Control Strategy Research on Drugs Input in Intelligent Pharmacy Express Dispensing System

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Abstract. In order to improve the working efficiency of drugs input in intelligent pharmacy express dispensing system, the route planning based on the improved genetic algorithms is proposed for express dispensing system with complicated boxed drugs and numerous storage space. This paper establishes a TSP problem model for drug input route planning, analyzes drug storage location information and drug prescription information, and performs simulation experiments on Matlab platform. The results show that the new strategy of drugs input can improve work efficiency greatly in comparison with the traditional modes. The time of storage is shortened, and the efficiency is increased from 11 percent to 48 percent.

Introduction

Express dispensing system is an intensive storage equipment for intelligent pharmacy to realize automatic supplies, intensive storage and automatic dispensing boxed medicine, which has a large amount of storage space and complicated storage space [1,2]. Although this kind of equipment greatly improves work efficiency and saves storage space for pharmacy, different route planning and picking strategy will affect the efficiency of drugs input and output.

In order to provide patients with more rapid drug services, the logistics automation technology has been introduced into the drug distribution and management [3,4]. At present, the efficiency of express dispensing system is not high enough, such as point by point greedy method, each step is traversed by selecting the nearest storage location from the current manipulator, but cannot guarantee the planning path is the shortest path [5]; Random storage planning method firstly randomize the storage of prescription drugs, then drugs are picked, only the first-in-first-out of drugs is ensured to solve the drug retention danger, but the picking efficiency is low [5,6]. Therefore, how to improve the work efficiency of express dispensing system and shorten the time of drugs input is a very worthwhile issue.

The route planning of drugs distribution and the least layer of dispensing drugs belongs to the NP complete problem [7-10]. In order to solve this problem, the method to optimize allocation sequence of the storage based on the improved genetic algorithm is proposed, which performance is compared with the traditional mode of drugs input.

Storage Layout of Express Dispensing System

There are more than 450 drug storage tanks and 12 storage layers in express dispensing system. There are 33 to 40 U-shaped storage tanks for each layer. The manipulator can quickly and accurately reach the designated storage according to the storage location information for drugging. Storage layout of express dispensing system is shown in Fig.1.

1240	1239	···	1206	1205	1204	1203	1202	1201
1140	1139	···	1106	1105	1104	1103	1102	1101
⋮	⋮	⋱	⋮	⋮	⋮	⋮	⋮	⋮
0440	0439	···	0406	0405	0404	0403	0402	0401
0340	0339	···	0306	0305	0304	0303	0302	0301
0240	0239	···	0206	0205	0204	0203	0202	0201
0140	0139	···	0106	0105	0104	0103	0102	0101

Figure 1. Storage layout diagram

The Route Planning for Drug Input

As can be seen from figue 1, storage position 0306 is set as the window position of the manipulator for drugging. Drugs are placed from 0306 to the manipulator, at the same time the sum of drugs and drug codes are entered on the client interface. System will retrieve the corresponding storage information, which are saved to the database. Then, the drug bill information is read by running program in the local database, the manipulator is drove to execute drug according to the selected storage information, and the drugs are sent to the storage tank. The drug manipulator should return to the initial position of the drug window before and after the drugging. and the amount of drug storage is set by the frequency of drug. Each drug can have multiple storage locations, so after obtaining the drug storage information, it will be planned from the most time-saving perspective of the drug route.

Each storage can store 20 to 30 boxes, and the capacity of drug manipulator is 15 to 20 boxes for common boxed drugs in express dispensing system. Only a storage position can be used for each drug input of the initial program design. The quantity of drugs on drug manipulator is limited by the quantity of storage due to the different quantities of stock, the work efficiency is relatively low.

In response to this problem, the improved initial procedure can realize the function of put drugs to multiple storage positions at a time, which improves the work efficiency of drugging.

From the principle of convenience of analysis and generality to consider, it is assumed that T_s is the time of placing drugs to manipulator by pharmacy doctors, T_m is the time for putting drugs into the storage, L is the distance between the adjacent points, V is the speed of the manipulator, the quantity of stock out on storage position is random. The initial position of the manipulator is set at 1st layer of No.01 position.

