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Research on Application of Genetic Algorithm in High School Course Arrangement System

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Abstract

With the increase of the number of students and the increase of teaching classes, the course scheduling task becomes more complex and time-consuming, which greatly increases the workload of teachers. Therefore, based on the genetic algorithm, combined with the actual teaching work of middle school, the web course scheduling system is designed and implemented. By importing the teaching tasks of teachers, it can automatically complete the timetable arrangement and display the timetable by types. The convenience of the system greatly improves the work efficiency of teachers.

Keywords

Genetic algorithm; Scheduling problems; Lesson Lesson arrangement algorith.

1. INTRODUCTION

In the teaching management work of high school, the traditional arranging class is manually arranged by the faculty and staff, which takes a long time and is inefficient, which makes it very difficult to use. Therefore, many schools use computer-assisted scheduling to improve efficiency.

The use of computer-assisted lesson arranging provides a good solution to the task of arranging lessons. How to scientifically and effectively arrange the courses of this semester in advance has become a hot topic now.

The scheduling algorithm has been studied since the 1950s. As of the 21st century, most scholars at home and abroad used heuristic algorithms such as genetic algorithm, simulated annealing algorithm, ant colony algorithm and tabu search [1].

According to the research results of a large number of scholars, the current algorithm for scheduling problems is mainly selected from ant colony algorithm, simulated annealing algorithm, and genetic algorithm.

(1) Ant Colony Algorithm

The ant colony algorithm was first proposed by the Italian scholar Dorigo to solve the classic traveling salesman problem [2]. Ant colony algorithm is a heuristic optimization method based on positive feedback mechanism, which specifically relies on heuristic information and pheromone. It searches in the field of location through individual efforts and group collaboration, and increases the pheromone on the optimal path based on positive feedback , Select the optimal path.

The ant colony algorithm performs well in convergence, and it is easy to find the optimal solution. However, the ant colony algorithm has high data requirements and large computational overhead. When dealing with large-scale groups, it is easy to fall into a local optimal solution.

(2) Simulated annealing algorithm

The simulated annealing algorithm simulates the annealing process of solid materials and is a random search algorithm. As the internal energy of the solid increases with heating, the internal particles become disordered, while the particles gradually become ordered when cooled. Finally reach the ground state, the internal energy is the smallest [3]. The model of simulated annealing algorithm can be roughly divided into three parts: solution space, objective function and initial solution.

The simulated annealing algorithm has better asymptotic convergence and global search ability. But the disadvantage lies in the setting of the initial temperature value. If the initial temperature is high, the possibility of searching for the optimal solution is high, but it takes a lot of time;On the contrary, calculation time can be saved, but the global search performance will be affected.

(3) Genetic Algorithm

Genetic Algorithms (GA) is a type of random search algorithm that draws on the natural selection and natural genetic mechanism of the biological world. It uses simple coding techniques to represent various complex structures, and performs simple genetic algorithms on a set of coded representations. Operation and natural selection of survival of the fittest to guide learning and determine the search direction [4].

Genetic algorithms are highly efficient and have simple, easy-to-operate and universal features, and these features are one of the main reasons why genetic algorithms are becoming more and more popular [4]. The operation object of this system is high school curriculum tasks, the data scale is small, and it is easier to express the data by coding. In summary, the genetic algorithm is more suitable for this system.

2. ANALYSIS OF SCHEDULING PROBLEMS

The mathematical model of the scheduling problem can be described as four sets, curriculum SC, class set CC, teacher set TC, time period set PC. Before arranging classes, you need to obtain the teacher's teaching plan to determine the relationship between the main sets, that is, a certain A certain course of the class should be taught by a certain teacher, and under the condition of ensuring that resources do not conflict, find the course time that meets the constraints. The results form a teaching set D={s, c, t, p}, among them s∈SC, c∈CC, t∈TC, p∈PC.

2.1. Restrictions

The task of scheduling classes requires us to consider different constraints to ensure that there are no conflicts in the courses.

(1) Hard constraints

Hard constraints determine the feasibility of the timetable [5]. It has the following three points:

There can only be one course in the same class at the same time, which is

$$\sum_{m=1}^{CC}\sum_{i=1}^{PC}\sum_{j=1}^{SC} c_m p_i s_j t_n \leq 1 \tag{1}$$

Formula (1) means the same class cm Only one course sj can be scheduled in the same lecture period pi and taught by teacher tn.

