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A mobile Internet-based instructional system design incorporating DPSO discrete particle swarm algorithm to construct course arrangement application research

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ABSTRACT

This paper combines the necessary functional requirements for teaching system generated by teaching activities in the context of mobile Internet, designs the general framework of the system, users and their rights management, and constructs a set of teaching system. Subsequently, the traditional PSO algorithm is introduced, and the processing scheme of the scheduling problem is defined as particles to form an initial particle swarm, while the particle swarm position in the algorithm is updated by drawing on the crossover idea of the genetic algorithm, so as to optimize and obtain the scheduling algorithm based on DPSO. Then we test the teaching system of this paper from three levels of pressure bearing, response delay and stability performance to ensure the operating environment of the scheduling algorithm of this paper. The courses of three colleges of a university are used as experimental data to analyze the performance of the scheduling algorithm in this paper. In the comparison of course arrangement in different colleges, the adaptability of this paper's scheduling algorithm is above 0.900, while the highest adaptability of manual scheduling is only 0.8147, which indicates that compared with manual scheduling, this paper's scheduling algorithm is able to make a more reasonable course arrangement.

Keywords: teaching system, course arrangement, discrete particle swarm algorithm, adaptability

1. Introduction

Education is the foundation of the country, about survival, in the new situation of “Internet +”, the whole field of education, set off a wave of reform. From school education to social education, from the early distance education, online school training, boutique course resources to the current micro-courses, cloud classroom, catechism, etc., education began to really enter the Internet era, that is, “Internet + education” [1-3]. University is a higher education institution, as the last and the most critical link between school and society, the reform of its teaching mode is directly related to the

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quality improvement of college students, which is directly related to the progress and development of society [4-6].

With the popularization of mobile Internet and smart terminals as well as the rapid development of cloud computing technology, mobile learning has entered a brand new era [7-8]. How to provide a personalized and intelligent mobile learning environment based on the characteristics of ubiquity, timeliness, and situationality of mobile learning, to enhance the learning interest and user experience of mobile learners, and to improve the learning efficiency of mobile learning is the main content to be concerned about when designing the online teaching system based on mobile Internet [9-12].

On the other hand, technological progress has correspondingly promoted the change of education and learning methods in colleges and universities [13-14]. As the application of information technology in the field of education, educational APPs are rapidly becoming a popular class of digital teaching and learning methods, providing strong equipment support for the development of mobile learning, and are becoming an essential tool and the main learning platform for teachers and students in their daily work and study [15-18].

The existing teaching mode integrated with the Internet is fragmented, arbitrary, and has a series of teaching status quo such as inconsistency and irregularity due to the different lecturers or different courses taught [19-20]. "Internet + education" is by no means just a means of adding information technology to the education process, but to break the limitations of the education system, through the Internet technology to build an Internet platform that connects schools, teachers, students, and courses, we can realize resource sharing and teaching management [21-24].

The research on "Internet+" teaching mode is the earliest research on distance education and network education, and the exploration of the real teaching mode for colleges and universities began with the application of information technology in classroom teaching. Literature [25] combined with the background of the Internet and the characteristics of vocational education, designed a set of new flipped classroom teaching system, which promotes the informationization and digitalization of vocational education. Based on a questionnaire survey, [26] analyzed the differences between face-to-face, online and blended teaching modes, and pointed out that all three modes were recognized by students. Literature [27] proposed a set of hybrid teaching model with SPOC platform as the core logic based on the actual teaching needs, and confirmed the effectiveness of the proposed model through the feedback of teaching practice. Literature [28] examines how the information technology foundation of the Super Star Learning Pass platform empowers the development of the blended teaching model, and makes a positive contribution to the reform and innovation of the blended teaching model in higher education. Literature [29] explored the classroom teaching evaluation system PAD adapted to network teaching in the Internet era, and concluded that PAD teaching evaluation can realize objective and scientific network teaching evaluation in the network teaching mode. Literature [30] used survey methods such as questionnaires and tests to empirically reveal that the digital teaching mode is superior to traditional teaching methods in stimulating students' learning motivation and improving teaching effectiveness. Literature [31] deeply analyzed the characteristics and complementarities of MOOC and SPOC learning platforms, with SPOC focusing on campus teaching and learning, while MOCC is more suitable for independent learning mode. The above studies mainly focus on the effect of Internet online teaching, teaching design optimization and teaching evaluation, and conduct in-depth discussion and research on how to optimize and develop Internet online teaching.

Some scholars also focus on scaffolding strategies, teaching ideas and data mining to explore how to better utilize the value of information technology in the Internet online teaching mode. Literature [32] uses the Predict, Observe, Explain, and Evaluate (POEE) instructional design methodology to construct multiple scaffolding strategies for online learning based on constructivist learning theories to support students' independent learning in a blended online environment.

Literature [33] introduces the UDL framework, which is commonly used to guide educators on how to better guide students to participate in the online teaching and learning process, and provides a detailed discussion of the UDL process and underlying logic. Literature [34] describes the importance of appropriate instructional models and methods in the popularization of online education, and proposes that different instructional designs and methods should be adopted for different online teaching. Literature [35] focuses on the data mining segment of the online education model based on data information technology, which strengthens the foundation for the development of personalized online teaching.

