An Evaluation Method of Logistics Optimization Schemes based on Multi Preference Group Decision Making

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Abstract — **To overcome the limitations of standard Particle Swarm Optimization (PSO) algorithm to solve the site selection problem for logistics distribution centers, the catfish (CF) approach is combined with PSO to form CFPSO. Simulation experiments are carried out on actual problems of site selection of logistics distribution center and compared with standard PSO algorithm and genetic algorithm, which is adopted to verify effectiveness of CFPSO. Simulation results indicate that CPSO algorithm preferably overcomes differences compared with other algorithms and obtains global optimum scheme with comparable advantages that other algorithms fail to match.**

Keywords - logistics distribution; preference information; multi-attribute group decision; logistics path; scheme evaluation

I. INTRODUCTION

With rapid domestic economy development and sharp increases in logistics distribution business, distribution center plays a pivotal role in logistics system for the target to deliver merchandise and goods to customers mainly according to different customer demands in the area, thus site selection of logistics distribution center is the core of logistics system research and choosing optimum logistics distribution center is of great significance of utility value [1].

In terms of site selection of logistics distribution center, domestic and foreign scholars have conducted substantial researches and proposed many location models [2]. Substantial researches indicate that site selection of logistics distribution center is a target optimization problem with complexity and constraint, belonging to NP-hard problem [3]. For this, scholors propose tabu search algorithm, genetic algorithm and ant colony algorithm which have achieved results to an extent [4-6]. Due to these algorithms belong to heuristic search algorithm, when the range of desired questions, optimizing site selection of logistics distribution center is slow and it is hard to obtain global optimum site selection of logistics distribution center words, thus location effect is not ideal[7]. PSO algorithm simulates foraging act of groups of birds, and its advantages such as fast speed, ability of searching optimization and simple parameter setting make it the mainstream algorithm of site selection of logistics distribution center solution[8,9]. In practical application, a few limitations exist in standard PSO algorithm, such as easily arisen “precocity” phenomenon, and in case of a great number of logistics distribution sites, it is easy for PSO algorithm to obtain locally optimal solution of site selection of logistics distribution center, but the effect of searching optimization is unsatisfactory [10].

II. LOGISTICS DISTRIBUTION

Site selection model of logistics distribution center can be expressed as:

$$\mathrm{Min}\,T = \sum_{j=1}^{M} h_j C_j + \sum_{i=1}^{N}\sum_{j=1}^{M} g_j W_{ij} + \sum_{i=1}^{N}\sum_{j=1}^{M} W_{ij} d_{ij} z_{ij} \qquad (1)$$

Where, W_{ij} expresses the quantity demand of demand point i ; l expresses upper limit of distance between demand point and distribution center; C_j is the construction cost of distribution center; g_j expresses unit management cost when the materials in distribution center are flowed; $h_j \in \{0,1\}$ expresses that j is selected as distribution center when it is 1; d_{ij} expresses the distance between demand point i and its nearest distribution center j ; $Z_{ij} \in \{0,1\}$ expresses the service distribution relationship between demand points and distribution centers and when it is 1, it can be expressed that quantity demand of demand point i is supplied by distribution center j , otherwise Z_{ij} $=0$[11]. Relevant restriction conditions of equation (1) are:

(1) Quantity demand shall be less than the scale of distribution center.

$$\sum_{j=1}^{M} W_{ij} \le B_i \text{ , } (i = 1,2,\cdots,N) \qquad (2)$$

(2) All demand points shall be serviced by their nearest distribution center.

$$\sum_{j=1}^{M} Z_{ij} = 1 \ , \ (i = 1,2,\cdots,N) \tag{3}$$

(3)There will no customers if the site is not equipped with distribution center.

$$Z_{ij} \le h_j \ , \ (i = 1,2,\cdots,N) \tag{4}$$

(4) p demand points are selected as distribution center.

$$\sum_{j=1}^{M} h_j = p \tag{5}$$

(5)Distribution center shall only provide service for neighboring demand points.

$$d_{ij} \le l \ , \ (i \in M, j \in N) \tag{6}$$

Where, N expresses the assembly of demand points; M is the assembly of selected demand points in distribution center; C_j is the construction cost of distribution center; $h_j \in \{0,1\}$ expresses that j is selected as distribution center when it is 1; g_j expresses unit management cost when the materials in distribution center are flowed; W_{ij} expresses the quantity demand of demand point i ; d_{ij} expresses the distance between demand point i and its nearest distribution center j ; $Z_{ij} \in \{0,1\}$ expresses the service distribution relationship between demand points and distribution centers.