The storage model is simplified as shown in Table 1, the number in the table represent drug shortage in the storage position.

Table 1. Storage model simplified schematic table

	No.04	No.03	No.02	No.01
4th layer	2	3	1	2
3rd layer	4	2	3	3
2nd layer	2	6	6	7
1st layer	2	3	7	1（the initial position）

The max capacity of drug manipulator is 18. Starting from the small number of drug-deficient storage position, the drug input process and the total time are shown as follows.

1) 18 boxes of drugs are placed to the manipulator by the staff, the time is T_s;

2) The manipulator inputs 1, 7, 3, 2, 5 boxes of drugs to the first layer 01, 02, 03, 04 and the second layer 01 respectively, and then returns to the initial position, the time is $(3+\sqrt{10}+1)L/V+18\times T_m$;

3) 18 boxes of drugs are placed to the manipulator by the staff again, the time is T_s;

4) The manipulator inputs 2, 6, 6, 2, 2 boxes of drugs to the second layer 01, 02, 03, 04 and the third layer 01 respectively, and then returns to the initial position, the time is $(1+3+\sqrt{10}+2)L/V+18\times T_m$

5) 18 boxes of drugs are placed to the manipulator by the staff again, the time is T_s;

6) The manipulator inputs 1, 3, 2, 4 boxes of drugs and 2, 1, 3, 2 boxes of drugs to the third and forth layer respectively, the time is $(2+3+\sqrt{10}+3+3\sqrt{2})L/V+18\times T_m$;

The total time of drugging is calculated as follows:

$$T=3\times T_s+54\times T_m+(18+\sqrt{10}+3\sqrt{2})L/V \tag{1}$$

It can be analyzed from formula 1 that the time of placing drugs ($3\times T_s$) and the time of putting drugs into the storage tanks ($54\times T_m$) are constant while the storage and the quantity of drugs need to be input are known, and the time $(18+\sqrt{10}+3\sqrt{2})L/V$ of traversing the storage positions is determined by the route. The route of input drugs from the smallest storage position is not the most efficient route.

It can be seen from the drugs input process that the model of a single drugs input process is similar to the mathematical model of the classic traveling salesman problem (TSP). The storage location of the drug in the drug list is equivalent to every city in the TSP problem. The problem solved in TSP is that the space distance is the shortest, and the problem to be solved in the drug route planning is that the drug input time is the shortest. Because the manipulator's single running path is always a straight line between the two storage positions, the ultimate goal of the drug route planning is to find the path with the shortest total distance, that is, the shortest time for the drug input.

Construction of Improved Genetic Algorithm Model for the Route Planning

According to Darwin's theory of biological evolution, genetic algorithm was proposed by John Halland, the theoretical core of which is chromosome selection, crossover and mutation. The genetic algorithm does not require an accurate mathematical model of the problem, so it has strong versatility and has successfully solved many optimization problems. In order to solve the problem of drug input route optimization in express dispensing system, improved genetic algorithm is applied.

(1) Hromosome coding

To apply the genetic algorithm, it is necessary to solve the representation of the problem solution, that is, the way of the chromosome coding. The solution to the route planning problem of the drug input contains a number of variables, the number of which is represented by the length of the chromosome, and each dimension of the solution is equivalent to the gene of the chromosome, and is encoded by a floating point number. Chromosome coding diagram is shown in figue 2.

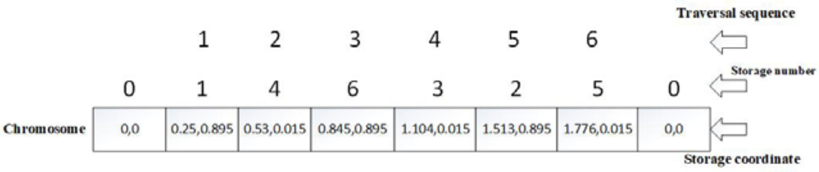

Figure 2. Chromosome coding diagram

(2) Group size design

The size of the initial evolutionary group is directly related to the operating efficiency and search ability of the algorithm. The experimental set population size is 80.

