Study on the Balance of Elevators Flow in Hospital based on GA and SVM

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Abstract: This paper mainly uses genetic algorithm to improve the scheduling efficiency of ordinary elevators and authorized elevators in hospitals and the satisfaction of elevator passengers, and uses support vector machine to predict the efficiency of improved elevators, and the improvement effect is remarkable.

1. Introduction

As the number of high-rise buildings continues to increase, elevators are increasingly entering people's lives. People hope that elevators can be efficient, comfortable, and intelligent, and can provide people with better service. The intelligent control technology of elevators emerges at the historic moment. It is a new technology developed in recent decades [1].

However, this research has found that the multi-ladder linkage scheduling mode on the market is still based on the original mode of “one ladder, one button, first call then first arrival”, which seriously affects the elevator scheduling efficiency and the elevator user satisfaction [2]. A lot of resources are wasted, especially in hospitals.

The scheduling efficiency of hospital elevators and user satisfaction are more important than other places. Therefore, alleviating the elevator transportation pressure of hospitals, improving the scheduling efficiency of elevators, shortening the waiting time of users, and improving user satisfaction are urgently needed for hospitals. The problem.2. Hospital elevator use status.

2. Hospital Elevator Use Status

2.1 Hospital Introduction

Tianjin People's Hospital is a third-grade hospital in Tianjin, covering an area of 160 mu and a construction area of 100,000 square meters. There are three medical buildings A, B and C, which were built in 2004, 2010 and 2016 respectively. The figure shows that there are 40 ordinary elevators and authorized elevators in the whole hospital. The ordinary elevators are open to all employees. The authorized elevators are open to medical personnel and need to be swiped.

2.2 Problems with the use of Elevators in Hospital

The problems existing in the elevators of Tianjin People's Hospital are as follows:

(1) Too many waiting people

The survey found that the three periods of morning, mid, and evening are the peak period for the medical staff, family members, and patients to take the elevator. Excessive users waiting for the elevator will cause the elevator to be congested, resulting in air circulation, which makes people feel bored and prone to quarrels.

(2) Waiting time is too long

There are 6 elevators in the elevator room, including the whole building arrival, single-floor parking, double-deck parking and special ladder for operation. However, due to the complexity of the personnel and the different floors to be reached, the elevator capacity is limited, there is a user waiting time. Through field research, the average waiting time of the elevator is 3.8 minutes, and sometimes it may even be if the user says about 10 minutes. This shows that the hospital elevator does have the problem of waiting too long.

(3) Uneven elevator utilization

The elevator type of the hospital is divided into two types: ordinary elevator and authorized elevator, and there is a problem that the utilization rate of the elevator is not balanced.

3. Problem Improvement

As far as the problem of unbalanced elevator flow is concerned, the unreasonable use of elevators in hospitals is the most important reason. Therefore, this problem should be improved for this main reason.

3.1 Analysis of Elevator Free Time based on SPSS

The statistics of the hospital elevators were collected for 6 months, and the data was analyzed by SPSS. The using frequency of the four elevators called A7, A8, A8E and A9 authorized elevators in the next week was predicted.

1. Do one-way ANOVA with SPSS software. The F statistic results are 749140.837 and 688.328 corresponding companion. The probability is 0.00, less than the significance level of 0.05, indicating that they are much larger than the difference within the group, and shows that there is a significant difference in the use time of elevators at different locations.

2. Taking the distribution of the usage time of the privilege elevator A7 on Monday as an example, the SPSS time series analysis is used to predict the elevator usage in the next week.

Figure 1 shows the elevator usage frequency at each time point within 24 hours on Monday. According to the actual situation, the frequency is negative and counts by 0.

