

Application of Improved GWO Algorithm in Course Scheduling System of University Teaching Management

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Abstract: The expansion of the scale of running a school in colleges and universities makes the course arrangement in colleges and universities face great challenges. Therefore, the improved GWO algorithm is used to study the process of setting up the algorithm in the college teaching management. Analyze the principle and process of GWO algorithm. On this basis, using chaos theory, the first gray wolf population of GWO algorithm is constructed using Chebyshev chaotic sequence, and Levi flight is used to improve the gray wolf position adjustment formula, which makes an improved GWO algorithm. Through simulation optimization for some school's teaching process, it is verified that the improved GWO algorithm avoids the algorithm from falling into the local optimization and achieves good results in setting up the curriculum resources. This study has certain value for optimizing the teaching process.

Keywords: improved GWO algorithm; University teaching; Manage the course arrangement system; app; application

1 Introduction

With the rapid development of vocational education in China, the scale of vocational colleges continues to expand, the teaching resources have become scarce, and there are more and more teaching rooms and courses in vocational colleges. The teaching resources of vocational colleges have become scarce. The shortage of teachers and classes makes the teaching model in the curriculum management more difficult [1]. Although each school is different, the substantive problems in teaching arrangement still need to be considered comprehensively. That is, the rational utilization and optimal allocation of many resources in variables such as courses, teachers, multimedia classrooms, training rooms in computer rooms, courses and time, and the combination planning with teaching plans and various special requirements as constraints. Traditional manual course arrangement is easy to make mistakes and is very troublesome. In order to solve this difficult problem, many schools have applied such methods as simulated annealing, domain optimization research, and genetic algorithm. Genetic algorithm is a random search algorithm which draws inspiration from natural genes and natural selection in biology. Its main significance is that it directly leads to structural characteristics, without restrictions on continuous and continuous operation; and Effective research methods can obtain and guide research facilities effectively, adjust research direction correctly, and have an equal and great international potential [2]. The rapid development of

national economy has promoted the rapid development of higher education in China. With the expansion of enrollment in various colleges and the advancement of college students. At the same time, with the continuous expansion of the scale of universities, the number of professional courses also increases. The increase of students and professional courses in colleges has posed a great challenge to educational administration, which is the arrangement of courses. It takes a lot of human resources to arrange courses by hand, and it is easy to make mistakes, especially in the current environment where the number of college students and courses continue to increase, this way of arranging courses becomes unrealistic. In order to solve the conflict of teaching resources and improve the efficiency of course arrangement, all major universities have adopted course arrangement software at present. The teaching affairs department of colleges and universities can solve the general problem of course arrangement by using course arrangement software, but it still can't avoid the conflict between teachers and students and the conflict between resources and courses, so it needs to be adjusted manually after course arrangement, which wastes a lot of human resources. The use of genetic algorithm and grey wolf optimization algorithm (GWO) can solve the problems of curriculum arrangement in college teaching management, but there are also some deficiencies in [3]. It is also presented. On this basis, this article improves the GWO algorithm and applies the improved GWO algorithm to the teaching process in the college teaching process, in order to provide a reference for solving the more difficult teaching problems.

2 Methods

2.1 GWO algorithm

(1) The principle of GWO algorithm

Compared with other optimization methods, GWO algorithm has the advantages of simple structure and less parameter setting, and has been widely used in parameter optimization, workshop scheduling, process planning, and so on. The algorithm has the advantages of simple structure and less parameter setting, and so on. Grey wolves are carnivores, usually in the group. There are about 10 gray wolves in a wolf pack, and the most powerful wolf is only one. In a small wolf pack, the most powerful wolf is responsible for all the affairs of the whole wolf pack and is at the core. For gray wolves, they follow the social dominance hierarchy and can be divided into four layers. In the first stage of the relationship, the wolf head is in the position of the whole grey wolf pack, deciding the forecast, location, and other functions of the whole grey wolf pack, which is the management system. Probably wolves are the heaviest victims in the entire gray wolf pack, but their control abilities are definitely the heaviest. All other wolves must obey the management of the wolf and carry out various activities according to the orders of the wolf [4].