III. CFPSO OF CATFISH EFFECT

In PSO algorithm, each particle represents a potential solution of problem which remains to be solved and fitness function determines advantages and disadvantages of particles. First and foremost, produce a group of particles randomly, calculate fitness value of particles , particles will fly in the solution zone finally and find the solution of the problem eventually. Set optimal position of individual and group particles as *pbest* and *gbest* respectively and the equation of speed and position of particles is updated as:

$$\begin{aligned} v_{i,d}^{k+1} &= \omega \cdot v_{i,d}^{k} + c_1 \cdot rand(\ ) \cdot \left(pbest_{i,d}^{k} - x_{i,d}^{k} \right) + \\ & c_2 \cdot rand(\ ) \cdot \left(gbest_{d}^{k} - x_{i,d}^{k} \right) \end{aligned} \tag{7}$$

$$x_{i,d}^{k+1} = x_{i,d}^{k} + v_{i,d}^{k+1} \tag{8}$$

Where, ω is the inertia weight; c_1 and c_2 are learning factors; $rand()$ is the random number between 0 and 1; $v_{i,d}^{k}$ and $v_{i,d}^{k}$ are the speed and position of particle i in d dimension, k iteration; $pbest_{i,d}^{k}$ is the position of particle i in d dimension; $gbest_{d}^{k}$ is the position of group in global optimization of d dimension.

It can be known from Equations (7) and (8) that in case premature convergence exists in PSO, *p*g must be locally optimal solution and particles shall be set free from locally optimal solution area by changing *p*g or *p*i.

Norwegians like to eat live sardines, but sardines are lazy in nature and they don't like swimming, which leads to that live sardines are almost not much left after long-time transportation. In case of putting catfishes to the fish tank, they will swim all around when encountering unfamiliar environment. Sardines become nervous when meeting catfishes, so they have to swim faster to escape from being swallowed by their natural enemy thus their vigorous vitalities will be maintained, and they will not die because of anoxia, which is famous "catfish effect" [12]. According to the inspiration from "catfish effect", when particles gather in local optimization and cause the search ceases, find a "catfish" to stimulate particle swarm, and the particle swarm will jump out from local optimization point and find global optimization, which is exactly the basic idea of CFPSO.

Deviation threshold value is adopted in CFPSO as the triggering condition and global extremum and individual extremum are disturbed by catfish operator. The following is the update change of particle speed.

$$\begin{aligned} v_{i,d}^{k+1} &= \omega \cdot v_{i,d}^{k} + c_1 \cdot rand() \cdot (c_3 \cdot rand() \cdot pbest_{i,d}^{k} - x_{i,d}^{k}) \\ & + c_2 \cdot rand() \cdot (c_4 \cdot rand() \cdot gbest_{d}^{k} - x_{i,d}^{k}) \end{aligned} \tag{9}$$

Where, c_3 expresses crash strength of catfish on the individual optimization, c_4 expresses crash strength of catfish on the global optimization, $c_3 \cdot rand()$ and $c_4 \cdot rand()$ are called catfish operator with the definition as follows:

$$c_3 \cdot rand() = \begin{cases} 1, & e_p > e_{0p} \\ c_3 \cdot rand(), & e_p \le e_{0p} \end{cases} \tag{10}$$

$$c_4 \cdot rand() = \begin{cases} 1, & e_g > e_{0g} \\ c_4 \cdot rand(), & e_g \le e_{0g} \end{cases} \tag{11}$$