In the academic research related to the design of scheduling system, more researchers explore how to promote the scheduling system scheduling intelligent and information construction, in which the scheduling accuracy and efficiency is the most noteworthy focus. Literature [36] explored the connection between the modules of the scheduling system and introduced artificial intelligence technology to realize intelligent scheduling, and realized intelligent and flexible scheduling in practice. Literature [37] proposed a student scheduling and class scheduling model based on genetic algorithm, which made a positive contribution to reduce the workload and work pressure of academic staff. Literature [38] envisioned a self-learning scheduling genetic algorithm with deep reinforcement learning as the underlying architecture and used it in the design of the scheduling system, which significantly improved the scheduling accuracy and optimization ability of the scheduling system.

In this paper, we first analyze the functional needs of teachers and students for the teaching system in the Internet era, and design the overall framework of the teaching system with user functions and permissions. Secondly, combining with the class scheduling problems faced by the current university teaching, we obtain the class scheduling algorithm based on DPSO by optimizing the traditional PSO algorithm of initializing particles and updating particle positions. Then, the comprehensive performance of this paper's teaching system is tested from different angles as a necessary precondition for the stable operation of the scheduling algorithm. Finally, the performance of this paper's class scheduling algorithm is analyzed by controlling the number of particle swarms and class scheduling data, comparing the results of manual class scheduling, and conducting simulation experiments to verify the unique advantages of this paper's class scheduling algorithm to assist in the construction of teaching in colleges and universities in the era of the Internet.

2. Design of the teaching system

2.1. *Functional requirements analysis of the teaching system*

In the teaching activities of colleges and universities, the necessary functional requirements of teachers and students for the teaching system can be divided into three modules: course management, student course selection management and system management, which are successively connected and indispensable. This section analyzes the requirements of the three necessary functions in turn, which serves as the core structure and design basis of the teaching system.

1) Course Management. Course management is the core module of the system, connecting teachers and students. Teachers teach courses and students choose courses, which is the core process of the whole system. Curriculum is the important basic data of college education, students learn through the curriculum, teachers teach through the curriculum. Only by managing the courses well can we realize the common progress of teachers and students. The application of course management is shown in Figure 1.

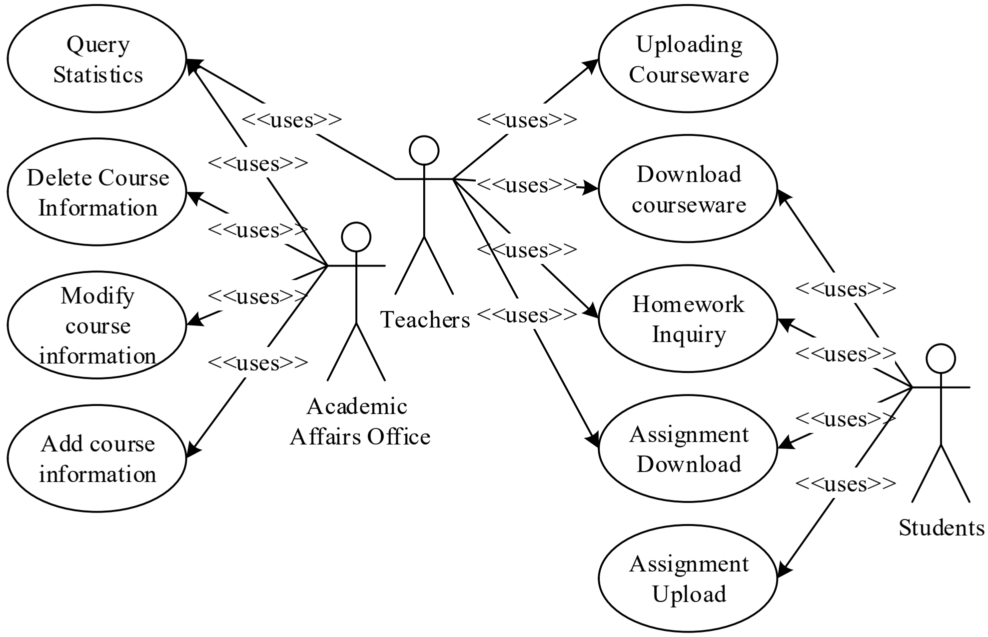


Fig. 1. Curriculum management use case diagram

In the course management, teachers can modify the basic information of the courses they teach, and they can also query and count the information related to the courses, and the Registrar's Office can complete the operation of course changes, while students can carry out classroom learning.

At the same time, teachers can upload courseware and students can upload assignments, and both teachers and students can download and query courseware assignments. The course content includes academic year, semester, major class department, teacher's department and name. The function of uploading and downloading courseware and assignments includes uploading and downloading courseware and videos for viewing.

The Registrar's Office creates course information according to the teaching plan and releases it to students for viewing, course selection, and study after approval by the Dean of Teaching. The Academic Affairs Office creates courses after studying and researching the curriculum, and generates final course information and associated instructors after the same research process. Teachers can view the information of the courses they teach and operate the basic information.

2) Student Course Selection Management. After logging into the system, students can understand the list of elective courses and course introduction in this semester, and only need to select courses within the specified time. At the same time, the system automatically restricts the number of courses students can choose, and automatically determines whether the course time is conflicting, and so on. The management of students' course selection includes viewing course list, querying course details, selecting courses, and viewing course selection results. The application of student course selection management is shown in Figure 2.