Wolf β is at the second level of social hierarchy, and it helps Wolf α to make decisions and deal with various activities among gray wolves. In the gray wolves, if the wolf is absent, sick or dead, then β becomes the wolf and undertakes all kinds of tasks of the wolf. For gray wolf β , on the one hand, it is necessary to give orders to other wolves in the gray wolf group, and at the same time, it is necessary to feed back the orders of other wolves to the head

wolf. δ is at the third level of social hierarchy, and its activities must obey Wolf α and Wolf β , and at the same time command the wolves at the bottom. For Wolf δ , it is often engaged in sentry duty, investigation, hunting, nursing and other work. For wolves α and β , when they are older, they will also become wolves δ . W is at the fourth level of social hierarchy, and its work must be subordinated to Wolf α , Wolf β and Wolf δ . On the surface, the W wolf is in a dispensable position in the whole wolf pack. In fact, the position of W Wolf is very important in the whole wolf pack, and W Wolf is responsible for the balance among all classes of the whole wolf pack. If there is no W wolf in the whole wolf pack, there will be cannibalism^[5].

(2)GWO algorithm flow

Using GWO algorithm, it is necessary to construct the social hierarchy model of grey wolves. Calculate the fitness of individual gray wolves in the gray wolves, and select three gray wolves with relatively large fitness according to the fitness, and record them as Wolf α , Wolf β and Wolf δ , and the rest as W Wolf. When the wolf searches for prey in nature, it will gradually approach and surround the prey, and its mathematical model is as follows: Formula (1) and Formula (4)^[6].

$$D = |C \cdot x_p(t) - x(t)| \quad (1)$$

$$x(t+1) = x_p(t) - A \cdot D \quad (2)$$

$$A = 2ar_1 - a \quad (3)$$

$$C = 2r_2 \quad (4)$$

Where D is the distance between the optimal gray wolf and the candidate gray wolf, A and C are the cooperative coefficient vectors, t is the number of iterations, x is the position vector of grey wolf, x_p is the position vector of prey, a linearly decreases from 2 to 0 in the whole iteration process, and r_1 and r_2 are random vectors on the closed interval [0,1]. In nature, gray wolves can only ensure the survival of wolves if they have the ability to identify the location of potential prey. The whole search for prey by gray wolves is completely completed under the orders of wolve α , β and δ . In order to better simulate the hunting behavior of gray wolves, the three gray wolves with the best fitness values are retained in each iteration of GWO algorithm, and the position information of W wolf is updated by combining the position information of Wolf α , Wolf β and Wolf δ . The mathematical model of hunting behavior of gray wolves is as follows: (5)- (7)^[7].

$$\begin{cases} D_\alpha = |C_1 \cdot x_\alpha - x| \\ D_\beta = |C_2 \cdot x_\beta - x| \\ D_\delta = |C_3 \cdot x_\delta - x| \end{cases} \quad (5)$$

$$\begin{cases} x_1 = x_\alpha - A_1 D_\alpha \\ x_2 = x_\beta - A_2 D_\beta \\ x_3 = x_\delta - A_3 D_\delta \end{cases} \quad (6)$$

$$x(t+1) = \frac{x_1 + x_2 + x_3}{3} \quad (7)$$

Where $D_\alpha, D_\beta, D_\delta$ is the distance between the candidate gray wolves and the optimal gray wolves α , β and δ , respectively, A_1, A_2, A_3, C_1, C_2 and C_3 are the synergy coefficient vectors, $x_\alpha, x_\beta, x_\delta$ are the position vectors of the optimal gray wolves α , β , δ , respectively, and x is the position vector of the gray wolves. For the GWO optimization algorithm, the first step is to set the maximum number of iterations t_{\max} and the size N of the gray wolf population, generate the position of the initial gray wolf population by combining random parameters, and calculate the fitness of individual gray wolves. According to the fitness value, the best three gray wolves in the gray wolf population are found, which are recorded as Wolf α , Wolf β and Wolf δ respectively, and the positions $x_\alpha, x_\beta, x_\delta$ of Wolf α , Wolf β and Wolf δ are saved. Secondly, modifying the function of wolf W using models (5) to (7), modifying the parameters of the updated function using models (3) and (4), calculating the fitness of each individual, comparing them with the fitness of the previous methods, and select three gray wolves with the best value of exercise to continue searching for the prey. Finally, determine whether the iteration has reached its maximum value. If so, stop the iteration and generate the function of Wolf X as the best value. The process of the GWO algorithm is shown in Figure 1 [8].

