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Optimization of Storage Location of Automated Pharmacy Based on Chaotic Particle Swarm Algorithm

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Abstract: In order to improve the storage efficiency and the space utilization, the optimization strategy of storage location of the automated pharmacy was researched according to irregular features of storage spaces.The improved chaotic particle swarm algorithm was proposed to solve the storage location optimization problem by using the ergodicity and randomness of chaotic motion for mathematical model of storage spaces. Simulation results showed that the algorithm got rid of the shortcomings that the Particle Swarm Optimization was easy to fall into of the local extreme point in late stages, while kept the rapidity in early search. The algorithm improved the efficiency of intelligent storage system, implemented intensive storage, which provided a theoretical basis and practical way to the optimization of irregular allocation of storage space of intelligent storage system in automated pharmacy.

Key words: Chaotic particle swarm algorithm, automation pharmacy, location optimization, intelligent storage system

INTRODUCTION

The efficiency of smart access system in automated pharmacy mainly depends on the allocation optimization of the storage spaces. Reasonable allocation strategy of warehouse location and storage spaces can greatly increase the efficiency of warehouse storage and can reduce the consumption of useless. It also can realize pharmacy modernization management, improve the functionality of the pharmacy.

Currently, scholars at home and abroad have made a lot of achievements of the storage allocation. Van den Berg and Zijm (1999) classified the methods of storage allocation in the reservoir area into three main ways: Class-based storage, randomized storage and dedicated storage. Byung *et al*. (2006) divided the storage spaces into two storage zones: high turnover and low turnover and the high turnover items are stored in the region closer to the input/output point while the low ones are stored in the more distant region. Thonemann and Brandeau (1998) presented applying turnover rate and classification in a random environment to allocate storage. A genetic algorithm with a new crossover operator was developed to solve the allocation problem of the automated warehouse (Poulos *et al*., 2001; Liu *et al*., 2006) adopted genetic algorithm based on Pareto optimal solution to solve the storage scheduling. Muppani and Adil (2008) built a nonlinear integer planning model by considering lower total cost of order picking and storage space of the AS/RS and researched reallocation of classified storage through using the branch and bound algorithm. To solve the problem of storage/retrieval frequently and dynamic change storage locations, a multi-objective mathematical model was formulated for storage location assignment of the fixed rack system by Li (2008) and an improved GA with Pareto optimization and Niche Technology was developed. Zhao *et al*. (2012) studied the irregular storage problem of automated pharmacy and put forward to a multi- objective reservoir allocation model to improve the storage efficiency and space utilization and presented a two-level genetic algorithm to solve the above problem. All the above researches laid theoretical foundations of our research, however, the above methods with the traditional models can not describe the rationalized allocation of drug storage in warehousing system better.Moreover,due to the slow convergence speed and being easy to fall into local optimum of the genetic algorithm, it is urgent to explore new ways to solve optimization problems of storage spaces in automated warehouse system.

MATHEMATICS MODEL OF STORAGE SPACES LAYOUT

Before establishing the optimization model of storage spaces, some constants and variables essential to build

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models need to be defined in advance. For convenience, the following assumptions are made: Storage storeroom had m layer and n column and the column nearest medicine-output exit was recorded as the first column, the lowest level as the first layer, the port storage location as (0,0) and the storage spaces in Layer i and Column j as (i, j), (i = 1, 2,…,m; j = 1,2,..n).

In order to make the drugs easier to find, the similar drugs in appearance were put together or in adjacent spaces. Certain types of drugs were placed in corresponding position according to their loading/unloading frequencies and thus we can define a central coordinate of the storage spaces of such drugs and can put the drugs on the closer position away from the center coordinate. The storage method can set different specifications of storage spaces according to the dimensions of the drugs to maximize the use of spaces and to contribute to the picking operations and adjustment operations of inventory, which facilitated searching of drugs, saving time and improving the working efficiency. According to the strategy, location model of storage spaces was established as follows:

$$\min F = \sum_{i=1}^{l} \sum_{j=1, i\neq j}^{s} f_j (h_i - h_j) x_{ij} \tag{1}$$

st.

$$h_j \in \{\min h_i, \max h_i\} \tag{2}$$

$$x_{ij} \in \{0,1\}, \sum_{i=1}^{l} x_{ij} = 1, j = 1, 2, \ldots, s, \sum_{j=1}^{s} x_{ij} = 1, i = 1, 2, \ldots, l \tag{3}$$

where, h_I is the height of the layer i in the storage area; h_j is the height of the drugs of the kind j; f_i is the frequency of the drugs of the kind j; n is the number of layers whose height are h_i. x_{ij} is the decision variable. When $x_{ij} = 1$, it expresses that the drugs of kind i are put in layer j; $x_{ij} = 0$ expresses that the drugs of kind i are not in layer j.