The same teacher can only arrange at most one course to teach at the same time.

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$$\sum_{n=1}^{TC}\sum_{i=1}^{PC}\sum_{j=1}^{SC} c_m p_i s_j t_n \leq 1. \quad (2)$$

Formula (2) means the same teacher tn in the same lecture period pi only one course sj can be scheduled and teach the class cm.

(2) Soft constraints

Soft constraints determine the quality and application value of the generated timetable [5]. According to different schools, the constraints set by users are also different. The soft constraints can be that two classes are connected as much as possible, the same class can be alternated one day, half a day on Saturday, and so on. For soft constraints, we will have a scoring system (weighted), the higher the score, the more in line with the user's soft constraints.

2.2. Schedule Elements

The essence of the scheduling problem is the rational allocation of teaching resources. According to the different teaching systems, the elements of the scheduling problem are also different.If it is an administrative class, the classroom is fixed, and the class can represent the classroom. When detecting conflicts, as long as the class does not conflict, the elements of the administrative class [5] are: teacher, class, course, and time.If it is a shift system [5], compared with the above-mentioned administrative class, the element will have one more classroom.

2.3. Data Storage Form

The data storage format uses decimal string coding information, and the data in different intervals represents different elements of the course, which is more intuitive.

3. SYSTEM DESIGN

3.1. System Technology Selection

This system uses SpringBoot framework, persistence layer framework Mybatis plus, Java language development, database uses MySQL8.0, cache uses commonly used Redis, and front-end pages use Vue.js+Ant to develop.

3.2. System Function Requirement Design

A course scheduling system should have the functions of logging in, importing course tasks, modifying course tasks, automatically arranging courses, querying timetables, and exporting timetables (Excel).

(1) Login

Login is divided into administrator login, teacher login and student login.

(2) Scheduling task

Teachers fill in the corresponding schedule information on Excel in accordance with the specifications, such as the class, grade, course, whether there is a fixed time, a week of class hours, etc. The system can import Excel and automatically store it in the database. Teachers or administrators can make secondary modifications to the scheduling tasks.

(3) Automatic class schedule

The system uses genetic algorithms to automatically schedule courses according to the imported course tasks.

(4) Query class schedule

This module includes administrator query timetables, students query timetables, and teachers query their own lectures.

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(5) Export timetable

The export function is indispensable. Export the class schedule to Excel format for teachers to print directly for viewing in reality.

The structure diagram of the scheduling system is shown in Figure 1.