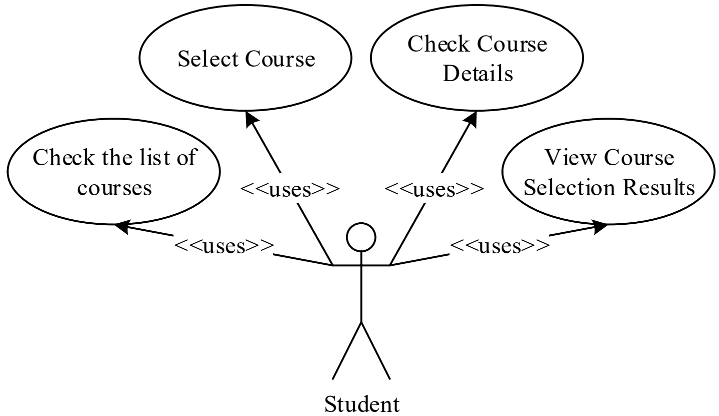


Fig. 2. Students' course selection management use case diagram

3) System Management. The system management module is mainly for user management, changing passwords, setting permissions, querying information and so on. The login interface and function of the mobile network teaching system is the most basic operation function, which is completed by the user. And all kinds of query information including combination query and fuzzy query and other functions, in the query process, you can print the query content and so on.

After logging into the system, the administrator can maintain and manage the system information while maintaining and managing the users. Teachers and students are ordinary users of the system, who can maintain and manage their own information and query related information.

2.2. Outline design of the teaching system

In this paper, from the perspective of the main users (teachers and students) of a teaching system, we describe and analyze the three core functions of a teaching system in the mobile Internet. This subsection starts from two perspectives: the overall framework and user rights, and analyzes the design ideas and details for realizing the three core functions.

The architectural design of the teaching system can be divided into: server, client and database modules. The server module contains an application server and a file server. The process is: the request is initiated by the client, the request is obtained by the server side, parsed, and then execute the business logic. If the request needs to call the image file resources, then the file server will run. Next, the database is operated through the DAO module control and then the result set is returned to the client.

2.2.1. General framework. The system described in this paper is built as a system framework based on its storage, application middleware, application support, its specific applications and all users during the design process is shown in Figure 3.

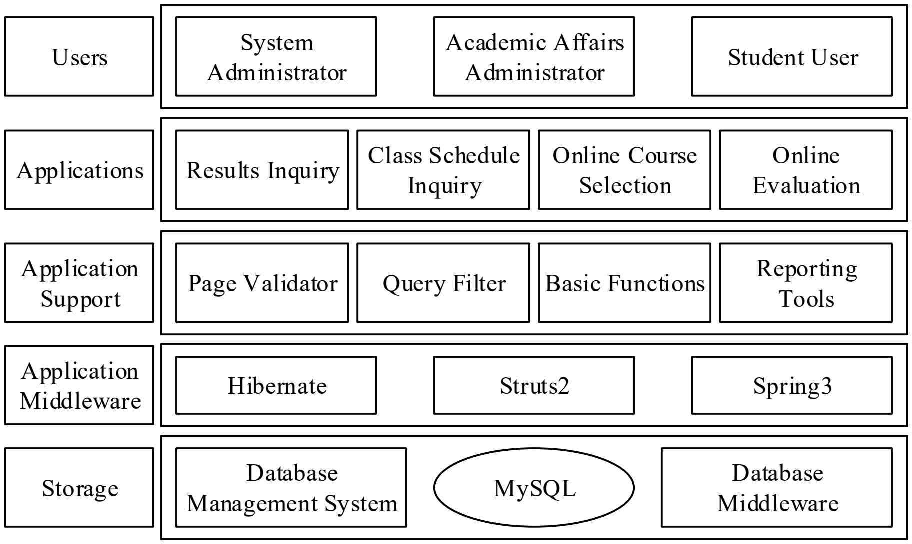


Fig. 3. System framework

This system according to a university student users in the current teaching management system use the process of using the higher frequency of functional boards to do the corresponding introduction of the design, so that it is more in line with the use of the habits of the student users, so the overall framework includes the home page, evaluation of the teaching, academics and menus, the specific framework is shown in Figure 4.

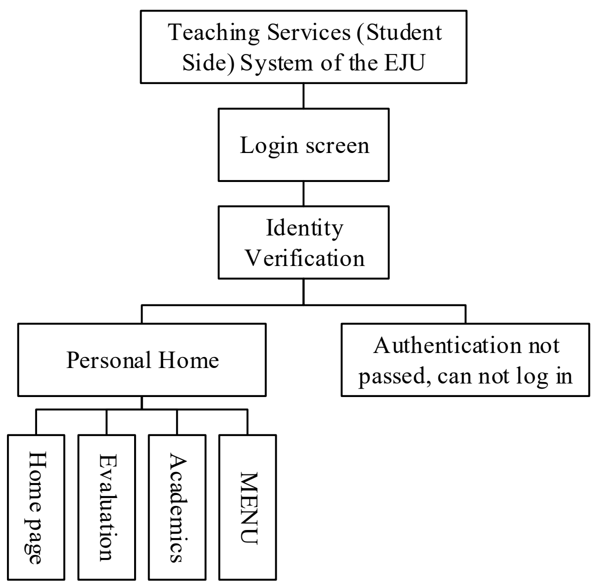


Fig. 4. Overall system framework

2.2.2. Design of users and their rights management. The content of the module varies for different users to log in and use. Student module is mainly for modifying student information. Teacher module is mainly responsible for adding and modifying teachers' information, viewing and modifying students' information. Administrator module is mainly for adding user information, managing and maintaining teachers' information, system management and maintenance.

When students log in, there are usually two kinds of cases, one is the registered users, this kind of users only need to enter the account number and the corresponding password to complete the login. The other is not registered users, this user to complete the login, first to complete the registration, and then use the account number and password to complete the login.

To summarize the above to get this paper based on the mobile Internet teaching system design, its use of advanced mobile Internet technology to assist daily teaching, improve the quality and efficiency of teaching. However, in recent years of college teaching, due to the increasing expansion of school scale, teaching resources appear relatively scarce. How to scientifically and rationally arrange the courses and fully utilize the limited teaching resources is an important issue in the teaching management of colleges and universities.