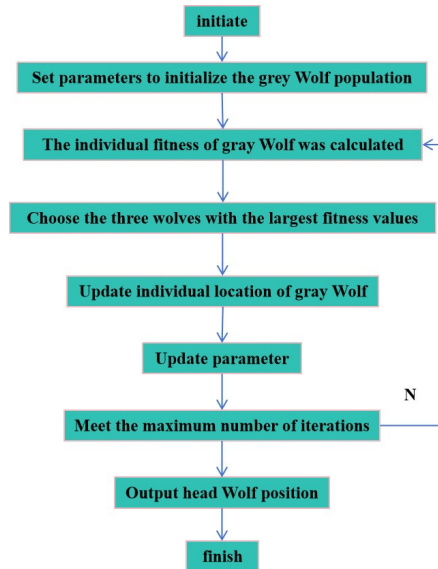


Figure. 1 GWO algorithm flow chart

2.2 Improved GWO algorithm

(1) Chaotic initialization population

The initial gray wolf population generated by the traditional GWO algorithm is random, which affects the diversity of gray wolf population and thus affects the iteration efficiency of GWO algorithm. Chaos is a determinant which has an uncertain character in natural science. It can be used to initialize gray fox in GWO algorithm, greatly improve the diversity of original gray fox and greatly improve the computation efficiency of GWO algorithm. In mathematics, many chaotic behaviors are often characterized by iterative operations. For different initial values, chaotic functions form different linear systems, but in detail, as the number of iterations increases, the linear limit values generated by chaotic functions are the same. In GWO swarm intelligence algorithms, various randomness have significant impact on searching. At present, chaotic sequences are widely used in many swarm intelligence algorithms and have achieved good results. In response to the improvement of GWO algorithm, the first gray wolf population of GWO algorithm is designed using Chebyshev chaotic sequences, which improves the self-diversity of population and greatly improves the computation efficiency of improved algorithm. The Chebyshev mapping equation is shown in equation (8).

$$x_{k+1} = \cos(k \cos^{-1}(x_k)) \quad (8)$$

(2) The position update of Levy flight improvement.

The traditional GWO algorithm may have the condition that the optimization falls into local optimum. While improving GWO algorithm, Levi flight was used to improve the population position adjustment model of GWO algorithm, thus broaden the research of GWO algorithm to some extent. The position adjustment formula of an improved GWO algorithm using Levi flight is introduced in formula (9).

$$\begin{cases} x_{\alpha}(t+1) = x_{\alpha}(t) + \alpha \oplus Levy(\beta) \\ x_{\beta}(t+1) = x_{\beta}(t) + \alpha \oplus Levy(\beta) \\ x_{\delta}(t+1) = x_{\delta}(t) + \alpha \oplus Levy(\beta) \end{cases} \quad (9)$$

Where alpha is the step control quantity, and the general value is 0.01; \oplus is the rule of point-to-point multiplication; $Levy(\beta)$ is the random search path of GWO algorithm, as shown in Formula (10).

$$Levy(\beta) = \frac{u}{|v|^{1/\beta}} \cdot (x(t) - x_m(t)) \cdot randn \quad (10)$$

Where, the value range of β is [1,3], v obeys the normal distribution $u: N(0,1)$, $x(t)$ is the position of gray wolves after t iterations, $x_m(t)$ is the position of a wolves, β wolves and δ wolves during t iterations, $randn$ is a random number obeys the normal distribution, and u obeys the normal distribution $N(0, \delta^2)$. Where δ is shown in formula (11).

$$\delta = \left(\frac{\Gamma(1 + \beta) \cdot \sin\left(\frac{\pi \cdot \beta}{2}\right)}{\Gamma\left(\frac{1 + \beta}{2}\right) \cdot \beta \cdot 2^{(\beta-1)/2}} \right)^{1/\beta} \quad (11)$$

By improving the formula of location update of GWO algorithm, the search scope is expanded to avoid falling into local optimum in the iterative process [9].