Where, e_p expresses the deviation between the current value and the current individual optimal value; e_g expresses the deviation between the current value and the current global optimal value; e_{0p} expresses the threshold value of the deviation between the current value and the current local optimal value; e_{0g} expresses the threshold value of the deviation between the current value and the current global optimal value

From Equations (10) and (11), when the deviation of current value is greater than the threshold value of the deviation, catfish operator is 1, and CFPSO algorithm is standard PSO algorithm at the moment; otherwise, it can be deemed that assembly exists in particles and catfish operator shall be introduced to crash individual optimal value or global optimal value in order to jump out of local optimization.

IV. LOGISTICS DISTRIBUTION SCHEME BASED ON INTELLIGENT ALGORITHM

A. *Coding Scheme Of Particle*

When CFPSO algorithm is adopted to solve site selection of logistics distribution center, particle code is the first and most key step. Specific coding scheme of particle is: $X = (x_1, x_2, \cdots, x_N)$, among which the length of particle N is the number of alternative points. In case ultimately desired optimum particle is X=(1,0,0,1,1,0,0), it expresses that the first, fourth and fifth alternative points will be selected as logistics distribution center in 7 alternative points of logistics.

B. *Specific Procedures of Solution*

Set parameters of CFPSO algorithm which mainly include particle number, ω, c_1, c_2 and particle speed and particle position

Initialize particle swarm. Initial particle swarm is produced in conventional PSO algorithm through a random way in which the particles are easy to focus on a part and feasible solutions are distributed unevenly. Even methods are adopted to the Thesis to generate initial particle swarm and ensure the evenness of initial particle swarm distribution.

Calculate fitness value of all particles and determine individual optimization value and group optimization value according to fitness value.

Determine catfish operator according to Equation (10) to (11) and update speed and position of particles.

Calculate fitness value of all particles in new positions. In case fitness value of particles is superior to individual fitness value, the individual shall be updated to a new position, and in case fitness value of particles is superior to group fitness value, the group optimization value shall be updated to a new position.

In case maximum iterations are reached, optimal site selection of logistics distribution center scheme shall be output, otherwise it shall be switched to Step 2 to continue searching optimization.

Specific procedure is shown in Fig.1.

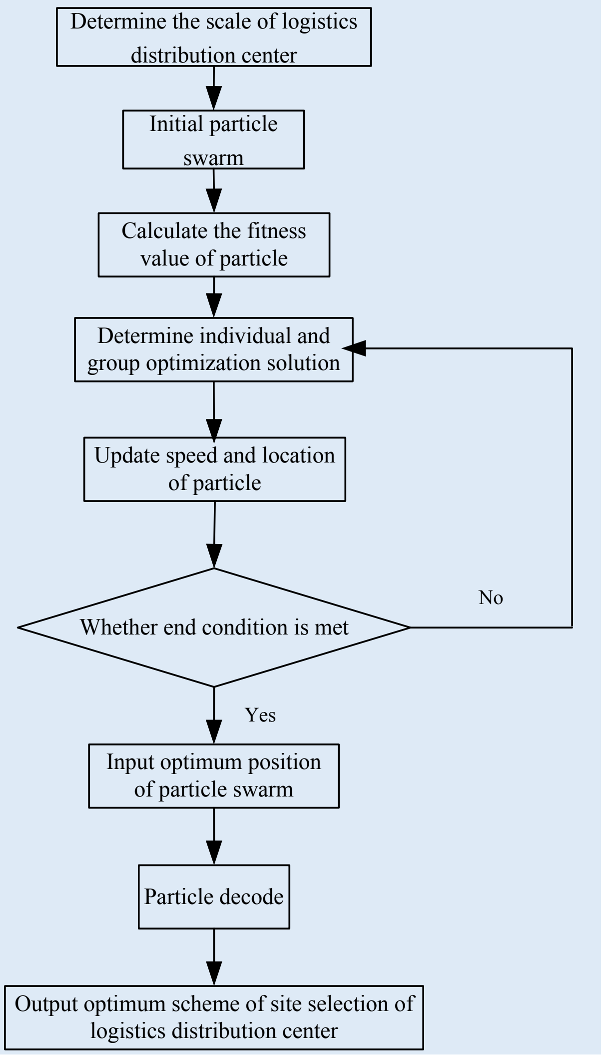

Figure 1. Logistics distribution center location solution procedure of CFPSO.

