# Imperial Competition Algorithm Improvement Considering Surgical Scheduling

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***Abstract:*** To address the lack of resources for doctors, nurses and operating rooms when scheduling surgery, a hybrid imperial competition algorithm considering the surgery scheduling problem is proposed based on setting assumptions and using the idea of crossover operations in genetic algorithms.
***Keywords:*** Surgical Scheduling; Doctor-Patient Satisfaction; Multi-Objective Optimization; Imperial Competition Algorithm

## 1. Introduction

For hospitals, a reasonable and scientific surgical scheduling plan can not only reduce the workload of physicians, but also more scientifically configure and improve the satisfaction of physicians and patients with surgery. This topic considers strained medical resources and takes into account doctor and patient preferences in the scheduling process, thereby improving doctor-patient satisfaction. Based on the hypothesis and its characteristics, an improved imperial competition algorithm is proposed to solve this problem.

## 2. Research Content

## 2.1 Basic Algorithm Process

Agaric and Lucas [1] specific research is based on the current situation of our national public health service industry. In the genetic algorithm, this array is called "chromosome", and we call it "kingdom". In the N-dimensional optimal problem, one country is a 1× N-dimensional array. This array is shown as follows:

$$\text{Country}=[P_1,P_2,P_3,\ldots,P_N] \quad (1)$$

The strength of a country can be measured by the cost function f and the variables ( 1, 2, 3,..., ), and the cost function can be expressed as

$$\text{cost}=f(\text{country})=f(P_1,P_2,P_3,\ldots,P_N) \quad (2)$$

On this basis, an initial population of size approximately p units is generated to start this optimal algorithm. We select the strongest country from the initial population as our imperialism. At that time, we will have two kinds of countries, one imperialist and one colonial. We colonized the imperialist countries according to their power in order to build an empire in the beginning. In order to make the colonies commensurate with the empire, we set the following standard cost for an empire:

$$C_n = C_n - \max_i\{C_i\} \quad (3)$$

Here the cost Cn is the cost of the nth generation of empire, and the cost Cn is its regularization cost. Based on the formalization cost of each empire, the size of the formalization power of each empire can be defined as

$$p_n = \left| \frac{C_n}{\sum_{i=1}^{n_{imp}} C_i} \right| \quad (4)$$

On the other hand, the power it has is also the power it should have to colonize. Thus, the first colonial population of an empire is

$$N.C._n = round\{p_n.N_{col}\} \quad (5)$$

$N.C._n$ Here it is the number of colonies owned by the nth imperialist power, while the c is the number of colonies as a whole. As for the distribution of colonies, it is an arbitrary piece selected from . . imperialist powers. Imperialism and its dependent colonies constituted an empire.

After the colonies were conquered, the imperialist powers proceeded to "recreate" them. X is a uniform (or any suitable) random variable. For the determination of x, we use the following method:

$$x \sim U(0, \beta \times d) \quad (6)$$

Here, $\beta > 1$ allows the colony to move in two different directions toward imperialism, d is the distance between the two regions, and x follows an average distribution on $(0,\beta \times d)$.

Moreover, to find differences between these individual countries of imperialism, we added some random bias. Where theta is the random number of the average distribution. To determine theta, we can take:

$$\theta \sim U(-\gamma, \gamma) \quad (7)$$

Here, $\gamma$ is the angle offline and $\theta$ fits the mean distribution on $((-\gamma,\gamma))$.

When a colony is annexed by an imperialist, it pays more than it has paid. In this way, the relationship between this colony and this imperialism changes, and the original colony becomes an imperialism of this empire, while that original place becomes a colony.Let us model this fact in terms of combinations:

$$T.C._n = f(imp_n) + \sigma \times \frac{\sum_{i=1}^{N.C._n} f(col_i)}{N.C._n} \quad (8)$$

where $T.C._n$ refers to the overall power of the nth empire and $\sigma$ refers to the colony's great influence. In other words, it refers to the great influence of the colony on an empire-wide scale. $\sigma$ is a positive number smaller than the value of 1. After unification, the strength of the whole empire was as follows:

$$N.T.C._n = T.C._n - \max_i\{T.C._i\} \quad (9)$$

These two countries, $T.C._n$ and $T.C._n$ the country of the nth country, and the unified country of the second country. The likelihood of each country having a vassal state in the weakest country chosen is then calculated based on the normalized total for each country:

$$P_n = \left|\frac{N.T.C._n}{\sum_{i=1}^{N_{imp}} N.T.C._i}\right| \quad (10)$$

where $P_n$ refers to the probability that the nth country has a colony.