(3) Design of evaluation function

The evaluation function distinguishes the merits of each chromosome by its adaptive value. The problem of drug route planning can use the reciprocal of route distance as the evaluation function. However, in order to highlight the adaptability of excellent individuals from a global perspective, the evaluation function of the algorithm is constructed as follows:

$$fitness(i)=1-\left(\frac{L(i)-Min_L}{Max_i-Min_i+0.0001}\right)m \tag{2}$$

In equation (2), $L(i)$ is the route distance of the i-th chromosome; Max_L, Min_L are respectively the max and min values of all the drug route; m is the normalized elimination acceleration index of fitness value, and the value is 2.

(4) Selection strategy

An improved roulette selection method is used for population selection operations, which is $f^{'}(x_i)=e^{af(x_i)}$, as shown in equation (3).

$$p_i = f^{'}(x_i)/\sum f^{'}(x_i)=e^{af(x_i)}/\sum e^{af(x_i)} \tag{3}$$

In equation (3), a>0, the experimental value is 8.

(5) Cross operator design

The partial matching crossover operator is selected for solving the route planning problem based on the floating-point coding method. The experimental crossover probability P_c is 0.4. Partial matching crossover operation is shown in Fig.3 to Fig.6.

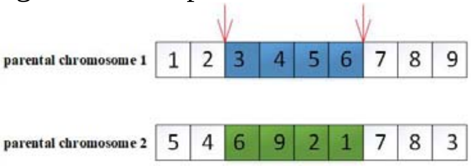

Figure 3. Partial matching crossover operation step 1

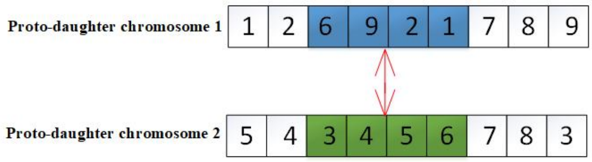

Figure 4. Partial matching crossover operation step 2

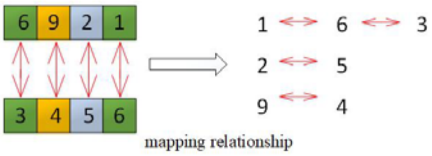

Figure 5. Partial matching crossover gene mapping

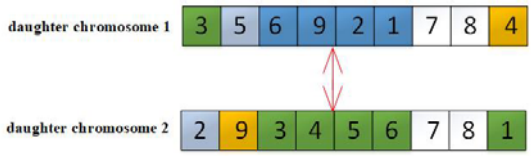

Figure 6. Partial matching crossover operation step 3

(6) Mutation operator design

The mutation operator can cause small probability mutations in the original population and increase the diversity of population evolution. However, since the variation has a certain destructive effect on the better solution that has been found, the mutation probability P_m should not be too large, and the experiment value of P_m is 0.05. This paper applies uniform variation, and the mutation operation is shown in figure 7.

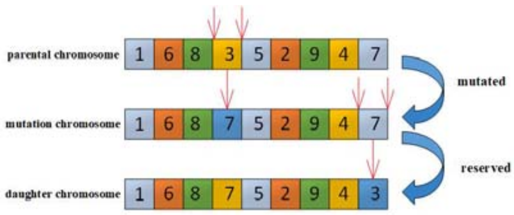

Figure 7. Schematic diagram of chromosome mutation

Implementation Process of Improved Genetic Algorithm for Drug Input Route Planning

According to the established genetic algorithm model for drug route planning, the picking route is evaluated according to equation (2), implementation process chart of improved genetic algorithm for drug route planning is shown in figue 8.

