simulated annealing is a kind of random search algorithm, due to the local search algorithm easy to fall into local optimum, aiming at this disadvantage, simulated annealing based on the use of a certain probability of two-way random search technique, accept new superior to that of the original solution, if the new carrier to the original solution, with exp $(-\Delta c/T)$ of probability to accept the relatively poor solution, including T as the control parameter, Δc two solutions of poor quality.

(2) Tabu search algorithm

Tabu search algorithm is a global optimization algorithm. Tabu table is designed to record the local optimal advantages that have been searched so far. In the subsequent search, the local optimal advantages that have been searched will be avoided selectively, so as to avoid falling into the local optimal value and achieve the global optimal.

(3) Ant colony algorithm

The principle of ant colony algorithm for the ants to find food on the way, can leave certain pheromones on the road, the pheromone concentration can be according to the distance of the road, then the ants can choose path according to the pheromone concentration, concentration

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of big at greater risk of path is selected, after many generations of iteration, the optimal path pheromone concentration will be bigger, eventually converge to the optimal solution.

(4) Genetic algorithm

Genetic algorithm is an algorithm based on biology. Within each generation of the population, better solutions will have a greater chance of passing on to the next generation, and each generation will have genes that cross and mutate, just as human evolution produces different individuals. After several iterations, the overall level of individuals in the population becomes better and better, and eventually an optimal solution will be approached.

3. The Model and Algorithm of Solution

This paper for a series of problems of target vehicle shortest route to make the entire journey, including the route should also meet some certain laws, for example, each customer service point can only be the same car and can only be a one-off after service, so that each customer point can only appear once in all vehicle routes, in view of some of these constraints, is to establish the following section of the model.

3.1. The Establishment of the Model

(1) Symbol definition

The symbol is defined as follows:

N -- Customer points

Dij: -- Distance of vehicle from I to node J

Q: The total deadweight of the vehicle

Qi -- weight of goods required at point I

K -- the number of cars

M -- Population size

(2) Model form

The mathematical model of the problem is as follows:

The overall goal of the problem in this paper is set as the total driving distance and the objective function is expressed as (1) :

$$\min \sum_{k=1}^{K} \sum_{i=0}^{N} \sum_{j=0}^{N} X_{ij}^{k} \times D_{ij} \tag{1}$$

Formula (2) and (3) indicate that for each point, only one car will be served and only once:

$$\sum_{k=1}^{K} \sum_{i=0}^{N} X_{ij} = 1, \forall i \in (0 \bigcup N) \tag{2}$$

$$\sum_{k=1}^{K} \sum_{j=0}^{N} X_{ij} = 1, \forall j (0 \bigcup N) \tag{3}$$

Formula (4) indicates that for a fixed customer point, the vehicle in and out is the same vehicle:

$$\sum_{i=0}^{N} X_{ji}^{k} = \sum_{i=0}^{N} X_{ij}^{k} = \{0,1\}, \forall k \in K, \forall i, j \in (0 \cup N) \tag{4}$$

Formula (5) indicates that if vehicle K leaves the distribution center, it must return to the distribution center:

$$\sum_{j=1}^{N} X_{0j}^{k} = \sum_{i=1}^{N} X_{i0}^{k} = \{0,1\}, \forall k \in K \tag{5}$$

Formula (6) indicates that the total demand of customer points served by the driving route of vehicle K cannot exceed the maximum vehicle load:

$$\sum_{i=1}^{N} \sum_{j=0}^{N} \left(X_{ij}^{k} \times q_i \right) \leq Q, \forall k \in K \tag{6}$$

3.2. Genetic Algorithm Design

Genetic algorithms are heuristic algorithms that mimic the natural selection of biological evolution. Genetic algorithm is mainly composed of selection, crossover and mutation. Such operation is carried out in each generation, and the result is that the whole population approaches to the optimal solution slowly. However, genetic algorithm is a global search algorithm, which lacks local search ability and is prone to precocity and local optimization. However, genetic algorithms have some natural features:

(1) Parallelism. In genetic algorithms, a population has multiple individuals who do not interfere with each other and evolve independently.

