**Automatic Course Scheduling System in Universities Based on Hybrid Genetic-Ant Colony Algorithm**

Yanbei Duan\(^1\), Wenjie Lu\(^1,\ast\)

\(^1\)Nanchang Institute of Science and Technology, Nanchang, 330108

\(*\)Corresponding author e-mail: 57368885@ncist.edu.cn

**Abstract.** Scheduling is the daily work of the Ministry of Education in Colleges and universities. In the past ten years, the scale of our colleges and universities has expanded rapidly, but the teaching resources are relatively limited. Many schools are facing the problem of insufficient classroom resources and teachers resources. The current way of organizing courses is increasingly difficult to make full use of existing resources to solve the changing needs and inefficiencies, which need to be improved urgently. This paper applies the hybrid Genetic-Ant algorithm to the automatic course scheduling system in Colleges and universities, and uses the cross-function to design and build the automatic course scheduling system in Colleges and universities. And select a college's course scheduling system from this city for research, and use the Genetic-Ant hybrid algorithm to improve the original system to form a new system, called the original system A, and called the improved new system B, to compare the operation time and system suitability of the two systems. The results show that the fitness of system B is better than that of system A. When the scheduling unit is 100, the fitness of system A is 181, and system B is 203. When the scheduling unit is 400, the fitness of system B is 14 higher than that of system A. When the scheduling unit is 800, the fitness of system B is 64 higher than that of system A. Thus, the hybrid algorithm of genetic ant colony can improve the rationality of the curriculum.

**Keywords:** Genetic-Ant Mixed Algorithms, Course Scheduling System, Operation Time, System Fitness

1. **Introduction**

Scheduling classes is a difficult point in the administration of education and an important and complex task [1-2]. The purpose is to arrange a series of suitable teaching time and space for the courses that are not arranged in the school, so that the whole teaching can go smoothly. It is characterized by large-scale, complex constraints and changing nature [3-4]. Theory and practice show that with a slight increase in the amount of information involved in the classroom, the overall index will increase. If only one loop is used to span each element to avoid conflicts, the effectiveness of the course planning is low [5-6]. Simple random fragmentation methods are also difficult to control effectively and find a reasonable scheme, and their applicability is usually very low.
In recent years, as an effective tool to solve and optimize problems, genetic algorithm has attracted more and more attention. Genetic algorithm is a repetitive algorithm that generates a set of solutions each time it is generated. This set of solutions was originally created randomly, creating a new set of solutions [7-8] each time. It is generated by simulated evolution and genetic behavior, and any solution is generated by a target function, and the process will continue to resume until a specific form of convergence is reached. In addition to finding the shortest path from the mound to the food source without visible information, ants can adapt to environmental changes. Entomologists have observed and studied that when ants provide food, they release a chemical called pheromone, which is part of the ant. Ants are aware of this substance as they move and tend to move toward higher concentrations [9-10].

This paper chooses a course planning system of a university in our city to study, compares the original system with the improved system using the hybrid Genetic-Ant algorithm, compares its operation time and applicability, and finds that the hybrid Genetic-Ant algorithm can better improve the rationality of the course schedule.

2. Hybrid genetic-ant colony algorithm and automatic course scheduling system in universities

2.1. Hybrid genetic-ant algorithm
(1) Advantages and disadvantages:
Genetic algorithm and ant colony algorithm are two main biomimetic algorithms, and their advantages and disadvantages are obvious. The advantage of genetic algorithm is its ability to search globally quickly and on a large scale. However, when dealing with feedback information, the utilization rate is very low, it is easy to converge prematurely, or when the solution reaches a certain range, it is easy to cause errors and lead to useless duplication, thus reducing the solution and reducing the effectiveness of the solution. Ant colony algorithm uses positive response mechanism, has strong resistance, makes the search process converge continuously, and has better global optimization ability. However, when the distribution of pheromones is lower at the beginning of the search, the resolution is slower. The essence of programming problem is a complete NP problem. The factors that affect the course arrangement do not change much, especially the small increase of information will lead to the destruction of "combinatorial explosion" in programming. When programming is large, individual algorithms have limitations on sorting issues, such as long-term normalization and unsatisfactory timetables for teachers and students. Therefore, the combination of the two programming algorithms is complementary. First, the genetic algorithm is used to quickly generate large-scale pheromone distribution. Then, the ant colony algorithm is used to find the best solution in the world, which shortens the response time and improves the accuracy.