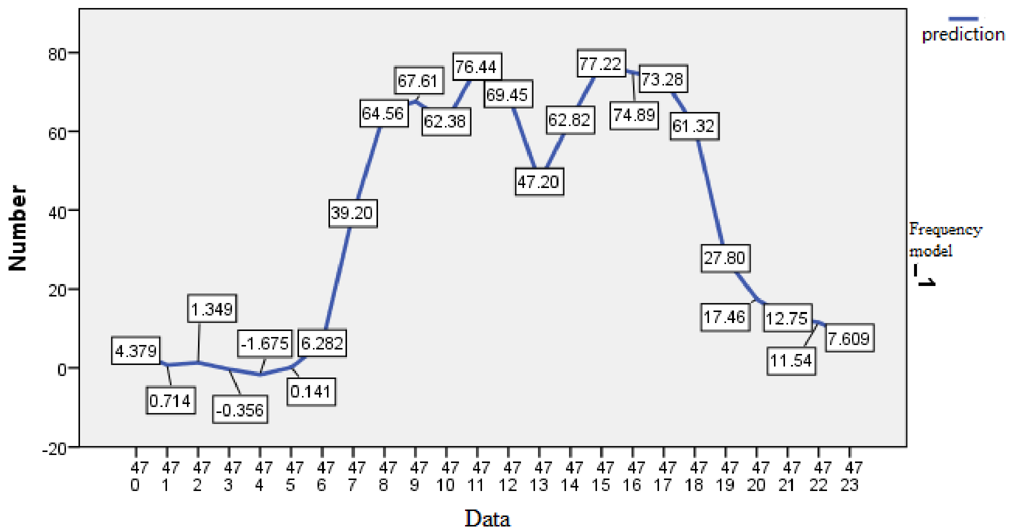

Figure 1. A7 elevator Monday time frequency prediction chart

Similarly, the permission closing times of the four elevators A7, A8, A8E, and A9 from Monday to Sunday are shown in Table 1:

Table 1. A7, A8, A8E, and A9 elevator privilege closing time periods

	A7	A8	A8E	A9
Monday	0:00-7:00 19:00-24:00	0:00-8:00 12:00-14:00 17:00-24:00	Open all day	0:00-9:00 10:00-24:00
Tuesday	0:00-8:00 13:00-14:00 19:00-24:00	0:00-8:00 12:00-14:00 17:00-24:00	Open all day	0:00-9:00 10:00-24:00
Wednesday	0:00-8:00 13:00-14:00 19:00-24:00	0:00-8:00 12:00-14:00 17:00-24:00	Open all day	Open all day
Thursday	0:00-8:00 13:00-14:00 19:00-24:00	0:00-8:00 12:00-14:00 17:00-24:00	Open all day	Open all day
Friday	0:00-8:00 13:00-14:00 19:00-24:00	0:00-8:00 12:00-14:00 17:00-24:00	Open all day	Open all day
Saturday	0:00-8:00, 10:00-11:00 13:00-24:00	0:00-8:00 10:00-24:00	Open all day	Open all day
Sunday	0:00-8:00 13:00-24:00	Open all day	Open all day	Open all day

The four privilege elevators obtained by SPSS analysis are the standard free time on Monday. The time permission of the privilege elevator is adjusted by PLC programming. The privilege is opened and closed according to the time in the table to ensure that the privilege elevator is closed when the passenger flow is low. Permission, become an ordinary elevator, serving all users.

3.2 Elevator Scheduling Scheme based on Genetic Algorithm

Taking into account various factors such as user waiting time and user riding time, the genetic algorithm is used to optimize the floor allocation problem of all elevators in hospital A [3].

1. Model assumption

1) It is assumed that the users arrive at a specific time period, and the number of people arriving at each time in the time is subject to uniform distribution;

2) Assume that the average running time of the elevator between each floor is 5 seconds, the average floor (1 floor) average stay time is 20 seconds, if you want to stay in other floors, the average stay time is 10 seconds, the elevator is at each floor. The user can complete the access to the elevator during the stay time;

3) Assume that all users (health care personnel, family members, patients) at all levels take the elevator up and down the building, and there is no bias in choosing which elevator to take;

4) Assume that the users arrive in the busy period, and the number of users arriving during the busy period is uniformly distributed;

5) Assume that each elevator reaches full load while it is running.

2. Definition and symbol description

K is the Kth elevator, a total of 10;L is the Lth layer, a total of 17 layers;R_l is the number of users in the Lth layer;n_k is the number of times the Kth elevator completes the target operation;x_{kl} is the stay of the Kth elevator in the L layer;$X_k = (x_{k1}, x_{k2}, x_{k3}, \cdots, x_{k17})$ is the operating mode of the Kth elevator;$X = (X_1^T, X_2^T, X_3^T, X_4^T)$ is the operating mode and scheduling of 10 elevators;B is the length of the elevator group;$\overline{B}$ is the average busy period of the elevator;t_k is the dwell time of each floor in the single operation of the Kth elevator;r_k is the travel time between floors in the single operation of the Kth elevator;$F(X_k)$ is the single running time of the Kth elevator [4].