(2) Robustness. Reasonable interference can also have a good effect.

(3) Large-scale search ability. Large search surface and random search, multi-dimensional search can be carried out.

(4) Generality. When solving the problem, as long as the reasonable coding method, crossover and mutation method, other parts can be applied without changing.

(5) Independent problem. For different problems, the genetic algorithm can find the solution that maximizes or minimizes the objective function by setting different objective functions and corresponding constraints.

3.2.1. Encoding

The encoding mode determines the gene arrangement mode of each solution, and different encoding modes have different characteristics. For a specific problem, a good encoding mode is conducive to the execution efficiency of the whole algorithm, so natural number encoding is adopted in this paper.

Coding method: distribution center is 0, N customer points are represented by natural Numbers 1~N, each car must start from the distribution center, that is, 0, and then return to the distribution center, that is, end with 0, if there is a chromosome: 032605410, then this chromosome contains the route of two cars, respectively 0-3-2-6-0 and 0-5-4-1-0. The algorithm in this paper will automatically mark distribution center 0 at the beginning and end by default, that is, for chromosome 3260541, its route is also 0-3-2-6-0 and 0-5-4-1-0.

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3.2.2. Initial Population

The algorithm initialization in this paper follows the following steps:

Step1: Randomly arrange and generate the natural number sets of N customer points.

Step2: Determine customer points in chromosomes from front to back. If the total demand for customer points on the current vehicle route plus the demand for customer points is less than the maximum load of the vehicle, then the current customer points join the route of the vehicle; Otherwise, the vehicle returns to the distribution center, adding 0 points to the end of the route and dispatching a new vehicle.

Step3: no consideration shall be given to the previous s customer points that have joined the vehicle route. Step1 and step2 shall be repeated from the customer points in the position of s+1 until all N customer points have joined the vehicle route.

Step4: repeat the previous three steps M times.

3.2.3. Fitness Function

Fitness represents whether an individual ADAPTS to the environment, that is, whether the solution is good or bad for the problem. The more fit a chromosome is, the better it is and the more likely it is to be selected into the next generation. The goal of this paper is to calculate the shortest total route distance. Assume chromosome I is 0820, which is the length of this route, and expressed as formula (7) :

$$Z_{\mathrm{i}} = D_{08} + D_{82} + D_{20} \tag{7}$$

Since the smaller the distance is, the greater the fitness value should be, so the fitness function is formula (8) :

$$F_{\mathrm{i}} = \frac{1}{Z_i} \tag{8}$$

3.2.4. Option

Selection fully embodies the principle of survival of the fittest. At present, there are many commonly used selection methods, such as tournament strategy, roulette strategy, etc. The selection method of tournament is to select 2 chromosomes at a time and enter the next generation directly with high fitness. The algorithm in this paper adopts roulette method, and the specific implementation method is as follows:

Step1: calculate the probability of selection of each chromosome according to the fitness of each chromosome, and the formula is as follows (9):

$$p_i = \frac{F_i}{\sum_{s=0}^{M} Fi} \tag{9}$$

Step2: calculate the selected interval from the first chromosome, whose interval is (,), where, according to step 1, it can be known as a decimal between 0 and 1, and its calculation formula is as follows (10):

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$$R_{\mathrm{i}} = R_i + p_i \tag{10}$$

Step3: Use the random function to generate a decimal between 0 and 1, and the corresponding chromosome in the corresponding interval of this decimal will be selected into the next generation.

Step4: repeat step 3 until a population size of M is selected.

3.2.5. Cross

As natural number encoding is generally adopted in vehicle path planning, discrete crossover is generally adopted in the process of crossing, that is, the value of variable is transformed among individuals, and each variable of child individuals is randomly selected as the probability of the parent. Crossover operation can generate new chromosomes and create new solutions, which is the key for the population to approach the optimal solution continuously. Common crossover methods include PMX crossover, single point crossover, multi-point crossover, etc. In this paper, OX crossover is adopted, and its steps are as follows:

Step1: Randomly generate two gene locations on a chromosome, as shown in the figure below:

Step2: Copy the gene between the two positions of the parent generation to the corresponding position of the descendant generation, as shown in the figure below:

Step3: Compare the gene of the other parent generation with the gene assigned to the descendant generation in turn. If the parent gene is not in the descendant generation, assign the gene to the spare place of the descendant generation in turn. The diagram is as follows:

Step4: Test the generated child. If the generated child does not meet the constraint conditions, it is an infeasible solution and will not be accepted.

