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Research on scheduling optimization of major event resources based on simulated annealing algorithm

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Abstract

At present, the world is still in the fight against novel Coronavirus major medical and health events, including fire, earthquake and other major events in the future will still test the response capacity and efficiency of all countries. This paper takes The Qiandeng Warehouse of Kunshan Metro Project as the research object, combines the specific impact of staff scheduling in various regions, and then optimizes labor resource scheduling in case of major events. First of all, consult relevant information and analyze the problems existing in labor resource scheduling in various major events. Secondly, through field research, six indicators, such as the volume of warehouse dispatch and the number of unloading orders actually completed on that day, are selected to find out the indicators that affect labor resource scheduling and establish a model based on the specific situation. Then, SPSS and MATLAB are used to process each index data, AHP is used to assign weights, and annealing algorithm is used to get the optimal scheduling method. Finally, according to the results of the model, the main line of optimizing the warehouse management of Sinotrans companies is defined, and the intelligent warehouse suitable for The operation of Sinotrans warehouses is constructed by combining the Internet of things.

Keywords

Labor resource scheduling; SPSS; MATLAB; Annealing algorithm.

1. Introduction

2020 the coming year will be coronavirus spread also silently in the crowd, according to the National Development and Reform Commission predicted that population control is one of the main measures to prevent the flow, on the other hand, the lunar New Year holiday and also to the family as the unit to carry out comprehensive isolation, reduce the isolation of social panic, and the lunar New Year holiday was idling period part hedge the shutdown losses. At that time, all the joy was enveloped by fear. People did not go out of their homes, and the demand for protective clothing and masks became very prominent. Almost all pharmacies ran out of masks, and doctors without protective clothing were still working at the front line despite the risk of being infected with the virus. Therefore, it is necessary for us to investigate the optimization of warehouse labor resource scheduling, so that the policy is more reasonable, feasible and can play a better role.

2. Literature Overview

Domestic scholars have carried out a lot of research work on the human resource scheduling problem and adopted a very rich and mature algorithm to carry it out optimization. Shougang Ren [1] starting from the actual situation of software enterprises, the introduction of the human skills proficiency integrity constraint factors model parameters and tasks, in use process type

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MASS scheduling strategy, design a kind of used to solve the problem of human resource scheduling genetic algorithm to solve the model, and as a standard degree of problem as an example to verify the effectiveness of the algorithm. Yingying Wang [2] started from the project cost and the satisfaction of multifunctional workers, applied the second band non-dominated sorting genetic algorithm and ant colony algorithm to study the assignment of multifunctional workers, and considered the matching between the skill combination of multifunctional workers and the task requirements of the project and the influence of skill proficiency level on people's working time. An optimization model is constructed to achieve the total duration of multiple projects and the workload balance between multiple tasks. Starting from the effective utilization of multi-skilled personnel scheduling problem, Xian Wang [3] adopted ant colony algorithm to optimize the completion time of decoration construction, established and solved the model, and minimized the total completion time. Ning Deng [4] established a model to minimize the cost based on Pool sizing problem design in the uncertain external market environment. Hang Gao [5] used structural equation model to study the efficiency of human resource scheduling in enterprise multi-project management. Yali Yi [6] uses ant colony optimization based heuristic algorithm, considering the minimum total cost of penalty cost of project delay, to establish a multi-project human resource scheduling model of R&D enterprises.

3. Data sources and processing

The data in this paper are mainly derived from the field investigation of the 1000 lamp warehouse of Kunshan Metro Project of China's overseas transportation, and six indicators including the number of working staff in the warehouse in June, the volume of receiving and receiving, the actual number of unloading orders on the day, the volume of unloading operations, the number of scheduled delivery orders on the day and the planned operation volume are taken into comprehensive consideration. The data of sending and receiving quantity, actual unloading order number of the day, unloading operation number, scheduled shipping order number of the day and planned operation quantity were put into SPSS for principal component analysis to obtain the work intensity equation. The sending and receiving volume and the number of shifts were imported into Matlab as sample data to predict the neural network model.