In order to classify these colonies into different empires according to the occupation rate, we express the occupation rate of the full set of empires by the vector P：

$$R=[r_1, r_2, r_3 \ldots, r_{imp}] \quad (11)$$

$$r_1, r_2, r_3 \ldots, r_{imp} \sim U(0,1) \quad (12)$$

We then subtract P from R to obtain the vector D:

Eventually, whichever country has the highest value in the vector D is designated as that colony.

$$D=P-R=[D_1, D_2, D_3 \ldots, D_{imp}] \quad (13)$$

## 2.2 Advantages and disadvantages of the Imperial Competition Algorithm

ICA, together with other evolutionary algorithms, has emerged as an effective method for solving a variety of complex problems. This view is based on the theory of socio-political evolution and is characterised by its universality and generality. One of the greatest advantages of the "Imperial Race" algorithm is its fast convergence.

The algorithm of the Imperial Competition still has many issues to be refined. The shortcoming of ICA is that it contains more parameters than particle swarms, differential equations and genetic algorithms, making the correction of the parameters of ICA more difficult, especially the error coefficient (theta). There are many ways to solve this problem, such as maintaining ethnic diversity.

## 2.3 Model assumptions for a surgery scheduling problem that takes into account the satisfaction of all parties

### 2.3.1 Problem description

In this paper, surgical scheduling is based on a working day as a cycle in which the number of surgeries to be scheduled is O. The better resources in the neurology department of the hospital during this working day are D specialist doctors, R doctors' offices, and a team of general manager secretaries (a team of four trainee nurses) who can perform surgery. Each operation can be divided into three specific steps: pre-operative preparation, intro-operative operation and post-operative rehabilitation, and only the operational steps are discussed in this paper.

Each operation was carried out in collaboration with a surgeon and an assistant. Each patient has his or her own desired time window and desired level of surgeon, and each surgeon has his or her own corresponding level of surgeon and average past success rates for various types of surgery, so each surgeon and assistant have different levels of collaborative proficiency. There are four levels of "proficiency": no understanding, good understanding, good understanding and very good understanding. There are also four levels of physician proficiency: chief physician, associate chief physician, attending physician, and physician.

There is a deviation between the patient's level of satisfaction and the distance between the patient's actual pre-determined time and the patient's expected distance, and between the patient's actual assigned physician level and the patient's expected level.

Maximizing the success rate is determined by the clinical experience of each patient, and the higher the success rate, the more the hospital will recognize it. Previously, the treatment success rate was 0 to 1. Generally speaking, the higher the rank of the surgeon, the more conditions he or she treats. This patient, therefore, has to be done by an experienced surgeon.

Designed for minimum time, minimum cost, maximum satisfaction and maximum treatment results. Calculate the minimum operating time required for the last operation. The total product cost covers: the cost of unused product in the doctor's office, the cost of overtime product in the hospital medical staff, the general manager of the specialist doctor attending the operation, and the cost of collaboration of the secretarial team. Of these, the collaboration costs refer to the differences in the consumption of the materials required for the operation due to the level of mutual understanding. The overall satisfaction level is divided into two parts: nursing staff satisfaction and patient satisfaction.

### 2.3.2 Model Assumptions

The following assumptions were made for this problem in the development of the model:

Assumption 1: Only one operation can be performed by one surgeon at one time

Assumption 2: Only one operation is allowed in an operating theatre at any one time

Assumption 3: A team of surgical assistants can only work with one physician at a time

Assumption 4: Once started, it cannot be interrupted

Assumption 5: The priority of each step is the same and all steps can be performed after office hours

Assumption 6: The number of resources per resource is determined and the number of auxiliary teams is not lower than the number of main operations

Assumption 7: The cost of overtime work is the same for surgical assistants

Assumption 8: Doctors with higher titles have a higher cure rate for more diseases, but also some doctors with higher titles have a higher cure rate for one disease

Assumption 9: The time taken for a procedure will be 90% of what would be expected when very cooperative, 95% of what would be expected when well cooperative, 100% of what would be expected when well cooperative and 110% of what would be expected when not well cooperative.

Assumption 10: When the level of collaboration between a practitioner and an assistant is equivalent, the level of collaboration proficiency is the same as that between an assistant.