V. SIMULATION EXPERIMENTS

A. *Simulation Environment*

To verify the effectiveness of CFPSO algorithm on site selection of logistics distribution center solution, experiments have been conducted on dual-core P4 2.8G CPU, 1G memory, Windows XP operation system and Matlab2009 environment. Customer address and logistics quantity demand are shown in Table 1. To make location result of CFPSO algorithm comparable, genetic algorithm and standard PSO algorithm have been adopted to carry out simulation experiment.

TABLE 1. DEMAND POINT POSITION AND MATERIAL QUANTITY DEMAND

Location No.	x	y	Logistics quantity demand	Location No.	x	y	Logistics quantity demand
1	2987	1456	160	14	3357	2634	200
2	3752	1450	160	15	3329	1675	120
3	3978	2589	100	16	4123	2217	120
4	3875	1997	100	17	3545	2967	120
5	3367	1479	160	18	4287	2145	120
6	2564	1395	100	19	4713	2476	120
7	2956	1365	180	20	3278	2835	140
8	2247	1893	100	21	3217	2546	160
9	2845	2437	80	22	3216	3376	140
10	2537	2678	80	23	3898	2431	180
11	3132	1878	100	24	4430	1745	120
12	3621	3386	100	25	2932	1219	80
13	2967	2304	100	26	2856	2248	120

B. *Result Analysis of CFPSO*

Adopt CFPSO algorithm to solve site selection of logistics distribution center and select 5 positions as the distribution centers in 26 customer points. $c_1 = c_2$ =2, w =0.55, the maximum iterations is 100 and particle number is 20, and convergence curve of CFPSO algorithm is shown in Fig.2.

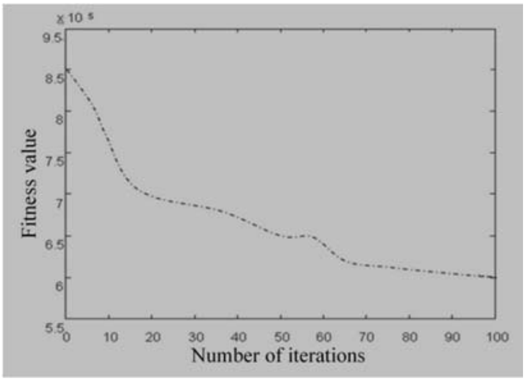

Figure 2. Convergence curve of CFPSO

Logistics distribution center location scheme is shown in Fig.3. It can be seen from Fig.3 that preferable site selection of logistics distribution center scheme can be obtained through the application of CFPSO algorithm. In Fig.3, dots express demand point and box expresses distribution center.

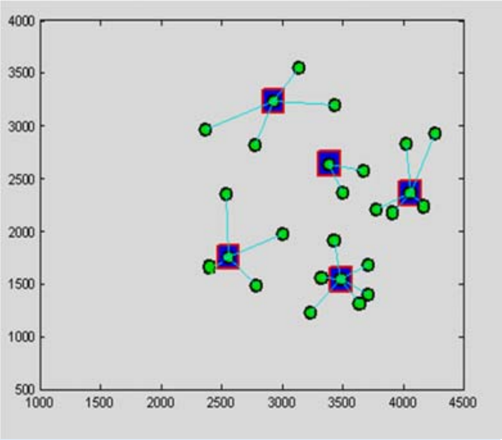

Figure 3. Location scheme of CFPSO.

