Operation Optimization of B Smart E-Commerce Logistics Center Based on Improved Dual Particle Swarm Optimization Algorithm

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Keywords: B Smart E-Commerce Logistics Center; Multi-Robot Task Scheduling; Improved Double Particle Swarm Optimization Algorithm

Abstract: Aiming at the problems of unreasonable random distribution mechanism and unbalanced shelf scheduling in the operation of B smart e-commerce logistics center, this paper firstly makes reasonable allocation of intelligent moving equipment on the basis of comprehensive consideration of multiple influencing factors. Secondly, the intelligent handling robot scheduling model is established and the standard particle swarm optimization algorithm is used for analysis. Finally, by optimizing and improving the algorithm, the two-particle swarm optimization algorithm is used to solve the problem, and the conclusion is given.

1. Introduction.

B electric business logistics center's main job are put in storage, procurement, inventory, and unloading, including outbound divided into picking and check packaging, handling work are completed by intelligent handling equipment, and carries on the unified scheduling by the WCS system, after the WMS system commands, WCS system will be according to the instructions, automatic randomly assigned to the corresponding idle intelligent handling equipment to complete the task, give preference to idle equipment; If there are more than one idle device, it is randomly selected. The walking path of the intelligent handling equipment can automatically identify the nearest walking path according to the coordinates, and can be scheduled in all job links.

In the long-term operation, it is found that the random assignment mechanism of intelligent robot is not reasonable. Firstly, from the perspective of intelligent robots, different scheduling tasks have different transport locations and distances, so the random distribution mechanism will increase the transport distance and reduce the transport efficiency. Secondly, from the perspective of task assignment, a single task exists the possibility of intelligent robot, scheduling and task within possible synergies, random allocation mechanism cannot assure efficient teamwork, at the same time, multiple platform between shelves scheduling uneven phenomenon, increased and intelligent robot platform waiting time, reduce the working efficiency.

To solve the problems about B electric business logistics center the need to consider the order quantity, picking efficiency, cost and other factors, analyze the intelligent handling equipment demand quantity and reasonable configuration, and from the perspective of intelligent robot scheduling and task allocation, rational design of more intelligent robots collaborative tasks scheduling model, choose the appropriate algorithm to solve, in order to achieve high efficiency and low operating costs.

2. Quantity Configuration of Intelligent Handling Equipment.

2.1 Order Quantity.

In the process of operation, daily 12:30-20:30 for order dense segment, the corresponding this time as the base for unloading, so the number of robots must meet the requirements of this period of time, based on historical order effectively, screening in the most of this period of time of a day of the week: 9.21 days (16:00-17:00) placing orders, part of the data in table 1.

Table 1 partial order data during peak hours of September 21.

Order	Name	Amount	Time
ON2018090800789	A snack	1	16:36
	Hand cream	2	
	Seaweed wave force	4	
ON2018090801005	Nestle coffee	8	16:03
	Tissue box	3	
	Spaghetti	1	

The corresponding coordinates of all commodities in this period are shown as follows:

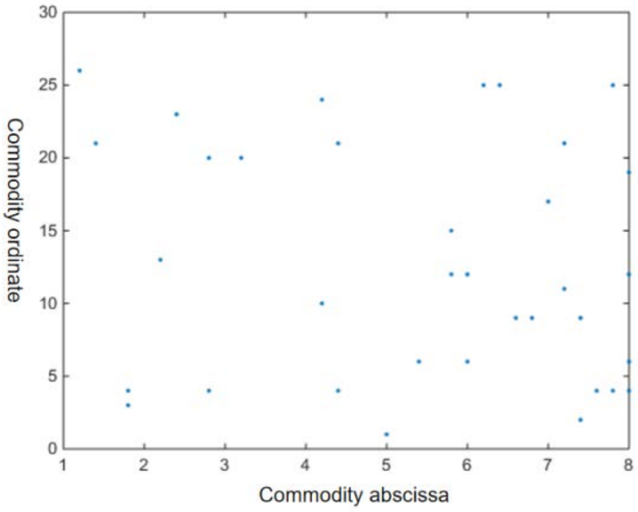

Figure 1 Coordinate of commodity location during peak hours on September 21.

2.2 Operating Efficiency.

Through the investigation of A logistics center, it is known that: Speed of intelligent robot: 1.2m/s; Robots move shelves one at a time; A shelf pick time of about 20 seconds; It will take about 45s for an order to complete. Total orders: 15; Total goods: 186; 6 picking tables operating simultaneously. And the activity cost is known that:

Table 2 Operating Cost of Intelligent Handling Equipment.