3. DPSO-based scheduling algorithm

As a typical multiple constraints and combinatorial optimization problem, the scheduling problem needs to arrange and combine the elements such as courses, students, teachers, classrooms and time through the optimization method, fully consider the internal connection of the courses, and reasonably allocate teaching resources. The traditional particle swarm optimization (PSO) algorithm, as a swarm intelligence optimization algorithm, is based on the principle of bionics, and by simulating the foraging process of bird flocks, it remembers the individual optimum and global optimum during the search process, so as to make all the particles in the population quickly move towards the optimal solution. However, the traditional PSO algorithm mainly focuses on the optimal solution of continuous problems and is very limited in discrete combinatorial optimization. In this chapter, we improve the traditional PSO algorithm by establishing a mathematical model of college course schedule, and realize the application of particle swarm optimization algorithm in college scheduling problem.

3.1. Mathematical modeling of the curriculum problem

In past studies, there is a mathematical model of the university course schedule problem based on the characteristics of the university lecture form, but this model is based on the academic year credit system, which is obviously no longer suitable for the requirements of the credit system of free course selection. After careful analysis and study of its model, this paper redesigns the mathematical model of course schedule on its basis.

There is M instructor, P different courses totaling N classes, R types of classrooms and D permitted time slots. The scheduling problem is to schedule these N teaching classes courses to D time slots in R classrooms and to make the scheduled program satisfy the set hard constraints, and soft constraints.

For the purpose of problem description definition is as follows:

t_m: m nd teacher, $m = 1, 2, \cdots, M$

c_n: nth teaching class, $n = 1, 2, \cdots N$ The same teacher in different classes may have the same curriculum.

R_r: r nd type of classroom, $r = 1, 2, \cdots R$, i.e., classified into R types of classrooms according to the number of people that can be accommodated in each classroom, and the larger the value of r the more people can be accommodated.

L_p: the pth course, $p = 1, 2, \cdots P$

d_k: Week $k, k = 1, 2, \cdots K$

u_d: dth time slot

$\alpha(d_k)$: Number of time slots for week k, notation $\alpha(d_0) = 0$

$\delta(k) = \sum_{k=0}^{k} \alpha(d_k) + 1$: Number of starting time slots for week k

$\beta(g_r)$: Number of classrooms of type r

γ_{c_0}: Ideal type of classroom for teaching class c_n, i.e. the type of classroom whose capacity matches the number of classes in teaching class c_n

$\lambda(c_n)$: teaching classes per week c_n number of classes

The introduced variable x_{tcur} takes values as in equation (1):

$$x_{tcur}=\begin{cases}1 & \textit{Teacher t teaches the c teaching} \\ & \textit{class during the r teaching u time period} \\ 0 & \textit{Other}\end{cases} \tag{1}$$

In order to make the objective function expression concise the variables are introduced to take values as in equation (2):

$$y_{tu_d u_{d'}}=\begin{cases}1 & \textit{Teacher t teaches to teaching class} \\ & \textit{c during } u_d, u_{d'} \textit{ time period} \\ 0 & \textit{Other}\end{cases} \tag{2}$$

In this paper, with the optimization objective of sufficient dispersion and full utilization of classroom resources in the lecture schedule of each teaching class, a mathematical model is established as Eqs. (3)-(12):

$$f_1=\sum_{m=1}^{M}\sum_{k=1}^{K}\sum_{d}^{\delta(k)+\alpha(d_d)-1}\sum_{n=1}^{N}y_{t_m c_n u_d u_d} \tag{3}$$

$$f_2=\sum_{m=1}^{M}\sum_{k=1}^{K}\sum_{d=\delta(k)}^{\delta(k)+\alpha(d_i)-1}\sum_{d(k+1)+\alpha(d_{k+1})-1}^{\delta(k+1)}\sum_{n=1}^{N}y_{t_m c_0 u_d u_d} \tag{4}$$

$$f3=\sum_{m=1}^{M}\sum_{d=1}^{D}\sum_{r=1}^{R}\sum_{n=1}^{N}x_{t_m c_a u_d g_r}\left(g_r-\gamma_{c_n}\right) \tag{5}$$

$$\max\left(\omega_1 f1+\omega_2 f2+\omega_3 f3\right) \tag{6}$$

$$\sum_{m=1}^{M}\sum_{n=1}^{N}\sum_{r=1}^{R}x_{t_m c_n \mu_i g_r}\le 1, d=1,2,\cdots D \tag{7}$$

$$\sum_{c=1}^{c}\sum_{r=1}^{R}x_{t_n c_0 u_d g_r}\le 1, m=1,2,\cdots,M; d=1,2,\cdots,D \tag{8}$$

$$\sum_{m=1}^{M}\sum_{d=1}^{D}\sum_{r=1}^{R}x_{r_a c_n u_d g_r}=\lambda\left(c_n\right), n=1,2,\cdots,N \tag{9}$$

$$\sum_{m=1}^{M}\sum_{r=1}^{R}x_{t_n c_n \mu_4 g_r}\left(g_r-\gamma_{c_n}\right), n=1,2,\cdots,N; d=1,2,\cdots,D \tag{10}$$

$$\sum_{m=1}^{M}\sum_{c=1}^{c}x_{l_m c_{c_u} \xi_d}\le\beta\left(g_r\right), r=1,2,\cdots,R; d=1,2,\cdots,D \tag{11}$$

$$x_{tcur}=0,1 \tag{12}$$

In this model, the first summation factor $f1$ of Eq. (6) denotes the sum of the number of repeated classes of the same instructional class in the same day, the second summation factor $f2$ denotes the sum of the number of repeated classes of the same instructional class in the adjacent days, and the third summation factor $f3$ denotes the sum of the difference between the actual scheduled classrooms of the instructional class and the ideal classrooms. Equation (7) indicates that each teaching class cannot conflict in any time period. Equation (8) indicates that teachers cannot conflict in any time period. Eq. (9) The number of classes in an instructional class satisfies the specified requirements. Eq. (10) indicates that the number of classes per instructional class cannot exceed the classroom capacity. Equation (11) indicates that the number of various types of classrooms required does not exceed the number of actual all classrooms. Equation (12) indicates variable constraints.

