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A Study on Optimization of Chemical Logistics Route Based on Improved Genetic Algorithm

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In this paper, the author mainly studies the optimization of chemical logistics route based on improved genetic algorithm. The author initially selects relevant populations, assigns individual values to populations and performs certain processing on crossover operators to allow individuals to evolve from generation to generation. Then the author carries out a mutation operation and improves the adaptive probability. The final result of 50 logistics distribution outlets in total is 549.276 and the improvement rate is 2.238%. For a total of 100, the final result is 21280 and the improvement rate is 0.463%. At the same time, the optimal route value obtained by using the GBLSA algorithm simulation is optimal. The GBLSA algorithm has a good performance in search efficiency and performance and can save a lot of costs for chemical logistics.

1. Introduction

Logistics distribution refers to the entire circulation of goods from a logistics company to the consignee, which is an important part of E-commerce enterprises, such as taobao.com and jd.com. The process consists of the following 7 steps: preparation, storage, sorting and picking, loading, shipping, delivery service and distribution. Logistics distribution is not just about sending, but more importantly, "distribution". It is a diversified model. At this stage, logistics distribution can not separate from commercial logistics and capital flow and the three supplement each other. The long-term development of the logistics industry is inseparable from the logistics and distribution system. The systematic and standardized logistics and distribution system can not only reasonably allocate relevant resources within the specified area, ensure the human and material resources for daily logistics distribution, but also realize the goal of real-time command of logistics vehicles by means of a dynamic dispatch system.
Generally, the logistics distribution system is a multi-route optimization issue and many factors need to be considered. The author believes that decomposing this into a single-vehicle route optimization issue can effectively address it, namely, by studying the route optimization problem a single vehicle. Based on this, in this paper, the author mainly studies the optimization of chemical logistics route based on improved genetic algorithm. The author initially selects relevant populations, assigns individual values to populations and performs certain processing on crossover operators to allow individuals to evolve from generation to generation. Then the author carries out a mutation operation and improves the adaptive probability and analyzes the shortest distance of the entire distribution route.

2. Literature review

With the increasingly fierce competition among enterprises, all kinds of enterprises begin to use all kinds of internal and external resources of enterprises to the maximum extent and establish strategic partner or enterprise alliance with upstream and downstream enterprises, and they also outsource some non-core businesses to cultivate and develop their own core business and ability professionally. The outsourcing of transport services has always been considered as a creative solution when enterprises are seeking ways of restructuring the distribution network. Especially in the chemical industry, the third party chemical logistics road transport industry has emerged quietly and plays a more and more important role in the chemical logistics road transport industry. With the continuous expansion of the road transportation market of chemical

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logistics, the third party chemical logistics will become a rapidly developing industry and has become an effective mode of developing the chemical industry in developed countries in the world.

At present, the pricing method of many chemical logistics road transportation enterprises is still to adopt a certain proportion of profit based on the cost of other competitors, which makes the operation of the whole chemical logistics road transport enterprise pay attention to the adjustment of the price of the external market. The pricing methods of chemical logistics enterprises do not consider the significance of the strategic layout, which often makes the price adjustment of the customers or competitors. It is lacking of scientific pricing system and reasonable price mark. The lack of planning for this price makes the operation of the company in a passive situation. In addition, the traditional method is often restricted by the one-way vicious game between the market enterprises, which is not conducive to the long-term development of the enterprise. It also does not reflect the autonomy and strategic planning of the enterprises in the formulation of the price and neglects the characteristics of the price in the special logistics operation of chemical logistics. Some enterprises adopt cost addition pricing method, this method is simple and easy to keep the price stability, but its disadvantage is that before the service price is determined, it must first determine the amount of transportation that the enterprise can or may provide, the static treatment of the market, that is to calculate the cost according to the size of the service. In the price of various services, it completely ignores the elasticity of price and does not think about the change of market supply and demand in the market, which is difficult to reflect the market law of the price itself and the leaping characteristics of the price factors in the market and cannot be analysed from the point of view of the price. At present, the strategic layout of the company is a problem, so the price made under this situation cannot reflect the change of market supply and demand sensitively and the current market acceptance of the price. The enterprise lacks the stability and long term of business flexibility and price planning.