4. Scheduling optimization based on simulated annealing algorithm

4.1. Staff scheduling optimization scheme design ideas

Firstly, we use two ways of thinking to predict the number of employees: the first one uses principal component analysis and CFTOOL tool fitting to get the forecast of the required number of employees. The second one introduces neural network model, after importing the actual data of Qiandeng Warehouse of Kunshan Metro project in June, the nonlinear minimization criterion is used to adjust parameters continuously, and the prediction results of employees with different amount of receiving and receiving are obtained after several training.

Then, based on the weighted average of the two predicted results, the simulated annealing intelligent algorithm is introduced. Different parameters and constraint conditions are introduced, combined with different temperatures and initial solutions in the simulated annealing algorithm, and a circular algorithm of reasonable employee scheduling is designed by constant parameter adjustment, and the optimal scheme of employee scheduling is obtained.

In the end, considering the existence of labor peak and valley peak in the scheduling process, the concept of per capita standard working intensity was introduced to design a temporary worker forecasting model to further optimize and supplement the scheduling model.

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4.2. Warehouse employee demand model based on principal component analysis and BP neural network

4.2.1. Principal component analysis index selection

In the principal component analysis, the data obtained according to the investigation of the thousand-lamp warehouse include the amount of receiving and sending, the actual number of unloading orders on the day, the number of unloading operations, the number of scheduled shipping orders on the day and the planned operation:

Table 4-1: Principal component analysis indicators

The index code	Names of Index	date range
F	The actual unloading order number was completed on that day	June 4-29, 2020
G	Discharge operation	June 4-29, 2020
H	Order number of scheduled delivery on that day	June 4-30, 2020
J	Planned operating quantity	June 4-30, 2020
K	Recovery turbine	June 4-29, 2020
X	The number of work	June 4-29, 2020

Through analysis-dimensional-factor analysis, the correlation between all factors is higher than 0.05, which indicates that there is correlation between data and further research can be carried out. Due to the high correlation between the data, the working strength equation Y1 can be written by the component matrix:

$$Y_1 = 0.191J_1 + 0.872F_1 + 0.987G_1 + 0.918K_1 + 0.044H_1$$

he working intensity data obtained from formula Y1 are expressed in the form of time series as follows:

Table 4-2: Time series table

time	Y value	time	Y value
2020-6-5	10227.51043	2020-6-18	12667.43928
2020-6-6	12962.25757	2020-6-19	9905.189841
2020-6-7	6403.328088	2020-6-20	10160.33249
2020-6-8	7242.545727	2020-6-21	8757.290194
2020-6-9	10796.20887	2020-6-22	6983.050419
2020-6-10	11812.19275	2020-6-23	12610.37829
2020-6-11	13173.32603	2020-6-24	11080.13316
2020-6-12	12713.86915	2020-6-25	11298.72629
2020-6-13	12754.40794	2020-6-26	1889.273525
2020-6-14	8322.410601	2020-6-27	4274.431162

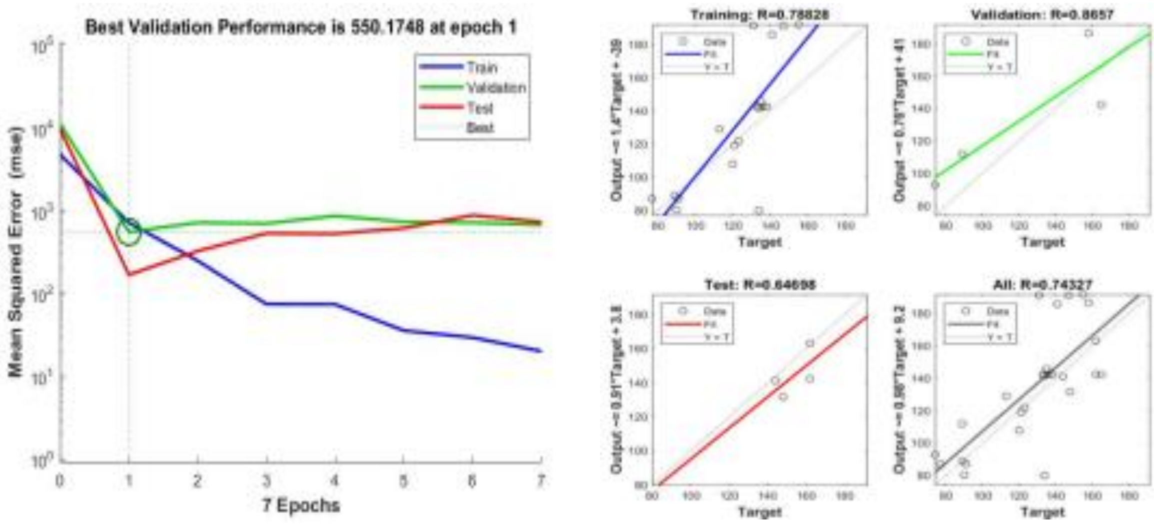
2020-6-15	7893.104793	2020-6-28	3492.328799
2020-6-16	6066.998855	2020-6-29	5830.225152
2020-6-17	9261.964466	2020-6-30	9142.697957