3. Establish an optimization model

Through analysis, the elevator scheduling scheme is first quantified, that is, the elevator grouping situation and the situation that each group of elevators can stay on the floor are expressed. Therefore, we use 10 vectors to represent the situation where 10 elevators in Block A can stay on the floor, as follows:

Use the 0-1 variable x_{kl} to indicate the condition of the Kth elevator in the L layer.

$$x_{kl} = \begin{cases} 1(\text{Indicates that the Kth elevator stays on the L floor}) \\ 0(\text{Indicates that the Kth elevator is not staying at the L floor}) \end{cases} \tag{1}$$

The operation mode of the Kth elevator is:

$$X_k = (x_{k1}, x_{k2}, x_{k3}, \cdots, x_{k17}) \tag{2}$$

The operating modes and scheduling conditions of these 10 elevators are:

$$X = (X_1^T, X_2^T, \cdots, X_{10}^T) \tag{3}$$

The three periods of early, middle and late are defined as the busy period, and the length of the busy period is used as an indicator to measure the efficiency of the elevator operation, and this is used as the objective function to optimize the scheduling of the elevator group.

From the perspective of probability, the target floor of the user in the elevator will cover the reachable floor of all elevators at each moment. It is considered that the elevator will stay on each reachable floor.

Therefore, during the single running time of the kth elevator, the time spent on the floor can be expressed as:

$$t_k = 10 \sum_{l=1}^{17} x_{kl} \tag{4}$$

The travel time between floors when reciprocating up and down is:

$$r_k = 2 * 5 \sum_{l=1}^{17} (l-1) x_{kl} \tag{5}$$

Then the single running time of the Kth elevator is:

$$F(X_k) = 10 \sum_{l=1}^{17} x_{kl} + 2 * 5 \sum_{l=1}^{17} (l-1) x_{kl} \tag{6}$$

Then the condition that n_k satisfies is:

$$\sum_{k=1}^{10} 20 * \frac{R_l}{\sum_{l=1}^{17} x_{kl} R_l} * n_k x_{kl} \geq R_l \tag{7}$$

Therefore, the busy period of the elevator can be expressed as:

$$B = G(X) = \max[n_k(F(X_k) + 20) - 20] \tag{8}$$

The average busy period for each elevator is:

$$\overline{B} = \frac{\sum_{k=1}^{10}[n_k(F(X_k)+20)-20]}{10} \tag{9}$$

4. Model solving:

It is solved by genetic algorithm based on MATLAB.

The standard genetic algorithm is described by six parameters, expressed as:

$$GA = (P_0, M, \Omega, \tau, \Delta, t) \tag{10}$$

Where P_0 is the initial population, M is the total volume, Ω is the selection operation, τ is the hybrid operator, Δ is the mutation operator, and t is the stopping condition.

Because that X_k, X is a matrix of 0-1, can be directly used as genetic coding, that is: X_k is a chromosome, and X is an individual's genome.

Individuals in the population are ranked according to their fitness in descending order, and the probability of selection is Ps to eliminate the total POP SIZE* Ps individuals with the least fitness.

The genes on each floor need to be cross-operated separately. For the first and second layers, a gene is selected as a crossover point on the genome according to the crossover probability $Pc_1=Pc_2=0.005$, and the genes after the intersection of the two fathers are interchanged. For the third layer, the crossover probability $Pc_3 = 0.01$.

Variations also need to be done independently on each floor. For the first and second layers, with the mutation probability $Pm_1=Pm_2=0.005$, determine the u mutation positions S_1, S_2, S_3, ⋯, S_u, and select the genes at these positions in the opposite direction. For the third layer, after determining the mutation position with the mutation probability $Pm_3=0.01$, the number at these positions is replaced by the random fraction of the [-10, 10] interval generated by the Gaussian distribution.