The relative prices of logistics services are relatively large, and all aspects of logistics services are also included in the pricing of transport services. Hope introduces a variety of pricing models and methods, as well as the dynamic and static pricing models that consider service quality priority, priority service and transportation strategy, in which time sensitivity is used in the price model (Hope, 2016). Fu and Fu, starting from the target of logistics enterprises and customers, construct the two stage game model of logistics service pricing, and analyse the pricing strategy of logistics service on the basis of complete hypothesis, and put forward some suggestions and methods for making logistics service price (Fu and Fu, 2017). Sohn points out that the goods carried by the logistics service as the implementation object of the service of the third-party logistics enterprises are essentially the supply of a service scheme. It should consider the combination of the whole and the division of the hierarchy and position the service pricing of the logistics scheme in the marketing. Through the analysis of the economics and marketing, it gives the logistics suggestions on pricing of service product (Sohn et al., 2017). Perez quantified the demand price elasticity through quantitative and qualitative methods and drew specific decision-making behaviours and decision-making methods (Perez et al., 2016). Guo fully considers a set of effective pricing methods that are in line with the economic and technological environment of the third-party logistics and the motivation of the participants and considers the relevant principles of the supply chain. Based on the basic pricing model and the pricing model considering exogenous factors, the theory is extended and optimized Related simulations have been conducted (Guo et al., 2017). Czichowsky refers to the service price to determine the ideal and reasonable logistics demand service. It is considered that the supply price of logistics depends on the shadow price of the supplier in the specific logistics service function. It is considered that the total logistics shadow price combined with the logistics service provider is equal to the full competitive market when the supply and demand side obtains the maximum margin. At the price level, the logistics service demand facilitates the equalization of marginal utility. Any attempt to deviate from the equilibrium price will tend to be equal under the mediation of the market mechanism (Czichowsky et al., 2016). Mulinari has discussed the application of traditional marketing methods in the marketing of logistics industry, and further theoretical exploration is carried out from the perspective of traditional marketing, which strengthens the theoretical guiding significance of the marketing facts of logistics enterprises (Mulinari, 2016). Choi and Choi established the price game model between different enterprises and carried out a basic game analysis on the related models. The relationship between the degree of product differentiation and the price sensitivity of the transportation enterprises was obtained. It was proposed that the enterprise should move from the simple price competition to the product differentiation as the main competitive direction on the problem of adjustment (Choi and Choi, 2017).

To sum up, the above research work mainly studies the essential concept of chemical logistics, the combination of quantitative and qualitative methods, the perspective of traditional marketing and the model of price game, but it is seldom studied in the improvement of logistics path optimization. Therefore, based on the above research status, this paper mainly studies the optimization of chemical logistics path based on improved genetic algorithm. The characteristic of this method is that it does not use the search space knowledge or other auxiliary information, but it uses the fitness function value directly to evaluate the individual without being limited by the derivation and function continuous and differentiable, and its definition domain can be set arbitrarily. The search direction is chosen by the change of probability, so it has better global optimization ability, therefore, it should be better and have a wide range of use.

3. Methodology

Genetic algorithm is a classic heuristic algorithm and also a kind of global search algorithm. Its main idea is "survival of the fittest" according to the survival rules in the nature, and the development of natural creatures is a gradual process of evolution from simple to complex, from low to high, from inadaptation to adaptation to the natural world. In this process, those adapt to the environment survive and good genes are inherited to the next generation. The offspring of different individuals is a gene combination of the parent and may be accompanied by gene mutation in the process, which produces better offspring. The genetic algorithm is applied to address the vehicle routing optimization issues in the logistics distribution center. The detailed steps are described as follows:

Step 1: Calculate the distance matrix $D = dij(n \times n)$;

Step 2: Randomly generate N chromosomes $TN=\{T1,T2, . . . , Tn\}$;

Step 3: Call the evaluation function to calculate the value of each chromosome fitness in the chromosome set TN;

Step 4: Firstly perform the selection operation on the set TN, then perform the cross operation and finally perform the mutation operation;

Step 5: Determine whether the number of cycles meets the specified generation number. If so, continue to Step 6 and output the optimal solution; otherwise, go to Step 3; and

Step 6: The last demodulation of the genetic algorithm iteratively generates the decoding function using the decoding function and the dispatch route and access sequence of each vehicle can be obtained. The hill-climbing algorithm is a local-optimal search algorithm. The algorithm starts with the current solution and then compares it with the solutions in its neighborhood to select the optimal solution as the current solution. The dynamic crossover strategy and the dynamic mutation strategy are mainly to choose a better solution in the process of solving. The hill-climbing algorithm is mainly to further optimize and improve the generated route and to exchange the order of the two clients to be dispatched in the route, if two are exchanged. After the route of clients to be dispatched is shortened, the order of delivery of the two clients to be dispatched is exchanged; otherwise, the order of client access of the original route is not changed.

Route optimization. The route optimization problem is a kind of NP problem. It is difficult to obtain an exact solution in many cases through mathematical modeling. Even after solving by simplifying, the result obtained is far from the actual result. The genetic algorithm repeatedly iterates the initial population, making the results always develop in a good direction and the implied parallelism greatly improves the computational efficiency. Currently, good results have been achieved in terms of knapsack problem, line production scheduling, TSP problem and holes machining route optimization.

