Study on Location Selection and Optimization of Logistics Center based on Particle Swarm Optimization

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Abstract

In the entire logistics system, the location of the logistics distribution center is very important. Optimizing the logistics distribution center can achieve the advantages of low operating costs, high transportation quality, and improved management efficiency. Therefore, to solve the problem of logistics distribution center location, particle swarm algorithm is used to select the location of the distribution center, and the solution is compared with the traditional location method. Through case analysis, particle swarm optimization has unique advantages in terms of optimization effects, and can optimize the choice of distribution center location to achieve the optimal objective function.

Keywords

Logistics, Distribution location, Particle swarm optimization.

1. Introduction

With the increasing maturity of the domestic e-commerce industry, the logistics industry also presents an explosive growth. Logistics is the intermediate link between manufacturers and consumers, is the necessary link to carry out time and space transfer of goods. As logistics cost is always an important part of enterprise cost, how to reduce logistics cost and improve distribution efficiency has become an urgent solution for various countries and industries. Research of logistics distribution center location selection can directly affect the quality of goods distribution costs, the effects of service, and distribution as a result, choose a good distribution center location, can minimize logistics cost, increase profit, improve customer trust, more can improve the operation efficiency of logistics system, improve the utilization of social resources. It can be said that the location of logistics center has a very important research value [1].

There are many research methods in academic and logistics field about the location of logistics center. Some scholars consider the influence of a single variable, such as the minimum sum of distance between logistics center and demand point; The other is a reasonable distribution of distribution center distribution scope; Still have to consider the relationship between traffic volume and distance to determine the distribution center. Feng[2] et al. proposed a OPTICS clustering algorithm in a more innovative way. The algorithm has a clustering density that can be adjusted and the parameters required by different data can be flexibly adjusted. However, due to its complexity, the running time and efficiency of the algorithm have drawbacks. Shi Hongyu [3] adopted the two-stage method to select the location of logistics park from the perspective of industrial cluster, and determined the location scheme. Li Shuang and Pan Xiu [4] applied DEA and AHP models to logistics location selection, selected scheme coefficients with DEA and ranked them with AHP method, and simply established the site selection scheme of logistics distribution center. In terms of green logistics, Fang Wenting [5] considered the mathematical model of path selection with the lowest total cost and
adopted the hybrid ant colony algorithm based on the global convergence of A* algorithm and the positive feedback construction of ant colony algorithm, but the algorithm had premature convergence. Zhao Gang et al. added the comprehensive weight value jointly determined by the distribution time of logistics transportation and the distribution time and demand, and set up different distribution centers in the region, and carried out simulation through MATLAB, further verifying the feasibility of the immune algorithm [6]. Of course, there are also many scholars who conduct logistics site selection by integrating with other algorithms, such as the combination of particle swarm optimization algorithm with immune algorithm, genetic algorithm and artificial bee colony algorithm [7].

Based on particle swarm optimization (PSO), this paper analyzes the location behavior of logistics center, and considers the factors of distance, cost and demand in the distribution process to ensure the rationality of the location of logistics center. Based on particle swarm optimization (PSO) and traversal search (ERGOc), a comparative analysis was conducted to verify the effectiveness of the proposed center site selection method, and Java was used for the simulation verification of logistics center site selection.

2. **Site selection Method**

At present, there are many types of distribution center site selection models, which can be divided into single site selection and multi-objective site selection according to the number of sites.

According to the discrete degree of site selection, it can be divided into continuous and discrete site selection method.

There are also dynamic and static siting methods divided according to time continuity.

With the increase of the dimension of the problem and the model, it is difficult to deal with the traditional mathematical solution, so it is necessary to optimize the modeling to solve the problem.

![Fig. 1 Relationship between distribution center and demand point](image-url)
3. Logistics distribution center location selection model

3.1 Distribution center cost analysis

The location of distribution center plays a key role in logistics distribution. A logistics center not only needs to consider the delivery cost, but also needs to consider the delivery distance and customer satisfaction, so as to meet the actual needs of modern logistics distribution center.

The cost of logistics distribution center can be divided into construction cost, storage cost, transportation cost, etc.