In equation (6), ω_1, ω_2 and ω_3 are weighting coefficients, because the effect of every other day class is better than the same day class, it is taken as $\omega_1 < \omega_2$. If the classroom resources are tighter, it can be taken as $\omega_2 < \omega_3$, otherwise it can be taken as $\omega_2 > \omega_3$.

3.2. Initialization of populations

Each particle in the particle swarm corresponds to a feasible solution of the problem to be solved, so the representation of the particle in the schedule problem is a feasible solution, which corresponds to a two-dimensional array in the data structure. The initialization process needs to complete the generation of the set of classes, the generation of the class start task book, the average distribution of class weeks according to the class start task book, the random arrangement of class sessions and the random arrangement of classrooms and other work. The existence of conflicts is checked during initialization to form a feasible solution. Repeatedly construct a specified number of particles to form the initial particle swarm.

3.3. Adaptation function

According to the constraints given in this paper, let x be a certain feasible class schedule, and X be the set consisting of all feasible class schedules, and establish the fitness function as in equations (13) and (14):

$$f(x) = \omega_1 * f_1 + \omega_2 f_2 + \omega_3 * f_3 \tag{13}$$

$$\max\left(f(x)\right) x \in X \tag{14}$$

Where x is a feasible class schedule, X is a set of all feasible class schedules, ω_1, ω_2, and ω_3 are the corresponding weights, and their sum is 1. f_1, f_2, and f_3 are the fitness functions to satisfy course dispersion, time utilization, and classroom utilization, respectively.

3.4. Particle Position Update Operation

In this paper, the particle position update formula is reconstructed by borrowing the idea of exchange order and introducing the crossover idea of genetic algorithm, which performs the crossover operation in genetic algorithm between the current position of the particle and the historical best position and global best position of this particle, and performs local exchange of the resulting new particles, which is specifically described as Eqs. (15) and (16):

$$X_i = c_2 \otimes g\left(c_1 \otimes g\left(X_i, Pbesti\right), gbest\right) \tag{15}$$

$$X_i = \omega \times f_{a,b}\left(X_i\right) \tag{16}$$

where c_1, c_2, $\omega \in [0,1]$, (ω can take a value greater than or equal to 0.6). The meaning of operation $g\left(X_i, Pbesti\right)$ is to cross with probability c_1 based on the relationship between the magnitude of the fitness values of the same columns of both. Operation $f_{a,b}\left(X_i\right)$ is a local exchange function, the meaning of which is to locally adjust each course in X_i according to the time period in which it is located in the same day, and if the time utilization of the time period in which this course is located is less than the time utilization of the time period in which the course is not scheduled, and the classroom utilization rate is greater than ω, then the course schedules of the two time periods are exchanged.

When the update operation is performed, the particle to be updated is first intersected with the historical optimum of the particle to be updated, and then intersected with the global optimum of the particle swarm, and the resulting solution is the new position. For the coding method in this paper, in order to reduce the influence of classroom type and classroom capacity on the schedule arrangement, this paper selects the particle to be exchanged to exchange with the same column of the two-dimensional array of global optimal particles or local optimal particles, which means exchanging the course schedules of the same classroom of the same classroom of the two particles for different time periods. And the conflict on particle coding is corrected during the crossover operation to meet the requirement of feasible solution. For the particle coding conflict, it can be regarded as a mutation operation of the particle to be updated. The purpose of the mutation operation is firstly to improve the diversity of particles, and secondly to locally optimize the particles, which must also correct the conflict on the particle encoding to meet the requirements of the feasible solution due to the possibility of leading to teacher conflicts and different teaching times.

The process of discrete particle swarm algorithm for solving the scheduling problem is as follows:

1) Initialize M, ω, c_1, and c_2 so that counter $k=0$.

2) Randomly initialize the positions of the particles in the particle swarm and calculate the fitness values of the initial particles.

3) Set $pB_i^k = X_i^k$ and gB^k as the positions of the best particles in the initial population.

4) Judge whether the convergence criterion of the algorithm is satisfied, if so, output gB^k and get the best schedule from gB^k, the algorithm ends. Otherwise, execute (5).

5) Perform the following operations on all particles in the population:

(1) Update the particle position according to Eq. (1) and Eq. (2).

(2) Calculate the adaptation value of the newly generated particle.

(3) If the particle adaptation value is better than pB_i^k, make $pB_i^k = X_i^k$.

(4) If the particle adaptation value is better than gB^k, make $gB^k = X_i^k$.

6) $k=k+1$, turn (4).

This chapter combines the characteristics of the scheduling problem, improves the traditional PSO algorithm, and constructs a discrete particle swarm algorithm (DPSO) based on matrix coding to effectively solve the scheduling problem in colleges and universities.

