Improved NSGA model for multi objective operation scheduling and its evaluation

Weining Li¹, Fuyu Wang¹, ²

¹. Anhui University of Technology, School of management science and Engineering, Anhui Maanshan 243032, China;
². University of Shanghai for Science and Technology, School of management, Shanghai 200093, China

Abstract. Reasonable operation can increase the income of the hospital and improve the patient's satisfactory level. In this paper, by using multi object operation scheduling method with improved NSGA algorithm, it shortens the operation time, reduces the operation cost and lowers the operation risk, the multi-objective optimization model is established for flexible operation scheduling, through the MATLAB simulation method, the Pareto solution is obtained, the standardization of data processing. The optimal scheduling scheme is selected by using entropy weight -Topsis combination method. The results show that the algorithm is feasible to solve the multi-objective operation scheduling problem, and provide a reference for hospital operation scheduling.

1. Introduction

With the rapid development of the medical and health undertakings, the competition of the medical and health market is becoming increasingly fierce. The hospital must reduce the cost of the hospital and improve the patient's satisfaction in order to occupy a place in the market. Operation room, as the main resource of income, is an important aspect of the performance of the hospital [1]. Traditionally, the single objective function of minimizing makespan is usually considered only in the management of surgical operation. The reality of the situation, for the hospital, not only hope for the shortest operation cycle, the minimum risk of surgery at the same time also want to spend the cost as low as possible, make full use of existing medical resources. Different managers want different goals, as much as possible to meet the various objectives, formulate feasible scheduling scheme, the multi-objective scheduling operation more in line with the actual situation of the hospital, it has more research value.

At present, domestic and foreign researchers on the operation scheduling using the most methods or through historical data summary, analysis of the scheduling scheme is the most reasonable, the operation sequence of patients effectively arranged. Foreign literature on the operation of the scheduling, mainly focused on improving the efficiency of conventional surgery [2-3].

At present, there are two ways to solve the multiobjective optimization problem with Pareto method and the Pareto method, non Pareto Law refers to each sub goal to be optimized a weight value, weighted aggregation, the multi-objective optimization problem is transformed into a single objective optimization problem [4-6].

2. multi-objective surgical scheduling model

The operation scheduling problem should meet the following assumptions:

(1) there is only one patient per bed
(2) The three phases of the operation of the same patient cannot be changed.
(3) The patient cannot be aborted once the surgery is performed.
(4) All patients were able to operate at zero time, with the same priority between different operations.
(5) Patients follow the first come first served rule.
(6) Do not consider the knife surgeon, medical staff and patients late, can be prepared in accordance with the scheduling time.
(7) Operating beds are available for continuous use.
(8) After the operation, the patient needs to be transferred to the recovery room immediately.

Model parameters:
- $m$: Number of operation stage
- $n$: Patient number
- $T_{ij}$: Patient $i$ was performed at the end of phase $j$ surgical stage
- $M_j$: Number of operating beds in operation $j$
- $F_{jk}$: Average cost per unit time of operating table $k$ on stage $j$ of operation
- $P_{i,jk}$: The time of the operation bed of patient $i$ at stage $k$ of stage $j$
- $Y_{i,jk}$: Patient $i$ is the first $j$ surgical stage on stage $k$ operating table, if it is 1, otherwise 0
- $R_{jk}$: Risk factors for stage $j$ surgery on stage $k$ operating table
- $S_{i,j}$: Patient $i$ start time of $j$ tract surgical stage
- $X_{il}$: Patient $i$ is arranged in the first $l$ position, if it is 1, otherwise it is 0.

Establishment of multi-objective optimization model:

Shorten the operation period, reduce the cost of operation and the risk of surgery is the three important goals of operation scheduling. The description of these three scheduling objectives is as follows:

(1) Shorten operation period. The shorter the operation cycle, means that the operation ability will be higher, but also means that the patient satisfaction, the rapid cycle of capital and enhance the competitiveness of the hospital.

$$f(1) = \text{Min} \left[ \text{Max}(T_{im}) \right] \quad (i = 1, \ldots, n) \quad (1)$$

(2) Lower operating costs. Cost reduction is the basic source of hospital income, income is the cost of compensation, reducing costs means that the increase in hospital revenue. In this paper, the cost of the operation bed is expressed by the time cost of the operating bed and the time of the patient on the operating table.

$$f(2) = \text{Min} \sum_{j=1}^{m} \left( \sum_{i=1}^{n} \left( \sum_{k=1}^{M_j} Y_{ijk} \times F_{jk} \times P_{i,jk} \right) \right) \quad (2)$$

(3) Reduced surgical risk coefficient. In the actual operation, the risk factor of surgery is affected by many factors. In this paper, we use the risk factor to describe the success rate of the operation. The lower the operation risk coefficient, the higher the success rate of the operation.

$$f(3) = \text{Min} \sum_{i=1}^{n} \left( 1 - \text{Prod}_{j=1}^{m} \left( \sum_{k=1}^{M_j} Y_{ijk} \times R_{jk} \right) \right) \quad (3)$$

Finally, the multi-objective optimization model is established:

$$\text{Min}F = \{ f(1), f(2), f(3) \}$$

Constraint condition:

$$\sum_{i=1}^{n} X_{il} = 1, \quad l = 1, 2, \ldots, n \quad (5)$$

$$\sum_{l=1}^{n} X_{il} = 1, \quad i = 1, 2, \ldots, n \quad (6)$$
The formula (5), formula (6) represents a full array of all patients. Formula (7) indicates that at any stage of surgery, each patient can only be operated on an operating table. The formula (8) indicates that the operative time of the patients in the same operation stage is the sum of the start time and the operation time. Formula (9) indicates that the starting time of the posterior surgical stage is completed after the previous surgical stage.