The effective theoretical basis of genetic algorithm is the schema theorem and building block hypothesis. The schema theorem guarantees that the genetic algorithm can have an exponential increase in the number of samples of a better solution during iterative evolution, ensuring the possibility of finding a global optimal solution. The building block hypothesis affirms the ability of the genetic algorithm to find the global optimal solution. That is, the “blocks” with low order, short distance and high average fitness are combined through the 3 operators of selection, crossover and mutation in the genetic algorithm iteration process, which can produce "building blocks" with high order, long distance and high average and finally obtain a global optimal solution.

The GBLSA algorithm proposed in this paper is different from simple genetic algorithm. Firstly, the first primary selection is carried out on the initial population selection to ensure the superiority of the initial population under random selection. Secondly, the three major operators of genetic algorithm are improved. The selection operator based on bit ordering is used to screen the population. The crossover operator based on the link state algorithm is used to complete the individual crossover operation and the optimization ability of the algorithm is improved. Lastly, an individual mutation operation is performed by a mutation operator based on the inversion of the gene value. In the implementation of the algorithm, the feature of adaptive probability is introduced, which effectively guarantees that in the initial stage of the algorithm, a rich population of individuals can be generated. In the later stage of the algorithm, excellent individuals can be retained without being damaged.

The algorithm uses the coding method to address the most easily understood route representation in the TSP problem. This method will not cause the issues of codes being too long caused by the binary code in solving the large-scale TSP problem. For example, the route (13524) shows a complete route from City 1 to City 3, City 5, City 2, City 4 and back to City 1.

In order to prevent the occurrence of individual extremalization in the initial population, we first randomly generates a cluster of initial population with a size three times that of the original population. Assuming that the number of individuals in the initial population is N, the initial population set is 3* N. For the initial population set, the N individuals ranked (N1, 2N) are selected as the initial population.
For the problem of optimizing the logistics distribution route to address the problem of minimum value, we use the total route length as the objective function. For individual $X=(x_1,x_2,\ldots,x_n)$, the corresponding route length is:

$$S(x) = \sum_{i=1}^{n-1} d(v_\lambda(i), v_\lambda(i+1) + d(v_\lambda(n), v_\lambda(1))) \quad (1)$$

The link state algorithm is based on the fact that each router that participates in link state routing has a complete topological graph of the entire network. According to the topological graph, the location of the next point closest to this node can be obtained, so as to obtain the shortest route. However, this algorithm requires that the nodes must have complete network topology information, which results in huge computational workload. In this paper, the author integrates the powerful searching ability of the link state algorithm into the crossover operator of the genetic algorithm, which also accelerates the convergence speed while making up for the lack of both. The 7-city distance matrix is shown in Table 1. The parent individuals A and B are (6574231) and (1372456) respectively.

Table 1: Distance Matrix of Seven Cities

	1	2	3	4	5	6	7
1	∞	10	14	19	27	21	28
2	10	∞	16	18	11	25	31
3	14	16	∞	27	8	12	17
4	19	18	27	∞	23	18	21
5	27	11	8	23	∞	10	24
6	21	25	12	18	10	∞	26
7	28	31	17	21	24	26	∞

In the entire algorithm system, the crossover operator is mainly used to generate new individuals and the fitness value of the population steadily increases. In the early stage of the algorithm, the individual fitness caused by the random selection of the initial population is not as good as expected. It is necessary to generate new individuals through the crossover operator to enrich the diversity of the population. In the execution of the algorithm, the average fitness value is treated as a threshold. For individuals below the threshold, its crossover probability should be increased so that it can have the opportunity to change its own fitness value.
The genetic algorithm has a strong global search ability, but it is weak in local space search. The optimal solution obtained usually does not meet the requirements of the global optimal solution. The simulated annealing algorithm is strong in local space search due to its own characteristics. Judging from the search space, if the genetic algorithm is to find the optimal solution by continuously generating new individuals, it is a kind of search from the breadth of the space, then the simulated annealing algorithm can be the optimal solution from the depth of space. Simulated annealing algorithm is used to determine whether the new individual is accepted according to the Metropolis criteria, the specific approach is shown in formula (2):

$$P(I,j) = \begin{cases} \exp\left[\frac{S(i)-S(j)}{t}\right] & S(j) \rangle S(i) \\ 1 & S(j) \le S(i) \end{cases} \quad (2)$$

