Study on Time-Dependent Vehicle Routing Problem With The third party Logistics Based on AFPSO

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Abstract: In this study, using intelligent algorithms to solve the dynamic network vehicle route, establish a dynamic mathematical model of network routing problem. Setting up and establishing a dynamic time-dependent function of network problems. Based on a comprehensive analysis of the time-dependent function, using Particle Swarm Optimization and Nearest Neighbor Method, to solve the vehicle routing problem in dynamic networks. An Adaptive Fuzzy Particle Swarm Optimization(AFPSO) based on the uncertainty of the PSO is proposed. The algorithm adds mutation operation in iteration process and adjusts the inertia weighting factor to enhance its ability to break away from local optimum, and the mutation probability is adjusted by variance of the population's fitness.

1. Introduction

Vehicle routing problem (VRP) in the logistics and transportation system plays an important role. At present mainly concentrated on the research on the capacitated vehicle routing problem and the open vehicle routing problem. And the cost (time) of the vehicle running on the line are considered to be static. In fact by traffic, weather and a series of objective factors when moving, the entire vehicle drive cost (time) dynamic change has occurred. And then the Time-Dependent Vehicle Routing Problem (TDVPR) [2]arises. How to optimize and control the dynamic network path, make full use of and give full play to the development of modern computer communication and information processing technology and intelligent traffic system, the third party logistics enterprise distribution to complete tasks, and can effectively control the operation cost of the vehicle (time) to become a new subject in the field of logistics.

Malandraki and Daskin[1] establish a static demand is not with time windows TDVRP mixed integer programming model, the operational sections of the network is represented as a function of time piecewise function, and in order to avoid overtaking phenomenon, assuming that vehicles waiting at the junction point. AlbertoV. Donati proposes the application of ant colony optimization to solve TDVRP. They will be the people in the traditional ant ants release pheromones to have a static time-dependent type dynamic pheromone to adapt to the needs of TDVRP time-dependent characteristics. Ali Haghani, who studied the dynamics of time-dependent vehicle routing problem, Using a continuous function represents driving speed changes over time, the lower bound algorithm and genetic algorithm proposed solution method, and with the exact algorithm are compared.

2. Mathematical model of TDVRP

TDVRP generally can be described as: A central warehouse has K cars, Known to each customer location i and demand point qi. Each car starting from the central warehouse, and finally return to the central warehouse, the maximum load for each car is Pk(k =1,2,…,K),Required to make arrangements for vehicle route smallest total distance vehicle, and meet the following conditions:

1) Warehouse location is known and only;

2) The warehouse is only one vehicle, and each customer demand can only be carried out by one car, all customers will be serviced;

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3) The sum of each line on the customer demand do not exceed the load capacity of the car;

4) The total length of each transport path does not exceed the maximum distance from a moving vehicle transport.

According to the above description, established the mathematical model(1), The constraint conditions is (2)~(6):

$$\min g = \sum_{k=1}^{K} \left(\sum_{i=1}^{n_k} b_{r_k^{i-1}, r_k^{i}} + b_{r_k^{nk}, 0} \right) \cdot \operatorname{sgn} n_k \tag{1}$$

Among the formula:

$$\operatorname{sgn} n_k = \begin{cases} 1, n_k = 0; \\ 0, n_k \geq 1; \end{cases} \tag{2}$$

Constraint conditions:

$$\sum_{i=1}^{n_k} p_{r_k^i} \leq p_k, n_k \neq 0 \tag{3}$$

$$\sum_{i=1}^{n_k} b_{r_k^{i-1}, r_k^{i}} + b_{r_k^{nk}, 0} \leq B_k, n_k \neq 0 \tag{4}$$

$$R_{k_1} \cap R_{K_2} = \varnothing, k_1 \neq k_2 \tag{5}$$

$$\bigcup_{k=1}^{K} R_k = \{1,2,\cdots,M\}, 0 \leq n_k \leq M \tag{6}$$

$b_{i,j}$ is the distance from customers i to customer j;Among them,i, j = 0,1,2, ..., M. When i, j = 0,it is a central warehouse;b_k is the maximum distance of vehicle k;The total number of the vehicle k distribution for customers is n_k, when n_k=0,show that the k is not involved in the transport; The collection for vehicle k distribution is r_k, k = 1, 2, 3,... , k. When $n_k = 0, r_k = \varnothing$;.When $n_k \neq 0$, $n_k = \{r_1, r_2, r_3, ..., r_n\} \subseteq \{1,2,3,\ldots\ldots,m\}$.