(2) Principle:
Based on the basic ant colony algorithm, this paper presents a hybrid ant colony algorithm combined with genetic algorithm. The improved ant colony algorithm takes advantage of the advantages of crossover and mutation in the genetic algorithm, introduces the crossover function and mutation algorithm to find the global optimal solution, and accelerates the convergence speed of the algorithm.

The introduction of mutator enlarges the search scope of the algorithm, avoids the development process from falling into local solution at an early stage, and improves the convergence speed of the algorithm to terminate the program. Mutation factors mutate parts of a new person with a certain probability. The possibility of mutation is very high, the search area is very large, and the search becomes blinded: the possibility of mutation is very low and will prevent the formation of new bases. "The mutation probability of this algorithm is 0.01. The mutation method uses the inverse transformation method. 9-7-8-6-5-4-1-2-3-10-11-12) A break occurred in space 8-6, and the fragments were inserted in the opposite order, thus completing the reverse chromosome: (9-7-6-8-5-4-1-2-3-10-11-12). Calculate the path length after each change, and if it decreases, keep the change or cancel the change.
(3) Crossover function:
Generally, genetic algorithms select two chromosomes directly from the previous generation to cross, and there may be no better solution due to local convergence. Therefore, we propose an ant colony algorithm, which divides the matrix into different spaces and sprays pheromones in each space. This gives you the types of pheromones and pickups:

\[ P_{ij} = C \sum_{i=0}^{N} \sum_{j=0}^{M} \left( F_i[j] + P_{(i-1)j} \right) \]

Among them, \( C \) is constant, \( P \) is a pheromone divided into intervals, and \( F \) is the fitness of each chromosome.

\[ W_{ij} = \sum_{i=0}^{N} \sum_{j=0}^{M} \left( P_{ij} \times F[j] \right) \]

Where \( W \) is the Wheel value for each chromosome, \( P \) is the pheromone value for the chromosome, and \( F \) is the fitness value for the chromosome.

2.2. Automatic course scheduling system in universities

(1) Significance:
Curriculum planning is one of the core of the daily work of the school education department, mainly because the theoretical basis of the curriculum is directly related to each student's academic performance, teachers' teaching results and the use of the classroom, and the classroom planning is the most complex of the teaching arrangements. It is not only necessary to ensure that the programming time of students, teachers and classes does not conflict, but also the basic principles of programming elements. Especially in University classes, there are many complex factors, and the mobility of teachers and students is great.

(2) Principle of rationality:
First, the rationalization principle of students' class and class time is mainly the consistency and best consistency of the overall curriculum layout of the same class. The overall consistency of class assignments means that all classes in a class must be assigned as evenly as possible to a five-day class. The total hours of a day should be as equal as possible, with a series of classes on a given day, avoiding having few or no classes in a given day. The best combination of time is mainly the best combination of individual courses and two-week courses. When there are multiple independent classes in a class, it is best to distribute them evenly between one week and two weeks. The schedule should be a two-week schedule for a group of individuals and a group of students. In this way, a class is divided into two consecutive sessions, so that students do not forget to attend because of the number of weeks, or they can use the time they choose other courses.

Secondly, the rationality principle of teachers and time is mainly the best combination of time between different courses and the minimum mobility of teachers. Optimal time coupling refers to the coupling of odd and even weeks with the teacher, which to a large extent improves the teacher's memory of the schedule. Reduced teacher mobility means that the same teacher's courses are organized on the same day as possible, but the courses need to be uniform and rational, and the number of courses per day should not exceed four sections. This not only guarantees the teaching effect of teachers, but also reduces the number of times that teachers return to and from schools.
3. Experimental objects and processes

3.1. Experimental objects
To verify the application of the hybrid genetic ant algorithm in the programming system, a college in a university was selected to test the scheduling system. There are 6 majors, 21 classes, around 800 students, 55 teachers and 22 classrooms available, of which 16 teachers have special requirements for class management.