Fitting the time series data obtained in step3 with the shift number data of the 1000 lamp warehouse through the cftool toolbox in Matlab software, the equation is as follows:

$$Y = 75.66 * \exp(5.54e - 0.5 * X)$$

4.2.2. Establishment of BP neural network model

The Levinberg-Marquardt method we use can provide numerical solutions for nonlinear minimization of numbers. An EPOCH is equivalent to training once using all samples in the training set, and parameters in the neural network are adjusted for each training. In theory, the more training sessions, the smaller the error. Here, we trained 7 epochs. Since we set six stops to be calculated after reaching the optimal model, we achieved the minimum mean square error (MSE) at the first time, that is, the optimal model.



When we further conducted goodness of fit test on the data, we found that R was at a high level at this time, indicating that the fitting effect was good. The prediction of warehouse personnel demand is realized by Matlab, and the results are as follows:

Table 4-3: Demand forecast table

July 1	July 2	July 3	July 4	July 5	July 6	July 7
147	120	91	134	148	155	162
July 8	July 9	July 10	July 11	July 12	July 13	July 14
158	123	90	134	162	141	138
July 15	July 16	July 17	July 18	July 19	July 20	July 21
133	113	89	131	144	135	89
July 22	July 23	July 24	July 25	July 26		
77	74	121	136	149		

Suppose that the demand for warehouse staff predicted by principal component analysis is X_{ci} and the demand for warehouse staff predicted by neural network is X_{si} on a certain day, the comprehensive prediction result is:

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$$X_z = \frac{X_{ci} + X_{si}}{2}$$

5. Scheduling model based on simulated annealing algorithm

5.1. Establishment of scheduling model

M: The number of time segments in a scheduling cycle.

N: Total number of employees.

$X_{it} \in [0,1]$: whether employee I is available at time period t, where t = 1,2,3... , M.

a: The average number of hours an employee works in a scheduling cycle.

The objective function

$$\min \sum_{i=1}^{N} \left(\sum_{t=1}^{M} X_{it} - \bar{a} \right)^2$$

5.2. Solving Algorithm

In the process of solving the simulated annealing algorithm, the core is to compare and calculate according to the adaptive value, in order to judge whether to accept the new scheduling scheme as the current best scheme and carry on step by step iteration. Therefore, the first problem of simulated annealing is to generate a feasible scheduling scheme that satisfies all scheduling constraints. To solve the initial solution, a tentative algorithm can be used to assign tasks for each shift cycle to each attendant, and the complex problems can be converted into a large number of easy-to-solve sub-problems. The final objective function is as follows:

$$\min \left(\sum_{t=1}^{M} \left(\frac{\frac{|a_t - R_t|}{R_t - a_t} + 1}{2} * H + \frac{\frac{|a_t - R_t - D|}{-D - R_t + a_t} + 1}{2} * H \right) + \sum_{i=1}^{N} \left(\sum_{t=1}^{M} X_{it} - \bar{a} \right)^2 \right)$$

H in the above formula is the penalty coefficient, which is an extremely positive number.