The above steps are the generation of one of the children, and the generation of the other is the same as in the figure above.

3.2.6. Variation

Crossover operation is gene recombination between populations, which is based on existing genes in the population, while mutation operator is random search in the neighborhood of existing genes to create genes not yet in the population, which can effectively deal with the situation of falling into the local optimal solution. In this paper, the method of single point variation is adopted, and the steps are as follows:

Step1: Randomly generate two locations of variation on a chromosome.

Step2: Exchange genes of the two mutation sites.

Step3: judge whether the new chromosome meets the constraint conditions, if so, complete the mutation process; if not, repeat steps 1 and 2 until a solution meeting the constraint conditions or a certain number of times is found.

3.2.7. Termination Conditions

Because genetic algorithm is the algorithm that approximates the optimal value gradually through many iterations, it is possible to find the optimal value or only the local optimal solution in certain algebra. Therefore, the setting of termination conditions is very important. At present, there are several common methods of termination:

(1) Maximum number of iterations

The method is to set up a fixed running algebra and stop iterating when running to the specified algebra, regardless of the intermediate iteration process. The advantage of this method is that the running time can be controlled within a certain range, but sometimes there is a big gap between the solution found and the optimal solution due to insufficient time or algebra.

(2) Solving error

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When the optimal solution obtained by the algorithm and a known optimal solution are within a certain range, the algorithm stops. Of course, the algorithm needs to know the optimal solution of the problem in advance.

(3) Mixing stop mode

Combining the first two methods, when the error reaches the predetermined error, the algorithm stops, otherwise it will run until the specified number of iterations.

The algorithm in this paper adopts the method of hybrid stop.

4. Conclusion

Vehicle path problem is a combinative optimization problem, which has been deeply studied by many scholars. However, for large scale cases, there is no particularly excellent algorithm that can calculate the optimal solution in a short time. At present, the popularity of online shopping makes the logistics industry has a huge development prospect, so the problem of vehicle path has been paid great attention to. In order to make rapid progress in the logistics industry, reducing transportation costs is an important step, and the reduction of transportation costs is closely related to vehicle path planning. Therefore, it is of great significance to increase the research in this aspect.

Genetic algorithm is a heuristic algorithm based on the mechanism of natural selection. It has strong self-adaptability. The idea of its global character is reflected in its crossover of genes and randomness of mutation. However, genetic algorithm has the characteristics of poor local search ability and easy to fall into the local optimal value. Therefore, it is necessary to make some improvements to the standard genetic algorithm to overcome its shortcomings. This paper summarizes its improvements as follows:

(1) Firstly, the essential idea and steps of genetic algorithm are deeply understood. The current research literature on the advantages and disadvantages of genetic algorithm is collected, as well as the relevant applications in vehicle path problem. The disadvantages and advantages of genetic algorithm in application are summarized and the improvement measures are proposed to overcome the disadvantages.

(2) according to some deficiencies of genetic algorithm on the vehicle routing problem, with the method of population more effective optimization into the local optimal value, and the main population and crossover and mutation rate of auxiliary populations with different different functions in different evolutionary way, on this basis, the increased local search algorithm to enhance the local search ability of genetic algorithm (ga) is insufficient, at the same time, the crossover operator is improved and increased the rate of the cross between high quality, in order to have more opportunity to create a more optimal solution chromosome.

(3) Apply the improved algorithm to the case. In order to test the effectiveness of the improvement, compare the corresponding improved algorithm with the one before the improvement. Experiments show that the improved algorithm is effective, and the improved algorithm improves the search efficiency and has good performance.

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