3.2. Experimental processes
(1) Method selection.
In the development of genetic algorithm, the development direction is determined according to the fitness function. Fitness is a manifestation of the advantages and disadvantages of timesheets. The more adaptable you are, the better your timetable will be. Therefore, the physical state function immediately determines the speed of course optimization and whether the best solution can be found, which requires the development of an appropriate physical condition function (expected value). The expected values of the course schedule can be divided into three categories: the expected values of course dispersion, the expected values of section optimization and the expected values of special courses.

(2) Experimental steps.
In this experiment institute, the scheduling system is based on the more common ant colony algorithm. On the basis of this institute, we delete the original algorithm and replace it with the pass-ant hybrid algorithm. We call the old ant colony algorithm system A system for short, and the improved new system B system for short. In the case of 100, 400, 800 rows of lesson units, we simply cross-function. Comparing the operation time and applicability of the two systems A and B, we get the average values of the three algorithms by testing 10 datasets.

4. Comparison of experimental results between three algorithms
A balance between exploration and development is the key to keep the algorithm searching effectively while avoiding stagnation. This means that the search area of the algorithm must be as large as possible to find the solution space for these best solutions; at the same time, to make full use of the available information in the community, the search focus of the algorithm is on the location of individuals with higher physical state values, that is, to reduce their search space and make the algorithm converge to the best solution in an acceptable time.

Insert artificial ants into the structure diagram to initialize each node's pheromone concentration. The first ant first searches for a map from an empty path and randomly selects a node based on the probability of pheromone concentration and genetic value, which is stored in the ant table. Each time an event occurs, the ant's process of building a path ends and produces a possible solution. The quality of this solution is then assessed and pheromones are notified according to the quality of the solution. If the solution is feasible, it should be retained or rejected. The next ant search is then performed and the solutions obtained in this round are compared with other available solutions. If it's better than the one available before, replace it with the one you've recently acquired. In this way, when the ants have finished their search, we will work together to find the best solution that each ant in the ant colony can find.

4.1. Comparing the operation time of two systems
The length of time the algorithm calculates the ideal result is an important performance indicator to measure the quality of an algorithm. The shorter the calculation result, the smaller the possible loss and more opportunities it can bring. In the automatic scheduling system of colleges and universities, all the data is not constant, especially at the beginning of school, there are many variables. This change is not only the great mobility brought by the change of teachers, but also the breakout point of students' course selection time. When the course selection system is open, students are always
crowding up. At this time, a university automatic course scheduling system with a shorter operation time is needed to provide reference and results as soon as possible. In this experiment, the operation time of the two systems is compared as shown in Table 1 and Figure 1.

| Table 1. Comparison of operation time of two systems |
|---|---|---|
|   | A  | B  |
| 100 | 36 | 50 |
| 400 | 132| 184|
| 800 | 528| 561|

Comparing the data in Table 1 and Figure 1 shows that System A takes less time to operate than System B. When the scheduling unit is 100, system A is 36, system B is 50, system A is 132, system B is 184 when the scheduling unit is 400, system A is 528, system B is 561 when the scheduling unit is 800. When the scheduling unit is large, although the absolute value of the gap is increasing, the relative number of differences that kill your two systems actually decreases.