The initial solution obtained above satisfies all constraints, that is, the feasible solution. Then, the scheduling scheme is subjected to a random "annealing".

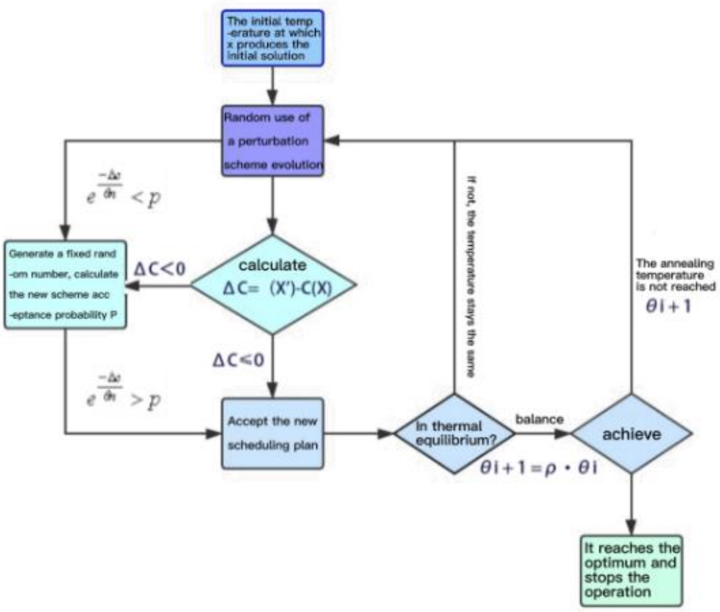

Figure 5-1: Simulation algorithm steps

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5.3. Comparison of scheduling examples

In order to show the results, we put the actual data of 1000 lamp warehouse of Kunshan Metro Project of China Overseas Transportation into the model for solving, and set the time range from June 4 to June 30, 2020. The experimental range is from June 4 to June 19, 2020, and the comparison and verification range is from June 20 to June 30, 2020. The results are as follows.

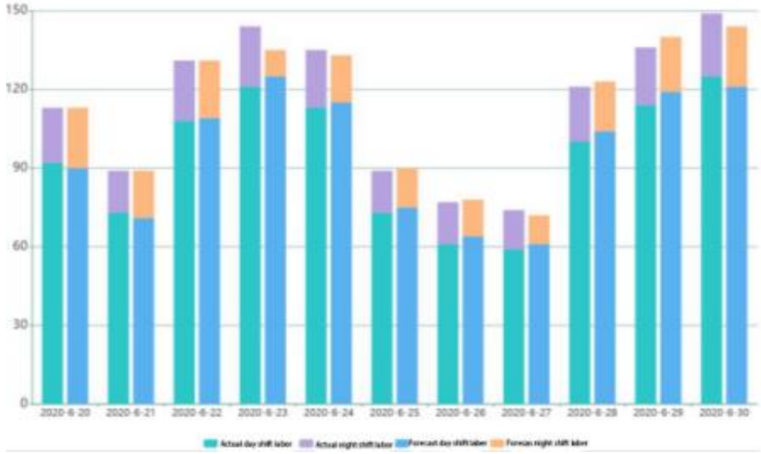

Figure 5-2: Comparison between actual and predicted labor numbers

According to the chart analysis, the predicted total employment of the warehouse is between 100 and 150 people, including 80 to 140 people in the daytime and 20 people in the night shift. The error between the number of employees assigned to the specific time and the actual situation of the 1000 lamp warehouse is very small, which is within the acceptable range. Concrete analysis, the model prediction results conform to the actual number of employment of employment, but also sometimes found labor shortage forecast model, that is, there are peaks and valleys of labor, lead to each warehouse employees often in a reasonable range, load affect the intelligent warehouse and KPI evaluation, so you need to continue to optimize the model.