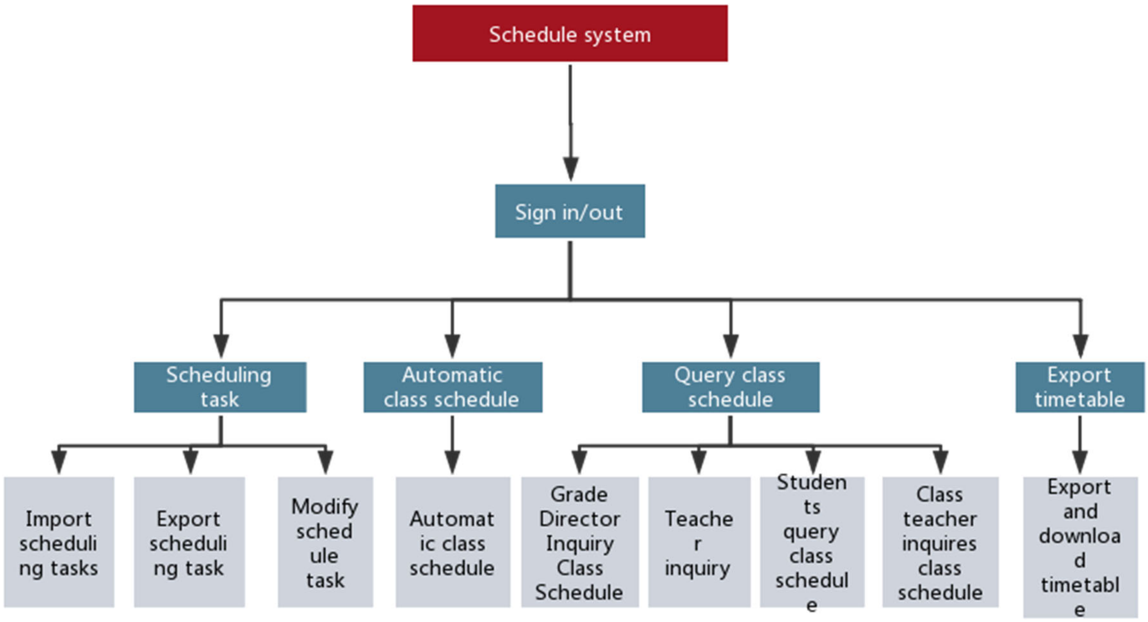

Figure 1. Function structure diagram of the scheduling system

4. USE GENETIC ALGORITHM TO SOLVE THE PROBLEM OF SCHEDULING

4.1. Introduction to the Application of Genetic Algorithm in the Course Arrangement System

In simple terms, genetic algorithm is the process of simulating biological evolution theory, from the initial population through crossover, mutation, selection and other operations, after a certain algebra until the final convergence, to obtain the optimal solution.

The course scheduling process of this system is to first store the imported course scheduling information in the database, and then allocate the class time for the courses with variable time through free allocation of inter-slices, and convert them into decimal strings to obtain the initial population. Then through crossover, mutation, and selection operations to evolve from generation to generation, conflict detection will be performed during each generation of evolution. Once the hard constraints are not met, the key fragments of the current gene will be replaced, and the cycle will continue until there is no conflict. The new population obtained should also be scored. The higher the score, the next cross-evolution is selected, until finally the optimal solution is converged.

The core flow chart is shown in Figure 2.

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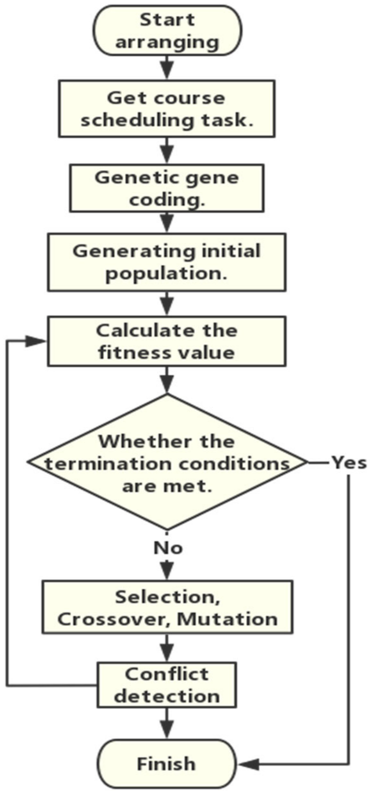

Figure 2. Genetic algorithm operation process

4.2. Genetic Algorithm Design

(1) chromosome [6]

One chromosome represents the arrangement of a class, and is the solution for a certain class

(2) Gene coding

Gene coding is the manifestation of chromosomes and the basic unit that constitutes chromosomes [6]. Use decimal string encoding. The specific design is shown in Table 1.

Table 1. Gene coding example table

#	Fixed time or not	Grade number	Class number	Teachers work number	Course number	Course type	Course time	Total bit
Digit	1 (0/1)	2	4	9	4	2	2	24
Illustrate	no	Senior one	Class 1, Grade 1	201702832	Required Chinese	Required	Monday first session	
Decimal string	0	01	0101	201702832	0101	01	01	24

The gene code is 0010 1012 0170 2832 0101 0101.

The above-mentioned genetic code is explained as follows: two grade numbers are more than enough for high school; the first two digits of the class number are the grade numbers, and the last two represent the class number, up to 99; the course type accounts for two, which is more sufficient; The number consists of four digits of course type + course program number; the course time consists of two digits, up to 99, up to 10 lessons in a day, and up to 70 in a week.

(3) Initial population [12]

The collection of all chromosomes constitutes an initial solution, the initial population, which is the starting point of iteration. In this system, the initial population is the initial solution for

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all classes, and each individual is the solution for one week of each class. When generating the initial population, it is not necessary to consider whether the curriculum resources conflict. [6].