4. Testing of the teaching system

As the only carrier of class scheduling management, the stable operation of the teaching system in the mobile Internet is the basis for the orderly development of class scheduling management. Therefore, in this chapter, the pressure bearing, response delay and stability performance tests of random modules of the teaching system in this paper are carried out successively.

4.1. Pressure carrying

The database of this paper's teaching system serves as a unified storage and management of massive teaching resources, allowing multiple users to upload or download resources at the same time. In order to test the operational performance of the system in this paper, the fatigue strength evaluation method is used to test the operational performance of the system. 30 teachers upload teaching resources, 30 students download resources, and 30 students complete the online assessment test. When the above 60 users operate and access the various functional modules of the system at the same time, the response speed of the system is observed and recorded, and the test results are shown in Table 1.

Table 1. Pressure bearing test results

Run time/h	response time/ms		
	Average of 30 teachers uploading resources	Average of 30 students downloading resources	Average online assessment of 30 students
2	10.52	9.88	11.35
4	10.66	9.92	11.42
6	10.75	10.01	11.56

8	11.23	10.12	11.76
10	11.62	10.21	11.82

Teachers uploading teaching resources time, students downloading teaching resources time, students online assessment test time with the extension of multi-user simultaneous online operation time to 0.1ms time per hour continue to extend, indicating that the system in this paper has a stable and reliable operational performance, stress test withstand capacity and other characteristics.

4.2. Response delays

This subsection focuses on selecting 100 sets of data information for the test exploration of the system in this paper, and randomly performs the related program access to the main interface of the system, and the final results of the response time test of the system in this paper are shown in Fig. 5.

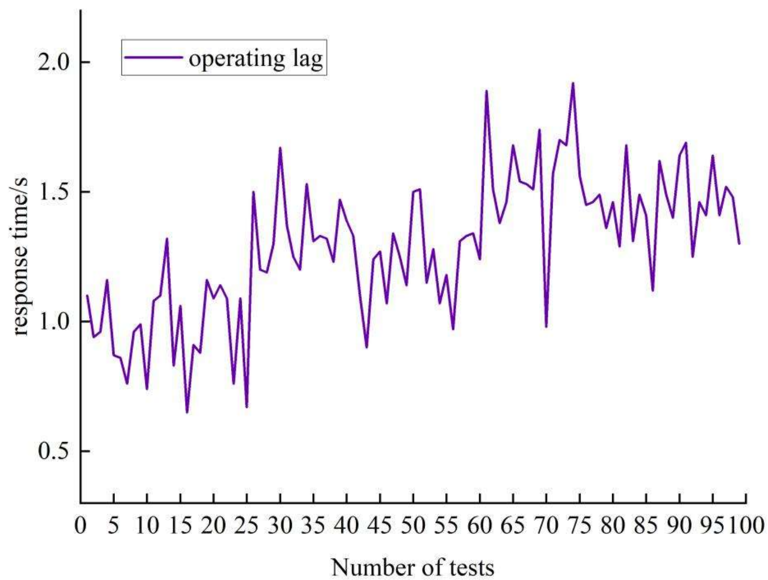


Fig. 5. system response delay test analysis

The number of experimental tests is affected by the operation cycle to a certain extent, and the response time of the whole system is rising with the increase of the number of tests, but its overall stability is within 0.5-2.0s. Therefore, for the current user's overall demand is still basically satisfied.

4.3. Stabilizing properties

System stability test is actually a unified test for the current operation, real-time monitoring of the memory as well as CPU occupancy of the system in this paper, focusing on the selection of 300 users for concurrency testing, the stability of the system in this paper to explore the stability of the system is shown in Figure 6.

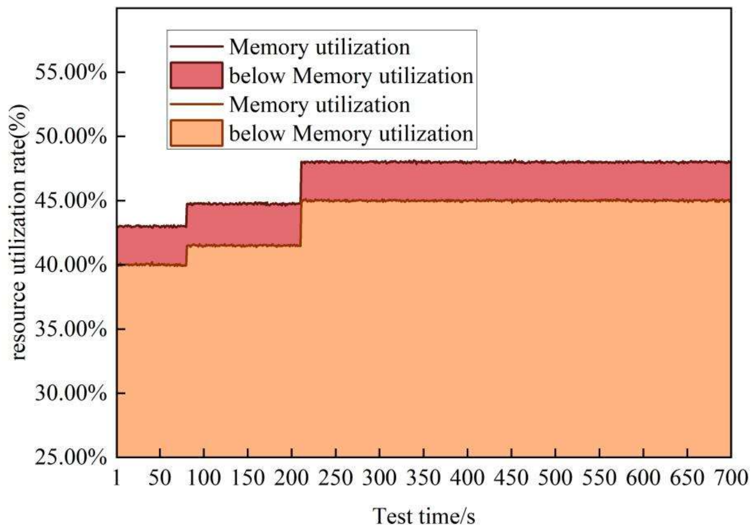


Fig. 6. system stability test and analysis

As the test time changes, to some extent the actual utilization of the available resources also changes. However, the overall system CPU occupancy rate is under 50.00%, which can basically meet the user's overall performance requirements for this paper's system.

In the above three different levels of testing, the system in this paper are excellent performance, indicating that the system in this paper can strongly support the continuous operation of the scheduling algorithm in this paper, so the performance testing of the scheduling algorithm based on the teaching system in this paper.