3 Application of Improved GWO Algorithm in Course Scheduling in Colleges and Universities

3.1 Overview of Course Scheduling Problems

The rapid enrollment expansion of colleges and universities makes the scale of running colleges and universities expand rapidly. To ensure the teaching quality of colleges and universities, we must ensure the synchronous development of various software and hardware facilities. The increase of college students and majors in colleges and universities makes the problem of course arrangement very complicated, and the course arrangement in colleges and universities must ensure that classes, teachers, courses and teacher arrangements do not conflict. The problem of arranging courses must meet the following five hard constraints: (1) You can't arrange the teaching tasks of two courses for the same teacher in the same time period, otherwise there will be conflicts between teachers' class hours and teaching accidents; (2) You can't arrange two courses for the same student at the same time, otherwise there will be conflicts in class time, students don't know what courses to take, and serious teaching accidents will occur; (3) Two courses cannot be arranged in the same classroom at the same time, otherwise there will be multiple classes and classrooms in the same classroom, which will lead to teaching confusion and affect the normal teaching work; (4) The scheduled class time should not be less than the time stipulated in the course. If the scheduled class time is less than the time stipulated in the prescribed course, it is possible that this course has not finished yet, and the next course has already started, resulting in teaching conflicts and affecting normal teaching; (5) The number of seats in the classroom should not be less than that of students in the classroom. If class seats are not enough, students will not be able to attend the normal classes. Using GWO algorithm to arrange courses in the teaching management system of colleges and universities, and constructing codes is the key to the algorithm design. As for the problem of course arrangement in colleges and universities, it involves five factors, namely teachers, classrooms, classes, courses and time. After the construction of course scheduling gene is completed, the improved GWO algorithm can be used to keep the high adaptability and repeat the cycle until the algorithm is terminated and the optimal solution of the problem is found.

3.2 GWO algorithm fitness function

The teaching management department of colleges and universities must pay attention to the above five hard constraints when arranging courses, but there are still some soft constraints when satisfying the influence constraints. For example, try to improve the utilization rate of

classrooms and avoid some classrooms not arranging a course in one semester. The weighted method is used to design the fitness function of GWO algorithm, so as to optimize the course arrangement. This paper mainly considers two aspects of soft constraints:

(1) The utilization rate of the classroom

There are many classrooms in colleges and universities, and each classroom is equipped with all kinds of equipment needed for teaching. The educational administration system of colleges and universities must consider the utilization rate of classrooms when arranging classes, so as to avoid that some classrooms are used in every class, while others are often not used. Use the following formula to evaluate the classroom utilization rate, as shown in Formula (12).

$$sl = \frac{\sum_{i=1}^n \frac{sn(i) \cdot ch(i)}{cr(i)}}{\sum_{i=1}^n ch(i)} \quad (12)$$

Where, i is the number of lesson elements, $sn(i)$ is the number of students included in the i th lesson element, $ch(i)$ is the number of hours included in the i th lesson element, $cr(i)$ is the classroom capacity of the classroom used in the i th lesson element, and sl is the classroom utilization rate.