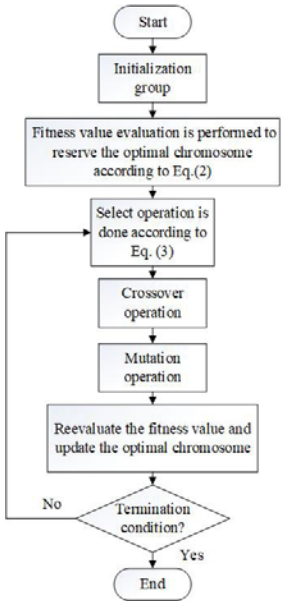

Figure 8. Implementation process chart of improved genetic algorithm for drug route planning

Comparison of Drug Input Route Planning

Combined with the storage position information in express dispensing system, the improved genetic algorithm is applied to optimize the drug input route on the Matlab platform. The drug input time is calculated by the length of the drug route and the speed of the motor. The route length is the sum of the distances among the drug storage positions, as shown in equation (4).

$$T = \frac{\sum_{i,j \in n}^{n} \sqrt{(s_{ix} - s_{jx})^2 + (s_{ix} - s_{jy})^2}}{V_S} \tag{4}$$

In equation (4), V_S is the stable speed of the motor for the drug manipulator, it is assumed that V_S is $(0.5 \times \sqrt{2}) m/s$; S_{ix}, S_{jx} respectively represent the distance value of the storage position for i and j in the X-axis direction; S_{iv}, S_{jv} respectively represent the distance value of the storage location of i and j in the Y-axis direction.

Table 2 contains five groups of the distribution of the drug storage position, the quantity of the drug storage position is from less to more, which includes both the general distribution of storage tanks and the poor distribution of storage tanks.

According to equation (4), the drug input time of the manipulator is calculated based on drug route planning of the improved genetic algorithm in contrast to the initial planning that traverses from the smallest storage position, which traversed all the drug storage locations and returned to the drug window. The experimental results is shown in table 2 and figue 9.

Table 2. The comparison between the drug time of improved genetic algorithm and the time of initial planning

Group of storage	Selected position coordinates of the storage tank(mm)	Drug route planning	Initial planning
1	(455,285)，(775,675)，(1104,375)	3.75s	3.75s
2	(130,454)，(985,895)，(1105,15)，(2486,755)	7.94s	8.96s
3	(63,755)，(395,225)，(920,835)，(1039,675)，(1039,15)	5.10s	5.79s
4	(250,895)，(530,15)，(845,895)，(1104,15)，(1513,895)，(1776,15)	6.91s	10.42s
5	(0,15)，(130,895)，(250,15)，(395,895)，(530,15)，(710,895)	4.12s	7.94s

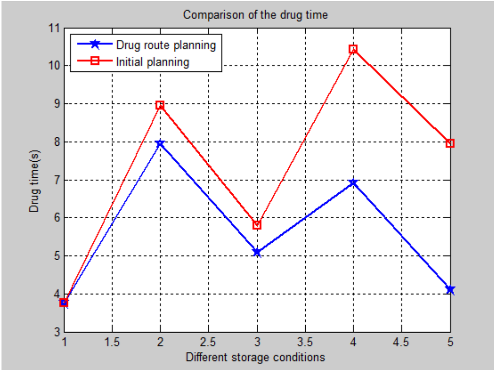

Figure 9. The comparison of drug time between two kinds of planning

According to the simulation results, the comparison between the drug input route planning based on improved genetic algorithm and the initial planning is obtained as follows:

(1) The time for the traversal of drug input route based on improved genetic algorithm is less than the traversal of initial planning, the 5th group of storage is even reduced by 3.82s, and the drug efficiency is increased by nearly 48%.

(2) As the number of storage positions of the drug increases, the reduction of the time of drug input becomes larger. That is, the more the number of drug input storage positions, the more obvious the advantages of improved genetic algorithm.

(3) The 2nd group and 3rd group of storage positions are relatively poor, the drug input efficiency is increased by 12%. The latter two groups of storage positions are better, the drug input efficiency is increased by 40%. That is, the better the storage positions distribution, the more obvious the advantages of improved genetic algorithm.

Conclusion

Aiming at the low efficiency of the traditional drug input mode in the intelligent pharmacy express dispensing system, this paper considers the important role of the drug input route planning and proposes the drug route planning strategy based on the improved genetic algorithm.

When the drug is put into storage, combined with the layout information of the storage location, the proposed drug route planning strategy and the traditional drug input mode are modeled, simulated and compared. The results show that the new strategy can reduce the time of drug input, especially for the case of more storage positions and better distribution of storage positions, the efficiency of drug input has been greatly improved.

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