5. Performance analysis of scheduling algorithms

Limited to the complexity of the class scheduling problem, in order to verify the performance of this paper's scheduling algorithm, this paper evaluates this paper's scheduling algorithm based on the scheduling data of the second semester of the 2020-2021 academic year in three colleges, namely, College of Arts, College of Economics, and College of Computer Science, and tests the influence of the number of particle populations (population size) on the performance of the algorithm, the adaptability value of the system-generated class schedules for different courses, the performance advantages and disadvantages of the class schedule and the manually scheduled class schedule under given indicators. The performance advantages and disadvantages of this algorithm and manual scheduling under the given indexes, in order to understand the performance and practicability of this paper's scheduling algorithm, and to carry out simulation experiments to test the feasibility of this paper's scheduling algorithm.

5.1. Effect of the number of particle swarms on the performance of the algorithm

In order to test the effect of the number of particle swarms on the performance of the algorithm, the number of particle swarms is defined as 15, 30, and 50, and three tests are conducted on 50 courses in the College of Computer Science. The effect of the number of particle swarms on the performance of the algorithm is measured based on the fitness value of the near-optimal solution obtained from the test. The test results are shown in Table 2.

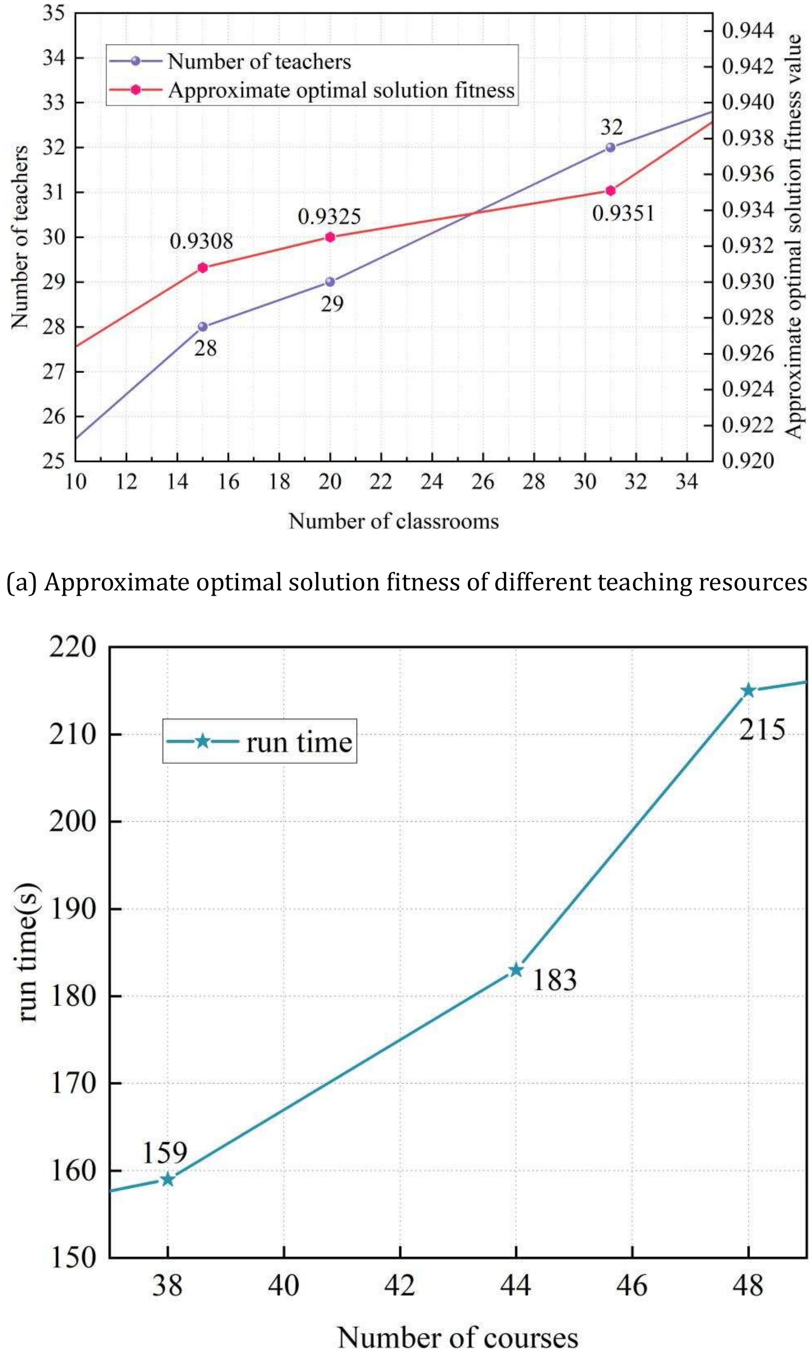
Table 2. Effect of particle swarm number on algorithm performance

Number of tests	Particle swarm number (PCS)	Initial particle fitness value range	Approximate optimal solution fitness value
The first time	15	0.8219-0.8874	0.9309
	30	0.8347-0.8771	0.9335
	50	0.8315-0.8813	0.9360
The second time	15	0.8188-0.8813	0.9259
	30	0.8216-0.8813	0.9289
	50	0.8219-0.8864	0.9289
The third time	15	0.8317-0.8722	0.9330
	30	0.8307-0.8834	0.9330
	50	0.8270-0.8823	0.9389

With the increase in the number of particle swarms, the fitness value of the obtained near-optimal solution improves, and the highest fitness value of the near-optimal solution reaches 0.9389. The higher fitness value indicates that the quality of the class schedule is higher, which indicates that the increase in the number of particle swarms promotes the performance of the algorithm in this paper.