Cost Type	Cost Account	Course Title	Cost
Charge equipment cost on time	Power forklift	Unit time cost of automatic forklift	1
Charge equipment cost on time	AGV	Unit time cost of AGV	1

2.3 Quantity Configuration.

Assume that the AGV truck is x, the power forklift truck is y, and the cost is x+y , and we pay attention to the single cost is the same, that is to say, the quantity should be reduced as far as possible. According to the service requirements of A e-commerce logistics center, orders can be received within half an hour, and robots should be sent to pick up the goods. By analyzing the time of the order, we obtain the following time and the quantity of goods.

Table 3 commodity quantity analysis table

Time	Amount	Items	Time	Amount	Items
16:00	10	Washing cosmetic	16:25	8	Cultural goods
16:03	12	Washing cosmetic , food	16:28	5	Food
16:04	14	Food	16:31	17	Electrical appliances
16:24	11	Health care products	16:33	21	Washing cosmetic

As for the time, the analysis shows that around 16:03-04, 16:24-25 and 16:31-33, there are a large number of orders. If the orders in this period meet the conditions for delivery, then the service requirements can be met.

After the above analysis, the number of devices that can meet the requirements of intelligent handling in the above period is as follows: automatic three-way forklift truck: 4, intelligent robot: 9. This can not only meet the situation of multiple orders at the same time, at the same time the quantity is relatively small, low cost.

3. Task Allocation and Planning of Multi-Robot Collaborative Operation.

On the basis of the above contents, the scheduling problem of multiple machines is considered, and the scheduling model is established and solved by particle swarm optimization algorithm.

3.1 Scheduling Model of Intelligent Handling Robot.

K represents the set of intelligent robots. If $|K|$=K, there are K intelligent robot to complete the transportation task, and there are k direct paths.J : Represents all tasks, $\text{J} = \{I, F\} \cup J$.

Parameters: t_{ij}: Represents the time interval between task i and task j of the intelligent robot. S_{ij}: The running time of an intelligent robot between tasks. hq_i: The time it takes the platform to process each task. hy_i: The time at which each task may be processed by the platform. w_{ij}: The time delay cost caused by the intelligent robot completing task i and then completing task j. qs_i: The platform can handle the time decision variable of commodity task i. X_{ijk}:0-1 variable, 1 means that intelligent robot k will complete task i after completing task j. W_{IJ}: There are two situations: if the intelligent robot arrives late, $qs_i + t_{ij} - qs_j \geq 0$,at this point the platform needs to wait for the intelligent robot; if early, $qs_j - t_{ij} - qs_i \geq 0$, at this point it has to wait for the platform.So $W_{ij} = a(qs_i + t_{ij} - qs_j) + b(qs_j - t_{ij} - qs_i)$.

Where, a is the time cost coefficient caused by the early arrival of the intelligent robot, and b is the time cost coefficient caused by the late arrival of the intelligent robot, both of which are positive random Numbers not greater than 1. t_{ij}: Represents the time interval between task i and task j of the intelligent robot. According to the transportation mode of the intelligent robot, the calculation method is as follows:

(a) $t_{ij} = hq_i + t_i + hy_i + s_{ij} \quad i,j \in J^-$ (b) $t_{ij} = hq_i + s_{ij} + hy_i + t_j \quad i,j \in J^+$

(c) $t_{ij} = hq_i + s_{ij} \quad i \in J^+, j \in J^-$ (d)$t_{ij} = hq_i + t_i + hy_i + s_{ij} + hy_j + t_j \quad i \in J^-, j \in J^+$

Because intelligent robot has strict requirements on smoothness of loading and unloading goods, so this article assumes that each platform has strict handling operation sequence, corresponding calculation can't violate the platform of A loading sequence. For example, for platform k, if i > j, $t_{ij} = M$, M approaches infinity, which means that platform k's task i cannot be completed before task j.

$$\min \sum_{j \in J} \sum_{i \in J} w_{ij} x_{ijk}, \forall k \in K$$

$s.t. \sum_{k \in K} \sum_{i \in J} x_{ijk} = 1, i \in J$ (a) $\sum_{k \in K} \sum_{i \in J} x_{ihk} = 1, j \in J$ (b)

$\sum_{i \in J} x_{ihk} - \sum_{i \in J} x_{hjk} = 0, h \in J, k \in K$ (C) $\sum_{i \in J} x_{ijk} = 1, \text{k} \in \text{K}$ (d)

$\sum_{i \in J} x_{iFk} = 1, k \in K$ (e) $x_{ijk} \in \{0,1\}, i, j \in J, k \in K$ (f)

Equation is the objective function of the scheduling model, indicating the minimum total delay time cost in the operation process; Constraint (a) means that the subsequent tasks of each task can only be completed by the same intelligent robot; Constraint (b) means that the previous task of each task can only be completed by the same intelligent robot; Constraint (c) indicates that the intermediate task needs transportation balance, that is, input equals output; Constraint (d) means that all k intelligent robots must complete the initial task, that is, a total of k intelligent robots participate in the dispatching; Constraint (e) means that k intelligent robots complete the end task, that is, there are k intelligent robots to complete the dispatching; Constraint (f) indicates that the order of operation of intelligent robot is 0-1 variable.1 means that the intelligent robot K completes task j after completing task i.