Equation 1 indicated that the smaller the difference in height of the reservoir area and the kit was, the more intensive medicines were placed. Constraint Eq. 2 expressed that the total height of the reservoir layers was not allowed to exceed the height of the effective storage. Equation 3 showed that when determining the height of the reservoir layers, all drugs meeting the requirements of the layer height should be placed in this area; a storage area stored one height range of drugs, a height range of drugs into one district can not be placed in other districts and after being placed drugs within a certain height, a district should not be put into other height range of drugs.

IMPROVED CHAOTIC PARTICLE SWARM ALGORITHM TO SOLVE MUTI-OBJECTIVE OPTIMIZATION PROBLEM

The location targets of storage spaces in rapid drug system need not only to meet the intensive storage requirements, but also to consider the efficiency of the system and at the same time the storeroom stability and the adaptability of drug agencies and storage spaces are constrained. It is a Multi- objective Pptimization Problems (MOP).

Particle Swarm Optimization (PSO) algorithm derived from the study on the predatory behavior of birds and it was first used by Kennedy and Eberhart (1995). The algorithm simulates social group behavior, searches for the optimal solutions of MOP through collaboration between individuals and updates the velocities and positions of particles by counting the optimal values found by each particle itself and the groups in iterative process.

In particle swarm optimization algorithm for storage spaces allocation, consider two different store ways as a group of replacement, i.e., the difference between the two particles. Let X be a storage method of the goods, that is, the position of the particles. Let V be is the replacement of the two different storage methods, i.e., the velocity of the particles. Set V_1 and V_2 as the replacement set of items in two different storage methods and then the sum of V_1 and V_2 is $V_1 \oplus V_2$. In accordance with the above method of calculating velocity change for the position difference and taking m×n, the total of the storage locations, as search space dimension of particle swarm , the speed of iterative equation was obtained:

$$v_{id}^{k+1} = w \times v_{id}^{k} \oplus c_1 \times r_1 \times (p_{id}^{k} - x_{id}^{k}) \oplus c_2 \times r_2 \times (g_{gd}^{k} - x_{id}^{k}) \tag{4}$$

where, v^k is the velocity vector of the particles, x^k is the current location of the particles, p^k is the position of the optimal solution found by the particle itself, g^k is the location of the optimal solution found by the entire population, r_1 and r_2 are pseudo-random numbers between 0 and 1,w is inertia weight, c_1 and c_2 are acceleration constants.

The sum of the position X and the velocity V is referred to as $X \oplus V$, which indicates that the replacement of V is applied to the position X, i.e., the storage space required replacing is applied to such a storage way of X and the result remains a storage method. The iterative equation of optimization problem of storage location based on particle swarm algorithm is:

$$x_{id}^{k+1} = x_{id}^{k} \oplus \lambda \times v_{id}^{k+1} \tag{5}$$

Speed iteration of conventional particle swarm algorithm has four factors: w, ,c_1, c_2 and rand(). In the optimization problem of storage allocation, the speed is used to exchange store states of a corresponding storage spaces in the two storage methods and (p_{id}^k-x_{id}^k) expresses the replacement of the best storage itself and the current storage, (g_{gd}^k-x_{id}^k) expresses the replacement of the best storage way of the whole group and the current storage. In conventional particle swarm algorithm, the four factors are real numbers, however, it is difficult to determine the meaning of the product of a real number and a replacement, therefore, in conventional algorithm the factors are taken as 1. In the calculation of the above equation, $w \times v_{id}^k$, $c_1 \times r_1 \times (p_{id}^k - x_{id}^k)$ and $c_2 \times r_2 \times (g_{gd}^k - x_{id}^k)$ all represent a set of some replacements.

To solve the problem that PSO method is easy to precocious, chaos algorithm and particle swarm optimization algorithm can be combined (Liu *et al*., 2005). The characteristics of ergodicity and randomness of chaotic motion are applied to the optimizing search process. When the particles fall into premature convergence, chaotic disturbance is used to escape from local optima and to quickly find the optimal solution, which can improve the accuracy and the convergence speed of the solutions. In the chaotic particle swarm algorithm in this article, we select the Logistic map to generate chaotic variable as shown in the Eq. 6:

$$z_{j,k+1} = \mu z_{j,k}(1 - z_{j,k}), k = 0, 1, 2, \ldots, 0 \le z_{j,0} \le 1 \tag{6}$$

where, μ is the control variable, when $\mu = 4$, $z_0 \notin \{0, 0.25, 0.5, 0.75\}$, Logistic is in a chaotic state:

$$x_j = x_j^* + \eta_j z_{j,k} \tag{7}$$

where, x_j^* is the current optimal solution; η_j is the adjustment coefficient; $z_{j,k}$ is the chaotic variable among [-1,1] .