(4) Fitness function

Perform weighted calculations on individual characteristics to obtain fitness values. The fitness function is the top priority of the entire algorithm. It not only determines the operating efficiency of the algorithm, but also determines whether the final result is satisfactory.

The fitness function design of this system is mainly designed around the types of courses. In high school courses, the system divides the course types into mandatory courses, restricted courses, and elective courses. K1, K2 and K3 are used to indicate their respective weights, and their corresponding expected value variables F1 , F2 and F3, and the calculation of the expected value of the course Need to use the course time to arrange the expected value set Fz = {tenExpectValue, eightExpectValue, fourExpectValue, twoExpectValue}(the four elements have corresponding values), in addition to adding the weight K4 of the degree of dispersion of the course and its expected value F4, the higher the degree of dispersion, the better the individual, indicating the probability of the same courses being arranged together Lower.

F1 , F2 and F3 are calculated as follows:

$$\mathrm{F_i} = \sum_{\mathrm{j=1}}^{\mathrm{SC}} \mathrm{F_z} (1 \le i \le 3) \tag{3}$$

Formula (3) indicates that the expected value of the course type Fi in an individual is the sum of the expected value of the time arrangement of all courses of that type.

In summary, the fitness value Fx can be calculated as Equation 4.

$$\mathrm{Fx} = \sum_{i=1}^{n} (\mathrm{F}_i \bullet K_i)(n = 4) \tag{4}$$

(5) Selection operator

The purpose of selection is to inherit new individuals or excellent individuals through pairing and crossover to the next generation. The higher the fitness value is, the better the individual is. Selection can improve calculation efficiency and speed up convergence. The selection methods include random traversal sampling method [7], local search method [8], tournament selection method [9] and so on. This system uses the tournament selection method to calculate the fitness value through the fitness function, and selects individuals with higher scores to inherit to the next generation.

(6) Crossover operator

Two individuals in the population exchange gene codes at a designated crossover position, or randomly exchange some genes. Crossover is used to carry out gene replacement and recombination, thereby generating new individuals. Crossover methods include discrete reorganization [10], single-point crossover, and multi-point crossover.

The crossover object is an individual in the population. The individual is stored in a Map, the key is stored in the class number, and the value is stored in the class's genetic code set-List<String>. Normally, the biological crossover should be two individuals, but the schedule is not the same. If the genetic code between the two classes is randomly exchanged, a large number of teacher-course conflicts will be caused. Here, single-point crossover is used to

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exchange genes within the individuals. The following is the design of the cross flow of this system.

Get the set of gene codes corresponding to each class in a loop.

Randomly take out two gene codes from the current class code set.

Determine whether the two genes have the same code, perform step 2 to determine whether the course time of the two genes is fixed, as long as one is fixed, perform step 2.

Get the time slice value of the two genes and exchange the time.

Calculate the fitness value of the new individual and the old individual, choose whoever has the higher the value, and replace it in the set.

Determine whether the individuals within the crossover rate have all crossed, otherwise obtain a new class gene coding set.

The cross flow chart is shown in Figure 3.

(7) Mutation operator

Mutation operator is another important operation of genetic algorithm to generate new individuals. It generates new individuals by replacing genes at certain positions in chromosomes with other alleles. The mutation operation can significantly improve the local search ability of the algorithm, and maintain the diversity of the group by preventing the loss of effective genes, which helps to avoid the premature phenomenon of genetic algorithms [13]. This system uses real-valued mutation to change the time segment of the course. The following is the specific process of mutation.

1. Get the number of mutations in the current population according to the mutation rate.

2. Determine whether the number of mutations is less than 1, if yes, go to step 3, otherwise go to step 4.

3. Set the current number of mutations to 1, and continue to step 4.

4. Determine whether the current mutation order exceeds the number of mutations, if yes, go to step 10.

5. Randomly obtain an individual's genetic code for mutation.

6. Determine whether the course time is fixed, if yes, go to step 5.

7. Generate a new time slice for the gene encoding.

8. Replace the current gene code to the original position.

9. Go to step 3.

10. End of mutation.

The mutation flow chart is shown in 4.

(8) Collision detection

After all the above are executed, it enters the conflict detection part. During the process of crossover and mutation, genes that do not meet our schedule requirements may be generated, which will conflict with existing genes. In order to resolve these conflicts, we must The conflicting genes are replaced by fragments-change the time slice until there is no conflict. (This process is relatively clear, no more drawing) Only the new generation of populations without conflict can calculate fitness values for comparison and selection.