Through the above model, the operation sequence of the intelligent robot is solved, that is, the scheduling scheme. Through the actual sequence of tasks of the intelligent robot, the actual operational time r_i of each commodity task can be obtained, and r_i is divided into the beginning and end time of the order. The calculation formula of r_i is as follows:

$$r_i = \begin{cases} qs_i, if\ i = I \\ r_{i-1} + t_{ij} \end{cases}$$

3.2 Particle Swarm Optimization.

Standard particle swarm optimization (pso) algorithm can be described as a particle in the process of maintain flight attitude, of its own position, find the best position to keep a record and the best location for the entire swarm particle flying experience by themselves and groups adjust speed of movement of the particles, and using the particle's fitness as the evaluation standard of the location. The iterative evolution equation of the standard particle swarm optimization algorithm is as follows. Velocity evolution function:

$$V_{ij}\ (t+1) = w * V_{ij}\ (t) + c_1 * r_1 \left(P_{ij}(t) - X_{ij}(t)\right) + c_2 * r_2 * \left(P_g(t) - X_{ij}(t)\right)$$

$$V_{ij}\ (t+1) = V_{max}, V_{ij}(t+1) > V_{max}$$

$$V_{ij}\ (t+1) = V_{min}, V_{ij}(t+1) < V_{min}$$

Position evolution function: $X_{ij}(t+1) = X_{ij}(t) + V_{ij}(t+1)$

Parameter description: In the above formula, i subscript represents the i-th particle, j subscript represents the j-th dimension of the particle, t represents the t-th generation, and w is the weight factor. For standard particle swarm optimization (pso), the particle changes its velocity and position following two main values. One is the best position the particle has found in the past iteration; Another is the best place to fly in a population of particles. Under the flight mechanism that follows the two optimal positions, it is easy to find the extreme point. However, since every iterative search follows the optimal value, after reaching a certain number of searches, the particle motion tends to be the same, and it is easy to fall into the local optimal state, resulting in the phenomenon of "premature".

In order to overcome the shortcomings of the basic particle swarm optimization (pso), this paper will introduce the "crossover" mechanism in the genetic algorithm to construct two improved pso algorithms for particle exchange according to different flight modes, and introduce the "crossover" mechanism according to probability to avoid the "island" phenomenon of the population.

In this paper, this model is taken as the flight model of the first swarm of particles. The iterative evolution equation is as follows: Velocity evolution function:

$$V_{ij}\ (t+1) = w * V_{ij}\ (t) + c_1' * r_1 \left(P_{ij}(t) - X_{ij}(t)\right)$$

$$V_{ij}\ (t+1) = V_{max}, V_{ij}(t+1) > V_{max}$$

$$V_{ij}\ (t+1) = V_{min}, V_{ij}(t+1) < V_{min}$$

Position evolution function: $X_{ij}(t+1) = X_{ij}(t) + V_{ij}(t+1)$

For the second group of particles, it will be conducted according to "own experience", "local group experience" and "whole group experience", and the group information will be Shared among particles, so that the particles can converge quickly. The iterative evolution of the model is as follows: Velocity evolution function:

$$V_{ij}\ (t+1) = w * V_{ij}\ (t) + c_1'' * r_1 \left(P_{ij}(t) - X_{ij}(t)\right) +$$
$$c_2'' * r_2 * \left(P_g(t) - X_{ij}(t)\right) + c_3'' * r_3 * \left(P_q(t) - X_{ij}(t)\right)$$
$$V_{ij}\ (t+1) = V_{max}, V_{ij}(t+1) > V_{max}$$
$$V_{ij}\ (t+1) = V_{min}, V_{ij}(t+1) < V_{min}$$

Position evolution function: $X_{ij}(t+1) = X_{ij}(t) + V_{ij}(t+1)$

Parameter description: The subscript i in the formula represents the i-th particle, the subscript j represents the j-th dimension of the particle, t represents the t-th generation, and w represents the weight factor. When w is large, it is suitable for exploring the solution space in a large range. When w is small, it is suitable for a small search. Particle acceleration, c_1'、c_2''、c_3''' said general Settings for the constant, can speed up the convergence and not easy to fall into local optimum, c_1' is used to adjust the particle flying towards its own best location step length, c_2'' is used to adjust the best position of particles to the based on the step length of flight, c_3''' is used to adjust the particle flying in the direction of the best location of the entire population, usually between the values. r_1、r_2、r_3 are three random Numbers independent of each other, which are evenly distributed.