Reasonable assumptions should be made for this model:
1). You need to know the annual demand for each demand point.
2). Transportation costs in the process of transportation.
3). The distribution speed of each distribution center is relatively constant and there is no difference.
4). There is no long-term inflow than outflow in the distribution center.

3.2 Logistics center location problem model

As can be seen from the above figure, the location of logistics distribution center is selected according to the known location coordinates of the customers and the distribution demand of the required goods, so as to optimize the objective function needed by the logistics distribution center.

The objective function is

$$\min \sum_{i=1}^{n} \sum_{j=1}^{q} t_{ij} q_{j} d_{ij}$$

(1)

Where, \( t_{ij} \) is the transportation cost between two points, \( q_{j} \) is the annual demand at Demand point J, and \( d_{ij} \) is the distance between the proposed location and demand point J.

4. Particle swarm optimization

Particle swarm optimization (PSO) is an iterative optimization tool created by Dr. Eberhart and Dr. Kennedy based on the study of bird flock predation behavior. By initializing a set of random solutions and searching for the optimal value through iteration, PSO has been successfully applied in functional optimization, scientific planning, artificial intelligence and other fields so far [8].

The PSO algorithm first initializes a group of random ions, and then the particles follow the current optimal ions to search for solutions.

Assume that the velocity position of the ith particle in the D-dimensional space is \( X_i = (x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iD}) \) and \( V_i = (v_{i1}, v_{i2}, v_{i3}, \ldots, v_{iD}) \), in each iteration, the particle updates itself by tracking two optimal solutions, of which Pbest is its own optimal solution \( P_i = (p_{i1}, p_{i2}, p_{i3}, \ldots, p_{id}) \) and the other is the population optimal solution Gbest, and its velocity and position are updated according to the following formula.

$$V_{ij}(t+1) = W V_{ij}(t) + c_1 r_1 [p_{ij} - x_{ij}(t)] + c_2 r_2 [p_{gj} - x_{ij}(t)]$$

(2)

$$X_{ij}(t+1) = X_{ij}(t) + V_{ij}(t+1), j = 1, 2, \ldots, d$$

(3)

Where, \( W \) is the inertia weight factor, \( c_1, c_2 \) is the positive learning factor, and \( r_1, r_2 \) is the random number uniformly distributed between 0 and 1. The number of particles is generally determined by the complexity of the problem. In general, very good results can be obtained within 20~50 for the general problem. For simple problems, about 10 particles can be used, while for
complex problems, more than 100 particles can be used for solving. Dimensions are generally based on the dimensions of the solution to the problem. The maximum particle velocity is generally set not to exceed the range width.

The learning factors $C_1$ and $C_2$ are usually 2, usually equal and within the range of 0~4.

5. Case Application

Suppose there are 50 demand points B0~B49 to be distributed in the logistics network of a certain region, and it is necessary to select a location near these 50 points or among them for the construction of logistics center.

Due to the lack of information between logistics points, the software was used to directly generate 50 random data points as demand points, and randomly generate coordinates and demand.

The annual demand and distribution locations of the 50 demand points are known, and the solving parameters are shown in the following table.

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<th>Y coordinate</th>
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Table 1 Coordinate of demand point, transportation cost and quantity demanded
Put the data into the algorithm, adjust each parameter in the algorithm, set the number of particles 20, iterate for 500 times, \( c_1 = c_2 = 2, \ W = 1.4. \)

The following results are obtained: At the point position (43.43021233, 50.89621711), the value of the objective function is 490790.5151. When using traversal search, the following results can be obtained: The minimum target value is 2, and then the minimum target value is 506428.73625039245.
It can be seen that PSO algorithm has better calculation results in solving logistics site selection, and the value of objective function obtained by solution is also better than that obtained by direct solution.

6. Conclusion

In the thorough analysis on the basis of research on logistics distribution center location planning problem, established the mathematical model of logistics distribution center location, introduces the particle swarm optimization (PSO) to solve the problem of the optimal solution, the empirical results show that PSO algorithm can reduce the iteration times and time, and can improve the optimization precision of location selection problem, reduce the total cost of logistics distribution center. Article in the Java language software set up calculation model easy to understand, can get ideal result, and has set up the model has generality and similar engineering problems can be through the change of part of the statement can solve, especially for large complex network, it can play a greater advantage, is well worth wide application in the logistics field.

References

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