Performance Comparison with Other Algorithms

Performance comparison result of Genetic algorithm, standard PSO algorithm and CFPSO algorithm in terms of site selection of logistics distribution center solution is shown in Table 2. It can be seen from Table 2 that CFPSO algorithm solves site selection of logistics distribution center in obviously quicker speed and higher efficiency compared with genetic algorithm and standard PSO algorithm. Comparison result indicates that CFPSO better overcomes deficiency during solving process of traditional algorithm. It is an effective solution algorithm for site selection of logistics distribution center and has advantage particularly for site selection of large-scale logistics distribution center.

TABLE 2. OVERALL PERFORMANCE COMPARISON BETWEEN DIFFERENT ALGORITHMS

Algorithm	Iterations	Performance period	Average distribution cost
Genetic algorithm	150	35.2	1445
Standard PSO algorithm	60	18.7	1214
CFPSO algorithm	32	10.5	998

VI. CONCLUSION

Due to the fact that premature convergence exists in standard PSO algorithm and defects such as local optimization tend to arise, catfish effect in nature is introduced and a location scheme of the logistics distribution center based on CFPSO is proposed. The introduction of “catfish effect”, particle activeness can be maintained soundly and the motion law of particles can be reflected more truly. Simulation experiment indicates that compared with genetic algorithm and standard PSO algorithm, CFPSO algorithm can obtain better site selection of logistics distribution center scheme and find the optimum logistics distribution center quickly and accurately.

REFERENCES

[1] Govindan K, Khodaverdi R, Jafarian A. A fuzzy multi criteria approach for measuring sustainability performance of a supplier based on triple bottom line approach[J]. Journal of Cleaner Production, (2013), 47(47):345–354.

[2] Chen N, Xu Z, Xia M. Interval-valued hesitant preference relations and their applications to group decision making[J]. Knowledge-Based Systems, (2013), 37(2):528-540.

[3] Zhu Y, Xu B, Shi X. A Survey of Social-Based Routing in Delay Tolerant Networks: Positive and Negative Social Effects[J]. IEEE Communications Surveys & Tutorials, (2013), 15(1):387-401.

[4] Xu Y, Yin W. A Block Coordinate Descent Method for Regularized Multiconvex Optimization with Applications to Nonnegative Tensor Factorization and Completion[J]. Siam Journal on Imaging Sciences, (2013), 6(3):1758-1789.

[5] Afolabi R O, Dadlani A, Kim K. Multicast Scheduling and Resource Allocation Algorithms for OFDMA-Based Systems: A Survey[J]. IEEE Communications Surveys & Tutorials, (2013), 15(1):240-254.

[6] Kannan D, Khodaverdi R, Olfat L. Integrated fuzzy multi criteria decision making method and multi-objective programming approach for supplier selection and order allocation in a green supply chain[J]. Journal of Cleaner Production, (2013), 47(9):355-367.

[7] Li K, Zhang Q, Kwong S. Stable Matching-Based Selection in Evolutionary Multiobjective Optimization[J]. IEEE Transactions on Evolutionary Computation, (2014), 18(6):909-923.

[8] Xu Z, Zhang X. Hesitant fuzzy multi-attribute decision making based on TOPSIS with incomplete weight information[J]. Knowledge-Based Systems, (2013), 52(6):53-64.

[9] Hamdy M, Hasan A, Kai S. A multi-stage optimization method for cost-optimal and nearly-zero-energy building solutions in line with the EPBD-recast 2010[J]. Energy & Buildings, (2013), 56(1):189-203.

[10] Omidvar M N, Li X, Mei Y. Cooperative Co-Evolution With Differential Grouping for Large Scale Optimization[J]. IEEE Transactions on Evolutionary Computation, (2014), 18(3):378-393.

[11] Zhang N, Wei G. Extension of VIKOR method for decision making problem based on hesitant fuzzy set[J]. Applied Mathematical Modelling, (2013), 37(7):4938–4947.

[12] Roijers D M, Vamplew P, Whiteson S. A Survey of Multi-Objective Sequential Decision-Making[J]. Journal of Artificial Intelligence Research, (2014), 48(1):67-113.

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