In the search stage, we hope variables jump out of local optimum, value of η_j should take greater and as the search for variables is close to the optimal value, the value of η_j should also be gradually reduced. In the study, the value of η_j changed adaptively according to Eq. 8:

$$\eta_j = \gamma\left[(k_{max} - k + 1)/k_{max}\right]^2 x_j^* \tag{8}$$

where, γ is the neighborhood radius, $\gamma = 0.1$; k_{max} is the maximum number of iterations of the algorithm; k is the current iteration number; x_j^* is the current optimal solution.

As previously mentioned, the steps of chaos particle swarm optimization algorithm based on the strategy of adaptive parameter are as follows:

- Random initialize the position and velocity of each particle in the population
- Evaluate the fitness of each particle, save g^k, the global best position and p^k, the personal best position
- Update the speed and position of each particle by Eq. 4 and 5
- Calculate the objective function value of each particle and then retain the best performance in the group part of fine particulates
- Execute chaotic local search on the optimal particulate according to Eq. 6 to 8 and update p^k and g^k
- If the stopping condition is met, the search stops, then output the results, otherwise go to step 2)

The above optimization algorithm of storage allocation delivery system was used for a large hospital in china. In order to ensure the loading/unloading of drugs smoothly, the clearances between the medicine storage tank and kits must be kept within certain limits. If out of range, it will occur that the kits are not easy to slide into the medicine storage tank, the kits overlap or hunch-up, the turning plate can not be drug ejection,which effects the normal execution of medicine placement and delivery. Therefore, the rational allocation of drug storage grooves can not only improve the drug storage efficiency, save the cost and improve the utilization of space, but also convenient processing and installation to improve system reliability.

The shelves of rapid medicine discharging system are fixed shelves with 15 layers, 43 columns and the total storages are 645. For the convenience of calculation, the codes of storage positions are abstracted to digital sequence. Because the drugs are relatively light and the design of shelf completely satisfies the bearing requirement, the storage load problem is not to consider. In the algorithm, encoding method used real value encoding and the population size was 100 and the largest algebra number was 1000. The change of the optimal path of drug storage and the optimal path of drug store that was obtained by applying MATLAB software to solving the warehouse district model were shown in Fig. 1and 2.

Through the results of analysis of algorithm, for permutation problem of the drug storage, it was not possible to get the real optimal solution while meeting a number of conditions. The permutation of storage position by the particle swarm algorithm adopted in this

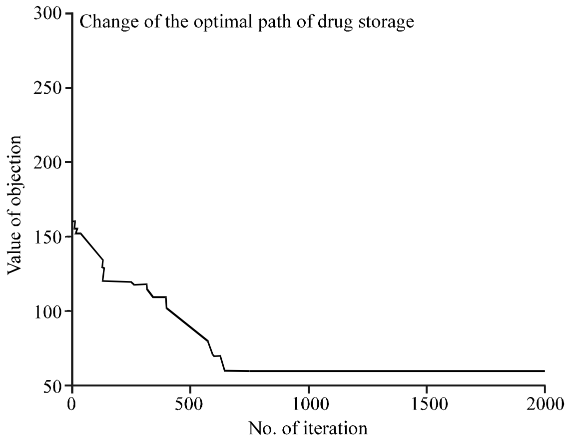

Fig. 1: Change of the optimal path of storage

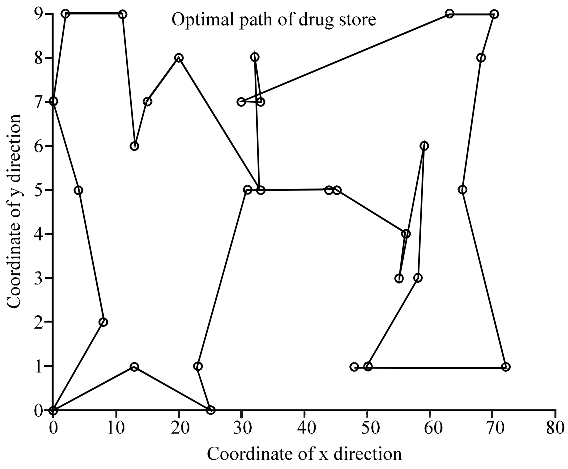

Fig. 2: Optimal path of drug store

study was suboptimal solution, however, it had played a very active role to improve the efficiency of system operation and utilization of the storage space.

CONCLUSION

The chaotic particle swarm algorithm proposed in the study got rid of the shortcomings that the Particle Swarm Optimization was easy to fall into of the local extreme point in late stages, while it kept the rapidity in early search. The algorithm improved the efficiency of intelligent storage system, implemented intensive storage. However, for the arrangement of drug storage, if you want to satisfy multiple constraints, getting the real optimal solution is impossible. In this study, the storage arrangement was suboptimal solutions by adopting chaotic particle swarm algorithm. And the parameters such as size, search space and speed of particle swarm population were set according to the reference literature, therefore, the rationality of the parameters setting needs further study.

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