(9) Termination condition [11]

The conditions for ending the genetic algorithm are that the fitness value of the individual reaches the given preset value, the fitness value of the optimal individual and the fitness value of the group no longer rise, and the number of iterations reaches the set number of generations.

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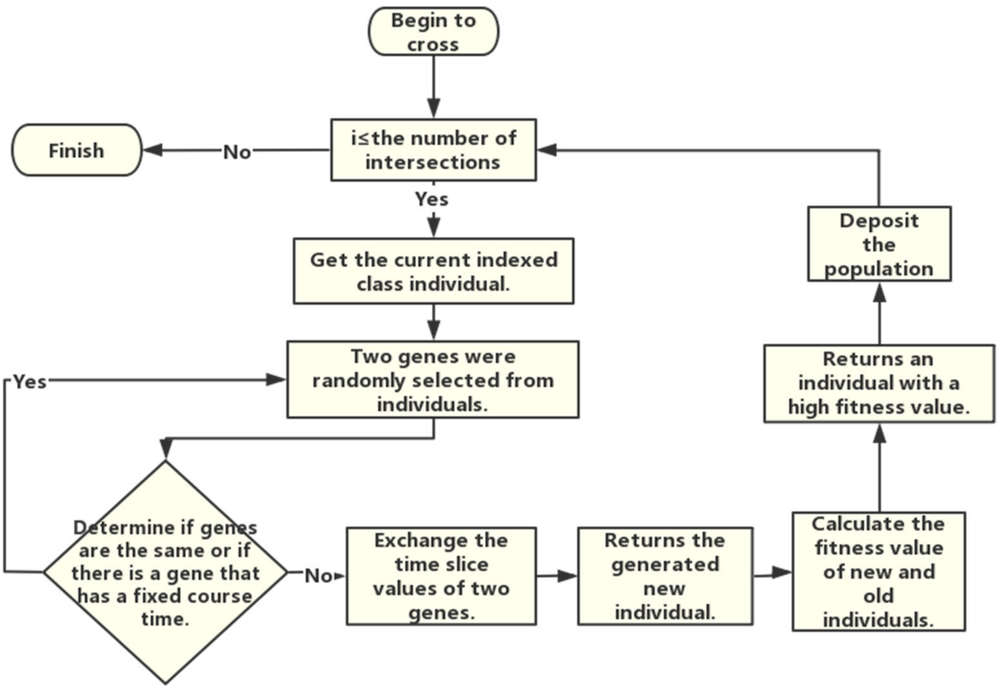

Figure 3. Cross flow chart

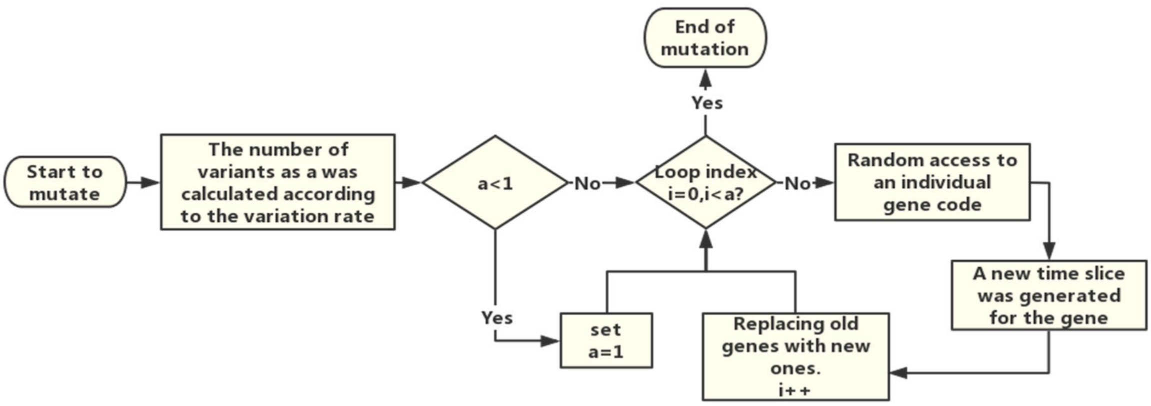

Figure 4. Mutation flow chart

5. FUNCTION TEST

5.1. Schedule Task Management Page

Click the Import button to export course tasks, click Start Schedule to automatically schedule classes, and you can modify or delete a certain schedule task. Specific as shown in Figure 5.