4. Results and discussions

In order to better prove the feasibility and efficiency of the algorithm, in this paper, the author selects several instances in the internationally recognized TSP test library to test the algorithm.
The parameters in the experiment are set as follows: The maximum genetic algebra G=200, the population size popsize=50, the crossover probability Pc and the mutation probability Pm are derived from the adaptive probability.
The above-mentioned examples eil76, oliver30, rat99 and rand75 are simulated by this algorithm and the resulting optimal route map is shown in
Figure. 1, Figure. 2, Figure. 3 and Figure. 4

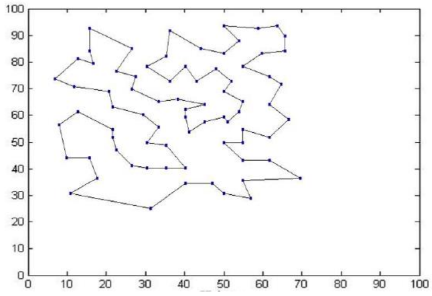

Figure 1: The optimal route diagram obtained by using the GBLSA for example eil76

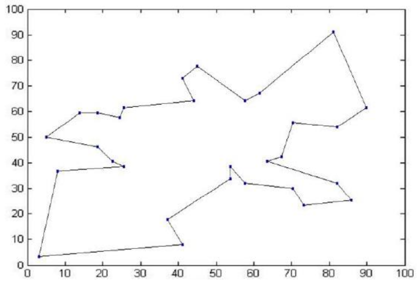

Figure 2: The optimal route diagram for the oliver30 via GBLSA

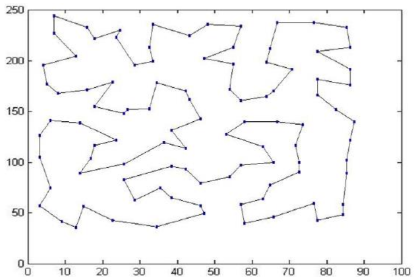

Figure 3: The optimal route diagram for instance rat99 through GBLSA

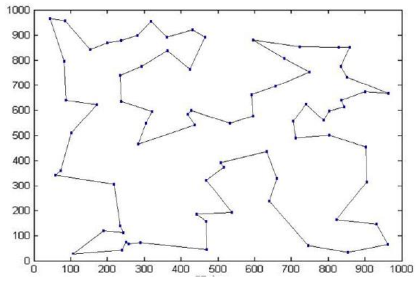

Figure 4: The optimal route diagram of the example rand75 through GBLSA

Use the GBLSA algorithm and the traditional genetic algorithm to simulate the instances of ePL76, oliver30, rat99 and rand75 in TSPLIB. After 10 tests, the optimal route values calculated are compared with the optimal route values provided in TSPLIB. The comparison is shown in Table 2.

The experimental data in Table 2 shows that the optimal route values obtained through the simulation of the GBLSA algorithm are better than the optimal route values provided by TSPLIB. This is also due to the powerful optimization ability of the improved crossover operator. The improved adaptive probability and the late annealing process make it possible to find the shortest route value in a short time.

In order to better verify the effectiveness of the algorithm, in this paper, the author adopts the same method as in related literature to solve the routes of 50 and 100 logistics distribution outlets. For 50 logistics distribution outlets in total, the final result in this paper is 549.276 and the improvement rate is 2. 238%. For a total of 100, the final result is 21280 and the improvement rate is 0.463%. By comparison, it can be seen that the method has been further improved.

Table 2: Comparison of Improved Genetic Algorithm, Traditional Genetic Algorithm and TSPLIB to Provide Optimal Path Value

	TSPLIB optimal route value	GBLSA algorithm	Traditional Genetic Algorithm
eil76	5283795	5369662	7436981
oliver30	4251276	4237406	6822634
rat99	12405284	12356608	15125318
rand75	70996507	70938241	73102653

5. Conclusions

In this paper, the author mainly studies the optimization of chemical logistics route based on improved genetic algorithm. The author initially selects relevant populations, assigns individual values to populations and performs certain processing on crossover operators to allow individuals to evolve from generation to generation. Then the author carries out a mutation operation and improves the adaptive probability. The results of this study show that for 50 logistics distribution outlets in total, the final result in this paper is 549.276 and the improvement rate is 2.238%. For a total of 100, the final result is 21280 and the improvement rate is 0.463%. At the same time, the optimal route value obtained by using the GBLSA algorithm simulation is optimal. From the research results, the GBLSA algorithm has a good performance in search efficiency and performance and can save a lot of costs for chemical logistics.

The study in this paper is carried out in a relatively ideal condition. After a series of calculations, the experimental results prove the effectiveness and accuracy of the improved genetic algorithm in this paper. However, there are still many aspects that need further improvement. In the selection process, the author has not incorporated third-party factors such as weather and road conditions into the scope of investigation. Therefore, the experimental results in this paper reflect the route optimization in an ideal environment.

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