3.3 Improved Dual-Particle Swarm Optimization Algorithm Flow.

Step 1: initialize each parameter of the two swarm particles: population size, initial position, initial velocity, inertial weight, acceleration constant, etc. Set the global invariant termination algebra and the counter initialization at the same time.

Step2: for the two populations, calculate the adaptive value of each particle, record the initial optimal position and the optimal adaptive value.

Step3: set different flight modes for the two populations. For the first population, the velocity and position of the swarm particles are updated according to the formula. For the second population, the velocity and position of the swarm particle are updated according to the formula.

Step4: update the best adaptive value and optimal location of individual history of each particle; Update the historical best fit value and the best position of each subgroup; Update the best fit value and the best position of the whole particle swarm.

Step5: if the optimal adaptive value and position of the whole particle swarm are improved, the counter will reset to zero and count again. Otherwise, the sum constant algebra.

Step6: if better adaptive value and better position are not found in the whole particle swarm within a certain algebra, the iteration will be terminated and the best result will be output. Otherwise, the first subgroup and the second subgroup exchange particles according to a certain probability and continue the iterative process.

Through the above algorithm, the final results can be obtained. Partial results are shown in the table:

Table 4 multi-intelligent robot task allocation

Order	**Time**	**Commodity location coordinates**	**Amount**	**Robot Allocation(code)**
ON2018090800789	2020/9/21 16:36	(2.8,4)	1	1
		(1.4,21)	2	2
		(8,4)	4	8
ON2018090801005	2020/9/21 16:03	(7.4,2)	8	3
		(4.2,10)	3	9
		(6,12)	1	4

4. Conclusion.

Smart business logistics center in country B, considering the order quantity, picking efficiency, cost and other factors, analyze the intelligent handling equipment demand quantity and reasonable configuration, and from the perspective of intelligent robot scheduling and task allocation, rational design of more intelligent robots scheduling model of collaborative task allocation, effective scheduling disequilibrium between the shelf, and intelligent robot platform waiting for long time, so as to maximize B smart business logistics center operation efficiency, reduce operating costs.

References

[1] Zhiye Chen, Xiaoyan Chen, Mengqi Liu et al.. Altered functional connectivity architecture of the brain in medication overuse headache using resting state fMRI[J]. The Journal of Headache and Pain, 2017, 18(1).

[2] Peter Murray-Rust, Sam E Adams, Jim Downing et al.. The semantic architecture of the World-Wide Molecular Matrix (WWMM)[J]. Journal of Cheminformatics, 2011, 3(1).

[3] Jerzy Dorosz, Line Hyltoft Kristensen, Nanda G. Aduri et al.. Molecular architecture of the Jumonji C family histone demethylase KDM5B[J]. Scientific Reports, 2019, 9(1).

[4] A. Ehlis, M. Maier, L. Zarantonello et al.. The role of the DLPFC in conflict resolution: Investigating the functional architecture of cognitive control using cTBS and combined NIRS/EEG[J]. Brain Stimulation, 2019, 12(2).

[5] Fu Suolan, Zhang Linlin, Lv Jiapei et al.. Two main stream methods analysis and visual 3D genome architecture [J]. , 2019, 90.

[6] Espen Oland, Tom Stian Andersen, Raymond Kristiansen. Subsumption architecture applied to flight control using composite rotations[J]. , 2016, 69.

[7] Espen Oland, Tom Stian Andersen, Raymond Kristiansen. Subsumption architecture applied to flight control using composite rotations[J]. Automatica, 2016, 69.

[8] Elisa Peranzoni, Ana Rivas-Caicedo, Houcine Bougherara et al.. Positive and negative influence of the matrix architecture on antitumor immune surveillance[J]. Cellular and Molecular Life Sciences, 2013, 70(23).

[9] Yi Liu, Jiawen Peng, and Zhihao Yu. 2018. Big Data Platform Architecture under The Background of Financial Technology: In The Insurance Industry As An Example. In Proceedings of the 2018 International Conference on Big Data Engineering and Technology (BDET 2018). ACM, New York, NY, USA, 31-35.

[10] Zhang Yanjun, Yang Xiaodong, Liu Yi, Zheng Dayuan, Bi Shujun. Research on the Frame of Intelligent Inspection Platform Based on Spatio-temporal Data. Computer & Digital Engineering [J], 2019, 47(03): 616-619+637.