4.2. Fitness comparison of two systems

In the genetic algorithm, fitness is the main index describing the individual performance and driving force of the genetic algorithm. From a biological point of view, normal conditions are equivalent to bio sustainability competition for "survival of the fittest", which is important in the genetic process. Establishing the mapping relationship between objective operation and individual adaptability of optimization problems can help to achieve the objective role of optimization problems in group development. Therefore, we compare the fitness of the two systems and the results are shown in Tables 2 and Figure 2.

| Table 2. Fitness comparison of two systems |
|---|---|---|
|   | 100 | 400 | 800 |
| A  | 181 | 275 | 300 |
| B  | 203 | 289 | 364 |
From the data analysis of Table 2 and Figure 2 above, it can be seen that the fitness of System B is better than System A. When the scheduling unit is 100, System A is 181, System B is 203. When the scheduling unit is 400, System B is 14 higher than System A. When the scheduling unit is 800, System B is 64 higher than System A.

5. Conclusion
The traditional way of organizing courses by hand has a lot of shortcomings in efficiency and rationality. However, using pure genetic algorithm and ant algorithm has some drawbacks such as long computation time and premature convergence. To solve this problem, we combine ant colony algorithm with genetic algorithm. Ant colony genetic algorithm first uses random search, which is fast and has good global convergence. Then, by making full use of parallelism, the forward response mechanism and validity are analyzed at a high level. An anti-population algorithm is proposed, and an effective genetic algorithm with high level analysis is established. This shows that using genetic ant colony algorithm can effectively improve the convergence speed of the algorithm and reduce the search area. Domain. Therefore, in the process of inheritance, the population is divided according to rules, pheromones are sprayed in space, and the dyeing ability interacts with the population space to form a positive evaluation system, which drives the entire algorithm to schedule classes. The experimental results show that the ant colony genetic algorithm significantly improves the efficiency and rationality of the course design system. The course planning scheme created by the algorithm should be evenly distributed during each course, which basically meets the requirements of the school. The disadvantage is that the restrictions are relatively simple, such as group classes, multimedia classes and so on, which have not been involved and need to be further improved.

Acknowledgments
Science and Technology General Project of Jiangxi Provincial Department of Education (No. GJJ191099) & (No. GJJ202509).

References
[1] Etminaniesfahani A, Ghanbarzadeh A, Marashi Z. Fibonacci indicator algorithm: A novel tool for complex optimization problems [J]. Engineering Applications of Artificial Intelligence, 2018, 74(SEP. ):1-9.
[2] Bailey T L. MD-SVM: a novel SVM-based algorithm for the motif discovery of transcription
factor binding sites [J]. Bioinformatics, 2019, 28(1): p. 56-62.

[3] Identification of influential spreaders in complex networks using HybridRank algorithm [J]. Scientific Reports, 2018, 8(1):11932.

[4] Wang D, Tan D, Lei L. Particle swarm optimization algorithm: an overview [J]. Soft Computing, 2018, 22(2):387-408.

[5] Maes K, Gillijns S, Lombaert G. A smoothing algorithm for joint input-state estimation in structural dynamics [J]. Mechanical Systems & Signal Processing, 2018, 98(jan. 1):292-309.

[6] Grassmann F, Mengelkamp J, Brandl C, et al. A Deep Learning Algorithm for Prediction of Age-Related Eye Disease Study Severity Scale for Age-Related Macular Degeneration from Color Fundus Photography [J]. Ophthalmology, 2018, 125(9):1410-1420.

[7] Gong D W, Jing S, Miao Z. A Set-Based Genetic Algorithm for Interval Many-Objective Optimization Problems [J]. IEEE Transactions on Evolutionary Computation, 2018, 22(99):47-60.

[8] Kumar D, Singh J, Baleanu D. A new numerical algorithm for fractional Fitzhugh–Nagumo equation arising in transmission of nerve impulses [J]. Nonlinear Dynamics, 2018, 91(8):307-317.

[9] Aljarah I, Faris H, Mirjalili S. Optimizing connection weights in neural networks using the whale optimization algorithm [J]. Soft Computing, 2018, 22(1):1-15.

[10] Tsai S E. Project Scheduling with Resource Constraints by Fuzzy Gantt Chart and Genetic Algorithm [J]. Journal of Aeronautics, Astronautics and Aviation, 2019, 51(4 Vol. 51 No. 4):391-402.