If the inheritance has reached the maximum number of iterations, it is necessary to determine whether the total network error E in the population produces an individual that achieves the user-specified precision. If so, the individual with the greatest fitness is selected as the result of the iteration. Otherwise, even this operation does not reach convergence. If the iteration is not complete, calculate the fitness of the chromosomes and rank the chromosomes from high to low according to the degree of fitness, then go to the "Select" step to continue the iteration.

In order to guide the genetic algorithm to search on demand, a fitness function needs to be defined. The purpose of the elevator scheduling problem is to shorten the busy period as much as possible, that is, to minimize G(X). However, the goal of the genetic algorithm is to maximize the fitness function of the gene. Based on this principle, the fitness function is defined as follows:

$$S = \frac{1}{G(X)} \tag{11}$$

In comparison, the average busy time of the elevator is easier to express, and the calculation time can be reduced. The effect is equivalent to the busy period. Therefore, $\overline{B}(X)$ is used instead of G(X), and the reciprocal is taken as the fitness function, namely:

$$S = \frac{1}{\overline{B}(X)} \tag{12}$$

Based on the above gene representation, design and write the corresponding MATLAB code and define the fitness function.

5. Results of the operation

After running the code, the results are as follows:

Besttargetfunvalue = 910 (910 seconds is the total time for 10 elevators to run once, which is the total busy period).

According to the results, the average busy period of the 10 elevators after reallocation of the reachable floor is 91s, which is about 1.5min, that is, the user's maximum waiting time is 1.5min, which is lower than the waiting time of 3.8min before redistribution, greatly improving the operating efficiency of the elevator, and increasing user satisfaction.

3.3 SVM-based Authority Elevator Load Forecasting

After the above improvement scheme is applied to the operation of the hospital elevator, the support function of the support vector machine is used to predict the load of the improved authority elevator, and the comparison of the load amount before and after the improvement is used to judge whether the generated improvement scheme is effective.

After the operation, compare the obtained raw data with the predicted data, as shown in Figure 2:

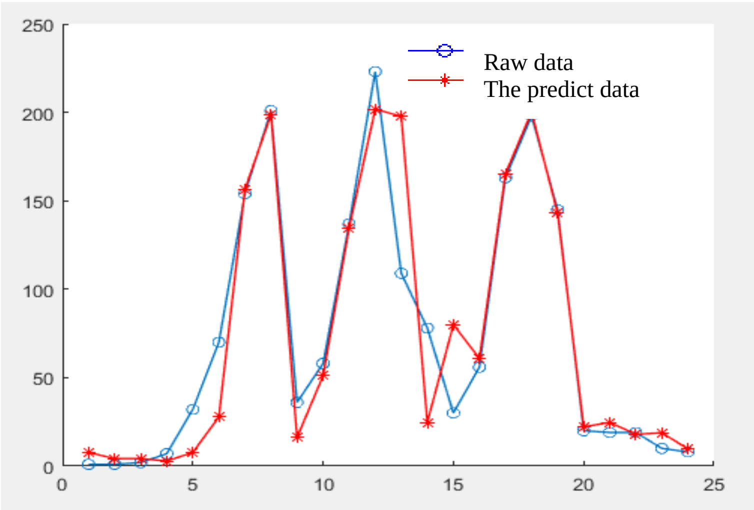

Figure 2. Data comparison chart

The predicted data is as follows:

Predict = [7.70 4.21 4.21 2.86 7.70 27.78 156.42 198.77 16.18 51.05 134.69 201.73 197.77 24.74 79.95 60.88 165.34 200.14 142.87 22.12 24.74 17.92 18.87 9.65].

From the peak period data, the load of the improved authorized elevator is significantly improved compared with the load of the former authorized elevator (figure 1), so that the above improvement scheme can be proved to be effective.

4. Summary

This paper uses SPSS to analyze the user's credit card time of hospital privilege elevators, and uses the method of closing the privilege for patients and their families to balance the flow difference between ordinary elevators and privileged elevators. The genetic algorithm is used to establish the mathematical model for hospital elevators. The reachable floor is allocated, and the result is that the elevator running time is 1.5 minutes after the improvement, that is, the maximum waiting time of the user is 1.5 minutes, which is 2.3 minutes compared with the average waiting time of the user before the improvement of 3.8 minutes. The elevator floor allocation scheme is obviously effective; the support vector machine is used to predict the running load of the improved authorized elevator, which is significantly higher than the elevator load before the improvement.

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