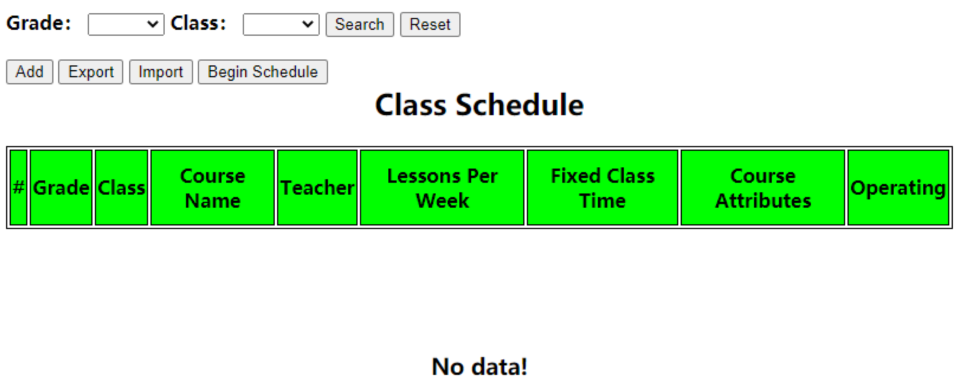

Figure 5. Scheduling task management

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5.2. Query Class Schedule

The system queries the class schedule according to the class selected by the user.

The class schedule is shown in Figure 6.

class: Senior one (1) class Search Reset

Export

Class Schedule

Week / Session		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
A. M.	Section One	Geography	Political	English	English	Physical	Chinese	Chinese
	Section Two	English	Physical Experiment	Math	English	Chinese	History	Physical
	Section Three	Math	Chinese	Political	Math	History	Math	Math
	Section Four	English	English	Political	English	Sports (Basketball)	Biological	English
Noon	Lunch break							
P. M.	Section Five	Chemistry	Physical	Geography	Chemistry	Political	Political	Biological
	Section Six	Chemistry	Math	Math	Chinese	Physical	History	
	Section Seven	Geography	Biological	Chinese	Biological	Sports (Basketball)	Physical	
7 P. M.	Section Eight	Math	English	Chinese	History	Political	Chinese	
	Section Nine	Math	Geography	Chinese	History	Biological	Chemistry	

Figure 6. Class schedule query

5.3. Teachers Inquire About Their Teaching

When the page is loaded, all the classes taught by the teacher will be automatically queried according to the teacher's job ID as the display data in the drop-down box for the teacher to select, and then query the teaching table of the class selected by the teacher.

The teacher's lecture table is shown in Figure 7.

Please select your teaching class: Senior one (1) class Search Reset

Export

Class Schedule

Week / Session		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
A. M.	Section One						Chinese	Chinese
	Section Two					Chinese		
	Section Three		Chinese					
	Section Four							
Noon	Lunch break							
P. M.	Section Five							
	Section Six				Chinese			
	Section Seven			Chinese				
7 P. M.	Section Eight			Chinese			Chinese	
	Section Nine			Chinese				

Figure 7. Teacher teaching inquiry

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Comparing Figure 7 with Figure 6, we can see that the Chinese teacher found only the courses of the teaching class, which is very concise and obvious from the display of the results.

5.4. Conclusion

Judging from the above system test results, the system page is concise and easy to operate. It can perfectly realize the series of functions such as class scheduling task import, automatic class scheduling, and curriculum query, and each functional module has been expanded. This system is fully capable of arranging classes for the students, which greatly improves the teacher's work efficiency.

6. EPILOGUE

This article mainly describes the application of genetic algorithm in the arranging system. It elaborates the design ideas of the arranging system from the aspects of arranging problem analysis, system design, genetic algorithm analysis and its design, and gives the system function test. . The system can arrange classes under simple soft constraints, free the hands of faculty and staff, can quickly generate timetables, and display the content of the timetable according to user types. However, when faced with complex conditions, the system's capabilities are still somewhat inadequate. In addition, for the encoding form, the matrix form can still be considered.

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