5.2. *Effect of different scheduling data on algorithm performance*

Considering the running time of the algorithm and combining the effect of different particle swarms on the fitness value of the approximate optimal solution obtained from Table 2, the number of particle swarms is selected as 50 for this test and all the following tests, and the scheduling algorithm of this paper is run and the test results are recorded. The test data are the scheduling data of the second semester of the 2020-2021 academic year in the College of Arts, the College of Economics, and the College of Computer Science, respectively, and the scheduling data of the three colleges and the value of the fitness of the approximate optimal solution are shown in Fig. 7(a), and the running time required for different numbers of scheduling classes is shown in Fig. 7(b).



(a) Approximate optimal solution fitness of different teaching resources

(b) Run time for different number of courses

Fig. 7. The influence of course scheduling data on algorithm performance

As the number of courses increases, the scheduling time grows, and when the number of courses is 48, it runs for up to 215 seconds, i.e., scheduling a large number of courses still takes a long time. This can be solved by splitting the large-scale problem into several small-scale problems. In addition, it can also be seen from Fig. 7(a) that the increasing trend of the number of classrooms and teachers is consistent with the increasing trend of the fitness value of the near-optimal solution, which indicates that sufficient scheduling resources are conducive to improving the quality of the schedule.

5.3. Comparison with manual scheduling

This subsection calculates the adaptability indexes of three colleges, namely, College of Arts, College of Economics, and College of Computer Science, respectively, and the specific results of each index are shown in Table 3, which shows that the manual scheduling and the algorithm of this paper scheduling class schedules are different in terms of course dispersion, time utilization, classroom utilization, and adaptability values.

Table 3. The indicators of the two schedules are compared

Name of Faculty		Faculty of arts	Faculty of Economics	Faculty of computing
Manual schedule	Curriculum dispersion	0.8202	0.8114	0.7592
	Time utilization ratio	0.9659	0.9201	0.9640
	Teacher utilization rate	0.5012	0.5043	0.9640
	Fitness value	0.8147	0.7935	0.7905
Algorithm schedule	Curriculum dispersion	1	0.9814	0.9997
	Time utilization ratio	0.9112	0.9080	0.9090
	Teacher utilization rate	0.7900	0.8756	0.8569
	Fitness value	0.9223	0.9309	0.9350

As can be seen in Table 3, the algorithmic class schedule has higher values of course dispersion, classroom utilization, and adaptability compared to the manual schedule, but not as high as the manually scheduled schedule in terms of time utilization. This is mainly due to the fact that manual scheduling is more flexible in terms of time control, whereas scheduling using algorithms weighs all the different metrics comprehensively. In terms of fitness value, the algorithm in this paper performs above 0.900 on different college courses, while the highest value for manual class schedules is only 0.8147.

5.4. Simulation experiments

In this subsection, Matlab 7.6 data processing software is applied to carry out simulation experiments of the scheduling algorithm of this paper, setting the population size (N) as 120 and the genetic algebra as 1100, and the actual solution effect of its fitness is shown in Fig. 8.

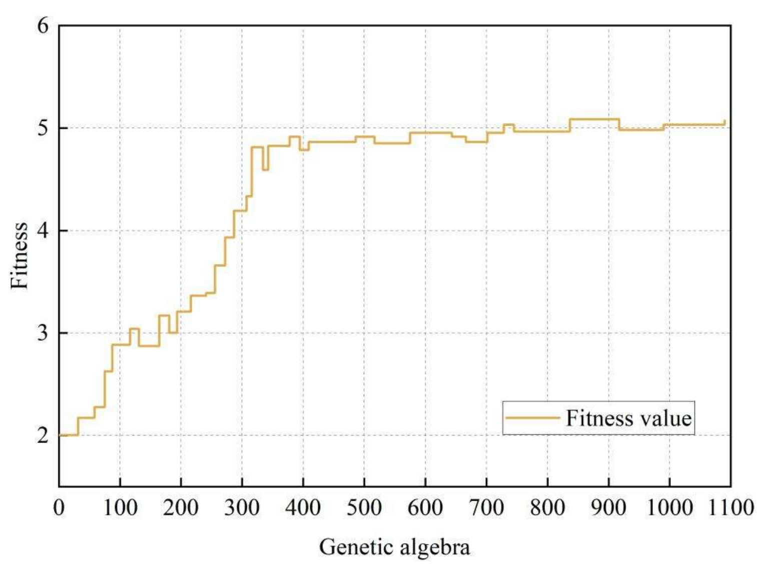


Fig. 8. Fitness value change curve

The adaptability of this paper's scheduling algorithm shows dramatic growth in the genetic algebra 0-300 times, increasing from 2 to approximate 5. After 300 times of genetic algebra, the growth of the adaptability of this paper's scheduling algorithm tends to stabilize, with small fluctuations in the adaptability value of 5. Overall, the adaptability of this paper's scheduling algorithm is not only improving with the increase of genetic generations, but also tends to stabilize with the increase of genetic generations.

6. Conclusion

For the class scheduling problem that exists in college teaching in the Internet era, this paper designs a teaching system to realize the operation of the class scheduling algorithm. At the same time, it proposes a scheduling algorithm based on DPSO, which represents particles as the corresponding solutions to the scheduling problem. The algorithm adopts matrix coding to redefine the position and velocity update method of particles, thus realizing the efficient and reasonable arrangement of college courses. In the simulation experiments, the fitness value of the scheduling algorithm in this paper can increase with the increase of the number of genetic generations, and stabilizes at 5 or below after 300 genetic generations, which indicates that the scheduling algorithm in this paper can effectively and stably solve the complex scheduling problems in colleges and universities.

The application of discrete particle swarm algorithm to college scheduling not only provides a new idea for solving the problem of class scheduling, but also expands the application field of particle swarm algorithm, which is a more successful research attempt.

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