3. AFPSO and its improvement

Dr Kennedy and Dr Eberhart inspired by the behavior of birds for food, proposed a new intelligent optimization algorithm in 1995 that is the Particle Swarm Opitimization. Its basic principle is sharing of information between groups and Summing up their experience to Correct the behavior of the individual, to obtain the optimal solution finally.

The groups composed of N particles to search the N dimensional space. Each particle represented as $X_i=(x_{i1}, x_{i2},\ldots, x_{in})$;The velocity of each particle is $V_i=(v_{i1}, v_{i2},\ldots, v_{in})$;The optimal location of the i particles to search in the k superposition is $P_i=(p_{i1}, p_{i2},\ldots, p_{id})$,call it Pbest particle; The optimal global position of the whole particle swarm to search is $P_j=(p_{j1}, p_{j2},\ldots, p_{jd})$,call it Pbest particle; The new formula (7) about the i particle, the k superposition, the d dimension space,v speed and x position.

$$\begin{aligned} v_{id}^{k+1} &= w v_{id}^{k} + c_1 r_1 (pbest - x_{id}^{k}) + c_2 r_2 (gbest - x_{id}^{k}) \\ x_{id}^{k+1} &= x_{id}^{k} + v_{id}^{k+1} \end{aligned} \tag{7}$$

In the formula: W is the inertia weigh;c1,c2 is acceleration factor;r1 and r2 are independent random number.

In PSO, each particle by pbest and gbest to update the velocity and position. If one particle searched a local optimal solution[3], The particles due to the optimal solution easily attract, quickly gathered around it. At this time, if measures are not taken to make each particle to jump out of local optimal solution, the algorithm will appear the phenomenon of convergence. So, this paper adopts the AFPSO. For offbeat operation by judging the degree of aggregation of particle swarm of gbest mutation. To change the direction of particle, expand the search space. Thus, in the subsequent search of particle, may find new pbest and gbest. So the cycle, until the algorithm find the global optimal solution.

4. AFPSO applied in dynamic networks vehicle routing problem

Coding strategy of particle. The key of AFPSO is to found position and problem of particle. This paper reference literature [5], Structure optimization of logistics distribution routing problem. Corresponding to each customer to complete the service vehicle and the vehicle in the path of execution order.

Decoding strategy of particle. Vehicle number for customer service. Rounding the vector of particle i INT(z_{ix}),can be obtained vehicle j which the central warehouse distribution to customer. For the route about vehicle j,can be determined according to the vector of particle i INT(z_{iy}).From small to large order number, to determine the order of vehicle j route.

5. The algorithm process description

Step 1: Initialization and enter the relevant data. Determine the size and related parameters on particle swarm, including inertia weight factor, learning factor, maximum number Nmax of iterations.

Step 2: Initialize the particle population. In the initial population of the build process, should make every particle vector *Zix* random values, and try to ensure that [1, K] were selected for each integer, namely to ensure that each vehicle are assigned to the customer point.

Step 3: Fitness evaluation. Decode generate vehicle allocation scheme for particle. According to the customer's position and formula (1)(2) to calculate each particle's fitness value, namely the vehicle driving distance, And check whether meet the formula (3) ~ (6) constraints. If the total demand of each customer on one path over this path distribution vehicle capacity, let $F = Fmax$, the *Fmax* is a big number. Then research.

Step 4: For each particle, compared them fitness value with *gbest* of all particles. Select the optimal pole, and Update the individual extremum and global optimization of particle swarm.

Step 5: Dynamic set of inertia weight factor *w*.

Step 6: According to formula (7) to update the position and velocity of each particle particle swarm.

Step 7: To determine whether the number of iterations current reaches the maximum number of preset. If yes, stop the iteration, the output optimal solution,else turn to step 3.

6. Conclusion

Particle swarm optimization algorithm is a stochastic global optimization technique, it is the optimal region to complex search space through the interaction between particles, and find the optimal solution of the problem. The approach could real-time describe the auto motived ynamic movement behavior in the traffic network accurately, therefore, evaluate accurately the transportation environment of city-wide modern traffic network and assess the environmental impacts of the particular intelligent transportation system, In view of the traditional heuristic optimization algorithm long search time, easy stagnation, can not search the space for further , a novel AFPSO is introduced, and it is applied to solve the dynamic problem of vehicle. Established the mathematical model and algorithm for the corresponding, Compared with traditional heuristic optimization algorithm that is proposed in this paper, the algorithm has better efficiency and solution.

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