3. Algorithm design

The operation scheduling problem belongs to the discrete combinatorial optimization problem. The algorithm improves the NSGA from three aspects: (1) a fast non dominated sorting method (2) the elitist strategy is introduced (3) The concept of congestion degree is proposed to maintain the diversity of population.

The basic flow of genetic algorithm can be divided into population initialization, fitness value calculation, selection, crossover, mutation. In order to improve the NSGA algorithm, the two parameters of the individual's non dominated level and crowding distance must be calculated before the individual selection. According to the level of non dominated individuals are classified, with the same level of non dominated individuals, large crowding distance of individual dominance. In order to solve the problem of multi objective operation scheduling, this paper calculates the non dominated level and crowding distance of the individual as the virtual fitness function.

(1) encoding and initialization. Take the real matrix encoding method for n patients, stage m surgery, the number of operation bed each operation stage for Mi (Mi = 1, j=1,2, m, Taiwan). Encoding matrix to construct a m * n, each row corresponds to each operation stage matrix, each column corresponds to a patient. Aii is the interval matrix elements (1, Mi+1) on a number of randomly generated number, operation bed it represents the integer part of patient J I surgery patients in the first stage, operation stage in order to decide according to the size of the decimal part, after the operation stage before the operation phase of the order according to the completion time to set the. For the generation of initial population, the random generation method is adopted.

(2) non dominated ranking. First of all, the calculation of the objective function value of each individual, according to the definition of Pareto dominance, determine the level of non dominated individuals, the current population of the Pareto optimal solution set, these individuals in the Pareto solution set up the first Pareto optimal solution layer, which is denoted as the non dominated rank=1, and then performs the same operations for the remaining individuals in the population (rank=2, 3...) until all the individuals in the population are sorted.

(3) individual crowding. The calculation of the individual crowding distance is carried out for individuals with the same non dominant rank, and the crowding distance of the individuals at the boundary is recorded as infinity:

\[ iD = \sum_{k=1}^{q} \frac{|f_k(i+1) - f_k(i-1)|}{f_{k_{max}} - f_{k_{min}}} \]  

In the formula (10), iD is the crowding distance of individual i; q is the number of targets; i+1 and i-1 are the same as the fk of the individual i; fk max and fk min are the maximum and minimum values of the objective function.

(4) selection, crossover and mutation operation. After sorting out the rank of non dominated individuals and calculating their crowding distance, the two - dollar tournament is used to select the individual. First, randomly selected from the population of two individuals, comparing the non dominated level, if the non dominated level value (rank value) using small; and if two individuals are the same level of non dominated, two individual crowding distance, choose crowding distance large
individuals into the next generation. After the operation is selected, followed by crossover and mutation, to consider the legitimacy of the new generation of chromosomes at this time, the single point crossover in the crossover operation, mutation operation directly with a 1 to Mi+1 between the real number to replace the corresponding gene. (5) elite retention strategy. The population size is N of the parent population and Pt progeny population with Qt, constitute a number of individuals for population Rt 2N, to calculate the distance of the nondominated sorting and crowding of Rt individuals, elected the next generation Pt+1 optimization of individual students population scale new N from.

4. Simulation Analysis and scheme selection

In this section, the improved NSGA algorithm is used to solve the multi-objective scheduling problem. According to the algorithm steps, the MATLAB program is compiled. The simulation involves 3 objectives: the operation cycle, the cost of the operating table and the target of the operation risk. This example involves 9 patients, the operation of the 3 phase of the multi-objective scheduling process, each stage of the operation of the number of beds as shown in appendix.

By using MATLAB software algorithm, the basic parameter is:

the initial population size is set to 50, the number of iterations is 300, the probability of crossover mutation probability of 0.8, 0.3, 36 after the end of the run of Pareto optimal solutions (i.e. 36 alternative scheme), as shown in Figure 1, each sub objective function mean evolution the curve as shown in Figure 2

![Figure 1](image1.png) Pareto distribution of optimal solution

![Figure 2](image2.png) mean evolution curve

In this paper, we use entropy weight Topsis method to select and evaluate the scheme to determine a satisfactory scheduling scheme. The basic principle is: the formation of the original data matrix by program and index, and then normalized to the original matrix, find the ideal point of each index scheme, the ideal point is divided into positive and negative ideal point, and the corresponding optimal index chosen in the worst value. The scheme as a fixed point in space, and the calculation of the best and worst value of the distance between the order according to the calculation results, obtained the degree to each candidate scheme and the optimal value of the evaluation of the scheme. The following is the introduction of the calculation procedure of entropy weight Topsis method [7].

The calculation shows that the optimal scheme is the scheme 21 (relative closeness degree is 0.927911992).
5. conclusion

In this paper, we consider 3 objective functions, the shortest operation period, the minimum operation cost and the lowest operation risk, these goals of multi-objective scheduling operation is very important, in reality, many factors affect the 3 goals, this paper optimized the standard of the 3 orders from the operation scheduling. In this paper, the improved NSGA algorithm and the use of entropy weight -Topsis method to solve the multi-objective scheduling problem, the hospital operation has certain reference significance.

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