(2) The class time is arranged evenly

Considering the actual situation of students' study, in order to improve students' learning efficiency and quality, the educational administration system of colleges and universities must consider the uniform arrangement of students' class time when arranging classes, so that students can have a rest and complete the corresponding homework after finishing one course, and then go to the second course. For a lesson element, its time distribution uniformity $T(i)$ is shown in Formula (13).

$$T(i) = \begin{cases} 0, ch(i) = 1 \text{ or } ch(i) > 3 \\ \sum_{j=1}^{eh} (Day(i, j+1) - Day(i, j)) \end{cases} \quad (13)$$

Where, $Day(i, j)$ is the j -th class time of the i -th lesson element and the class day entered. The calculation formula for evaluating the even arrangement of class time for the course arrangement scheme is shown in Formula (14).

$$s2 = \sum_{i=1}^n T(i) \quad (14)$$

The calculation formula of individual fitness for GWO algorithm is obtained by weighting the classroom utilization ratio sl and the evaluation $s2$ of the even arrangement of class time, as shown in Formula (15).

$$fitness(s) = a \cdot sl + b \cdot s2 \quad (15)$$

Where fitness(8) is individual fitness, and a and b are undetermined coefficients.

3.3 Comparison of test results

In order to verify the effectiveness of the improved GWO algorithm, taking University A algorithm as an example, the simulation study used the traditional GWO algorithm and the improved GWO algorithm. The relevant data of the experimental results are shown in Table 1.

Table 1 Relevant data of simulation test

parameter	Number of courses	Number of classrooms	Number of teachers	Number of classes
numerical value	30	20	15	six

The GWO algorithm and the improved GWO algorithm are used to optimize the course arrangement and compare the fitness under different iterations, as shown in Figure 2. The undetermined coefficients a and b are both 0.5.

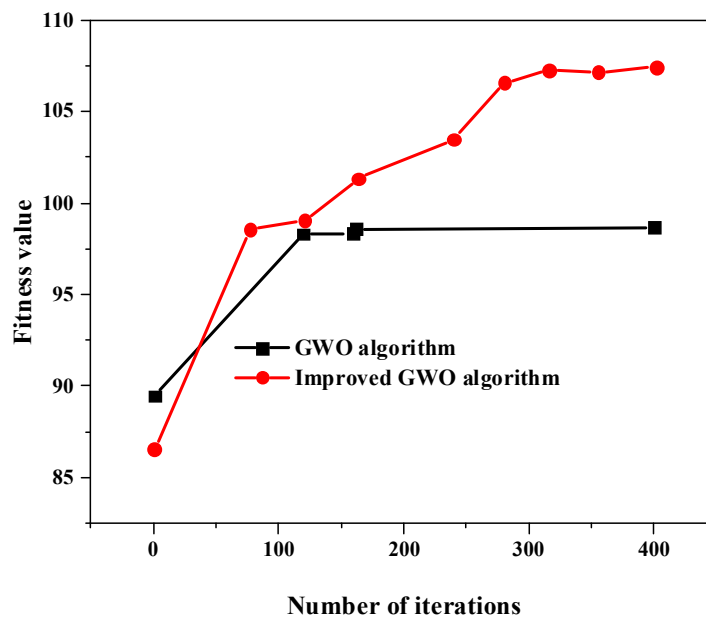


Figure. 2 Comparison of test results

From Figure 2, it can be seen that the growth performance of the optimization algorithm of the improved GWO algorithm is faster than that of the traditional GWO algorithm. After about 120 iterations, the traditional GWO algorithm enters the local optimum state, while the improved GWO algorithm does not enter the local optimum state. However, it sees positive growth with the increase of iterations. It can be seen that the improved GWO algorithm can

better arrange courses in colleges and universities, which can achieve good results and provide reference for improving the teaching quality in colleges and universities ^[10].

4 Conclusion

The teaching process involves the quality of teaching in colleges, and in the current environment of the development of the legal system for running colleges, the optimization of the teaching process is very important. This article develops a GWO optimization algorithm. Establish the initial gray wolf population of GWO algorithm using Chebyshev chaotic sequence, and improve the update rate of gray wolf position using Levi flight. By applying GWO algorithm and an improved GWO algorithm to the learning process, it is verified that the improved GWO algorithm avoids falling into local optima and achieves good results in class planning. The research in this article has certain practical value for optimizing the curriculum management system in universities.

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