## 2.4 Design of an improved imperial competition algorithm

### 2.4.1 Ideas for algorithm improvement

The concept of the "imperial race" was first introduced by Atashpaz-Gagari and Lucas etc. and applied to solve "continuous" optimization problems. Since the surgical scheduling problem in this paper is a discrete optimization problem, it was only after a specific analysis of the same imperial least squares method that it became necessary to modify it and then propose a discrete hybrid least squares method, i.e. task-driven least squares, in which the rules of scheduling commands and the cross-logical operations of genetic algorithms were introduced in the design and production of this least squares method, making this algorithm able to be adapted to the needs of surgical scheduling. A more detailed description of the key improvements is given below.

### 2.4.2 Generating a workable solution

In generating an efficient solution, it is important that both the hard constraints are adequately met and that the soft constraints are also met as closely as possible. Thus, in order to ensure that a valid solution can be generated, a new approach is used where a valid solution is determined based on the patient's preferences ， which not only ensures that the resulting solution is a valid solution, but also improves the quality of the solution by satisfying some soft constraints.

On the basis of the above analysis and thinking, the following approach can be derived that can be implemented: for the combination of personnel, the specific approach is to use a randomized occurrence that directly corresponds to the number of patients with brain haemorrhage, specialist doctors and operable general manager secretaries in the four groups. After generating the total combination of all personnel, the total combination of personnel is driven by the specific method of the minimum task-driven square rule 1 will hopefully time is not known window to cover the current moment (the current moment is the time when the last person in the doctor's office will be able to start the surgery and when the next person will be able to start the surgery is not yet known). How to assign priority to surgeries, and how to assign market expectations of when a surgery can be performed without knowing the longest time it can be performed, gradually leading to a complete and feasible solution.

### 2.4.3 Imperial Assimilation

In the specific process of how the imperialist invading countries and overseas colonies manipulate parental crosses, the crossover points of genetic least squares are simulated to obtain the Arabic numbers pos1, pos2, pos3, pos1, pos2, pos3derivedde three gene numbers selected from the chromosomes of the imperialist invading countries, pos2 and pos3 are three gene numbers selected from the chromosomes of overseas colonizing countries, pos2 is three gene numbers selected from the chromosomes of overseas colonizing countries, and pos3 is three numbers of completely random genetic numbers. In some ways, this appears to have 1+2+3=1 for Pos1, Pos2 and Pos3, and Pos1, Pos2 and Pos3 are all greater than 0. The crossover chance in the genetic algorithm is 1 because in the assimilation algorithm it is performed on each colony under each empire.

Under the modified assimilation algorithm, after assimilating each colony in the population, the new membership is converted into a feasible solution to the surgical scheduling problem, thus achieving a cycle. The modification of the existing feasible solution generation method and the absorption operation for empires allows subsequent empire substitution, competition and extinction operations to be performed in accordance with the original empire competition operation.

## 2.5 Algorithm flow design

The method was then designed on the basis of the above modified ideas and the imperial race as follows:

Step 1: Set the number of countries in the initial population, the number of imperialist countries, the number of colonial countries, and the corresponding number of iterations, and the colonial impact factor；

Step 2: use weighted single value 1, weighted single value 1, weighted single value 1, weighted single value 3, and weighted single value 4 for the four indicators in the surgical scheduling problem as the fitness function for the method;

Step 3: generation of a primitive population for the national competition, following the principle of first generating the membership and then generating a fully possible solution with reference to a heuristic algorithm;

Step 4: generation of the designated initial states according to the underlying empire race algorithm, based on the relationship between the original population and adaptation;

Step 5: for major colonies within major empires, reference to the crossover operations in the genetic algorithm to achieve unification of the major colonial systems;

Step 6: If there is a colony more powerful than the empire, then replace the original empire with that colony；

Step 7: estimate the overall cost for each country;

Step 8: Choose the weakest country and then let the other countries fight over it, ending the fight for that country；

Step 9: If a country is without all its colonies, then that country is considered destroyed；

Step 10: Repeat steps 5 to 9 until the most cycles occur or until finally there is only one kingdom, and this evolution ends.

# 3. Conclusion

In terms of problem construction, though, a method is proposed for the difficult problem of quantifying patient satisfaction and incorporating patient satisfaction into the patient's decision making process, and incorporating patient satisfaction into the patient's decision making process. How the relevant research in this paper can be integrated with the real operating theatre scheduling process remains to be explored in depth.The performance of the algorithm, such as the complexity of the algorithm, is not addressed.

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