5.4. Prediction model of the number of temporary workers based on the peaks and troughs of wave based on principal component analysis

Warehousing enterprises in the employment will appear in a short period of time workload surge, or in a quarter of the workload changes greatly, that is, the "peaks and troughs" problem, in reality, thousands of lamp warehouse through long-term employment of formal staff plus a certain number of short-term employment of "temporary" to deal with. In the principal component analysis to reasonably predict the number of warehouse staff demand, the model obtained the fitting equation Y1 between the working intensity and the number of staff, and compared the real-time calculated staff working intensity with the standard per capita working intensity. When the real-time working intensity of employees (Y_1) is less than the standard per capita working intensity (Y_2), it can be judged that the warehouse operation is in the trough, and the warehouse operation can be timely processed; When the real-time working intensity of employees (Y_1) is greater than the standard per capita working intensity (Y_2), it can be judged that the warehouse operation is in the peak period of employment, and "temporary workers" need to be hired to reduce the average load of employees.

If it is necessary to hire "temporary workers", the standard working intensity (Y_2) should be calculated by the difference of the product of the total actual working intensity (Y_1) minus the actual number of employees (X) and the standard working intensity (Y_2). The equation is expressed as follows:

$$X_2 = \frac{Y_1 - (X * Y_2)}{Y_2}$$

Finally, the number of "temporary workers" employed by labor service companies is X_2.

In summary, the actual daily labor quantity X_{XQ} is:

$$X_{XQ} = X_Z + X_2 = \frac{X_{ci} + X_{si}}{2} + \frac{Y_1 - (X * Y_2)}{Y_2}$$

5.5. Comparative analysis of staff scheduling before and after intelligent optimization of 1000 lamp warehouse

According to the on-the-spot investigation of thousand lamp warehouse operation daily report, we found that the warehouse work more time for June 4, 2020 to 12 JCP nine days, the period of staff scheduling, most difficult so we choose the period before and after the business situation to optimize staff demand forecast, the introduction of "temporary" number of peaks and troughs forecasting and scheduling scheme is calculated and compared. The forecast of employment demand and the real number of staff before and after optimization are shown below.

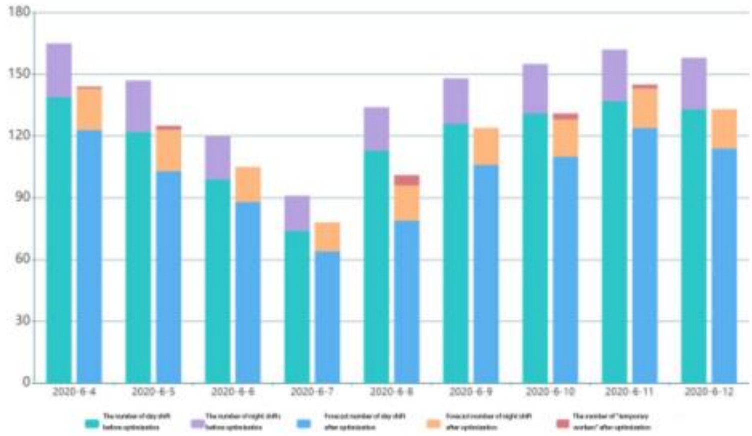

Figure 5-3: Comparison of predicted and real staff numbers before and after optimization

The analysis shows that the optimized warehouse has the following significant advantages compared with the pre-optimized warehouse:

(1) The intelligent optimized warehouse is more suitable for the prediction model, and the average number of staff in the optimized warehouse is reduced by about 19 people per day. Among them, the number of day shift demand decreased by about 15 people a day, night shift reduced by about 4 people. This means that with the improvement of warehouse intelligence, the reality is more able to save labor costs, can better improve the management and operation efficiency.

(2) The prediction of the number of employees during peaks and troughs reflects its accuracy in the optimized intelligent warehouse: the prediction of the model for the employees during both peaks and troughs is close to the real value of the survey, which greatly reduces the occurrence of "temporary workers". This shows that the higher the intelligence is, the higher the accuracy of the forecast of the number of employee demands, and the intelligent optimization will greatly reduce the loss of the enterprise caused by the surplus or shortage of employee labor.

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