Consulting Scheduling of Vocational Planning in Colleges and Universities Based on Improved Genetic Algorithms

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Abstract. In the work of promoting vocational planning education and consultation in colleges and universities, there are some problems, such as fewer teachers and more students, will make it difficult to complete the consultation for all students in a limited time. Focusing this problem, this paper makes a research on consulting scheduling of vocational planning in colleges and universities based on an improved genetic algorithms (IGA). Firstly, an improved genetic algorithm (IGA) is proposed in combination with the characteristics of the problem, which can realize the full coverage of the student consultation as soon as possible under the reasonable consideration of the workload and consultation time of the consultation teacher. The problem is coded by double-string method, different genetic operators are used for different characteristics of the string, and enhanced search operation is introduced to strengthen the optimal individual in the population. The results show that the IGA is more accurate and stable than the traditional genetic algorithm for promoting vocational planning education and consultation. The effectiveness of the improved strategy is verified by a simulation test. It is a feasible and reasonable scheduling algorithm for allocating consultation resources.

Keywords: Consulting Scheduling, Career Planning, Mixed Integer Programming Model, Genetic Algorithms, Enhanced Search

1 Introduction
Carrying out scientific and reasonable career planning education for college students are conducive to helping them to fully recognize themselves, objectively analyze the social situation, reasonably arrange the academic process and scientifically plan their career. [1] This job is very important not only for students' personal development, but also for the country, society, school and family. Scientific career planning should examine one's career choice and career development in a dynamic and developmental perspective. [2] At present, there is a serious shortage of career planning instructors in colleges and universities, which has become a bottleneck restricting the development of career education in colleges and universities. It is an urgent problem that how to make use of the existing teacher resources and provide targeted career planning for college students with high efficiency and high quality [3-4]. Up to now, there is rare literatures can be available to provide a reasonable
scheduling algorithm for the allocation of "one-to-one" tutoring teacher resources, so it is necessary to strengthen the research on the allocation of teacher resources scheduling algorithm.

Aiming at other types of scheduling problems, Decerle et al. [5] designed a memetic algorithm for the medical resource scheduling problem. Kardir et al. [6] used artificial bee colony algorithm to solve the same problem and achieved good results. Qin et al. [7] established a mixed integer programming model aiming at the scheduling problem of airport.

Genetic algorithm is a classical optimization algorithm [8], the simulation theory of evolution by natural selection and genetic mechanism to realize the optimization of complex problem solving. It has the characteristics of the adaptive and parallel search, with the stability of the inherent parallelism and better optimization ability, more suitable for large-scale complex optimization problem. At the same time, the genetic algorithm of the model requires less, thus good extensibility, has been widely used in various engineering fields [9-11]. However, it has not been studied much in the scheduling problem, including the scheduling problem of career planning consulting in colleges and universities. Therefore this paper gives an improved genetic algorithm to solve the scheduling problem of career planning consulting in colleges and universities based on the characteristics of the problem.

Aiming at the problem of career planning consultation scheduling in colleges and universities, this paper designs a resource scheduling algorithm based on genetic algorithm considering the problem characteristics. By introducing the enhanced search mechanism on the basis of the traditional genetic algorithm to improve the search ability of the algorithm, the problem is coded in the way of double string. Different genetic operators are adopted according to the characteristics of different strings, so as to achieve the efficient completion of the consulting schedule.

2 Problem Description
The main problem of universities students' career planning resources scheduling is the shortage of professional teachers and the huge quantities of students. Thus, it is difficult to cover all the students in a limited time. Therefore, it is important to make a reasonable visiting order, supporting students to the maximum extent.

Suppose there are \( m \) consulting teachers and \( n \) students who need to consult, and the time for each student \( j \) to consult at each consulting teacher \( i \) is set as \( p_{ij} \), and each student only needs to find a teacher to consult. Each consultation takes a different amount of time because each student is different, and each teacher is in a different school.

The constraints for teachers are: each teacher can only carry out consulting work for one student at a time; At the same time, considering the quality of the consultation and the individual situation of the teacher, each consultation teacher \( i \) needs to have a rest time \( T_i \) every working time \( w_i \). Considering the individual differences of teachers, the continuous working time \( w_i \) and rest time \( T_i \) of each teacher are also different. Take the continuous working time of teachers as a working interval. If the teacher completes the consultation, the continuous working time has not reached, but the remaining time cannot complete the next student's consultation task, then the remaining time will not arrange the consultation, and the follow-up consultation will be arranged after the teacher finishes taking a rest.

Here is an example of two teachers and four students, where \( T_1=2, \ T_2=3, \ w_1=10, \ w_2=9 \). The consulting time matrix is:

\[
p = \begin{bmatrix} 8 & 7 & 3 & 2 \\ 4 & 7 & 9 & 8 \end{bmatrix}
\]

Among them, teacher 2 could not complete the consultation of student 1 in the remaining time after completing the consultation of student 4, so the consultation was not arranged in the remaining time. Teacher 2 continued to carry out the consultation of student 1 after the break. Figure 1 shows the gantt chart corresponding to the scheduling instance.
In this paper, considering the goal is to minimize the advance consulting time, specifically shown in the following type, where \( C_{\text{max}} \) is the objective function, \( C_i \) is the student \( i \) complete consultation time.

### 3 An IGA for Resource Scheduling of Career Planning

#### 3.1 Encoding and Decoding

This problem involves two sub-problems to be solved, one is to allocate teachers reasonably, and the other is to arrange the visiting order of students reasonably. Therefore, this paper considers choosing one solution of two string description problems. The first string is described as \([A_1, A_2, \ldots, A_m]\), where \( A_i \) is the integer between 1 and \( m \), used to represent the counseling teacher \( A_i \) assigned to student \( i \). The second string is described as \([B_1, B_2, \ldots, B_n]\), which is a arrangement between 1 and \( n \), used to indicate the sequence of student visits.

#### 3.2 Crossover Operation

Crossover operation is an important operation of genetic algorithm. The specific crossover operator needs to be selected by combining the characteristics of the problem and the properties of the coding string. In view of the different characteristics of the two strings in this paper, two different crossover modes are selected, respectively. The crossover method of the first string is described as follow: Select a segment from parent 1 and insert it into the parent 2. For the second string, since it is an arrangement from 1 to \( n \), it is different from the crossover of string 1. The specific operation mode is given as follow: Select a fragment \( s \) is extracted from parent 1; Copy parent 2 and delete the same elements as the \( s \) fragment, and record the location of deleting the first element; Insert the fragment \( s \) into the location of the first element deleted, thus generating child 1.

#### 3.3 Mutation Operation

Mutation operation is another important operation of genetic algorithm. By appropriately carrying out mutation operation on the current solution and partially disturbing the individual, the algorithm can jump out of the local optimal solution. The selection of mutation operator also needs to be designed by combining the problem properties and coding characteristics. For the design of double-string coding mode in this paper, the specific mutation operation is as follows: for the first string, randomly select an element \( i \) and reselect the assigned teacher, so as to complete the mutation of string 1. For the second string, randomly select the two elements \( B_i \) and \( B_j \), reverse the sequence number between the two elements to produce the new string 2. Through the above way, we can complete the mutation operation of an individual.

#### 3.4 Enhanced Search

It is pointed out in the literature that it is easier to obtain excellent offspring by searching for the optimal individual in the population [12]. In this paper, enhanced search is introduced on the basis of traditional genetic algorithm, and the specific operation of enhanced search is as follows: Select the
best individual $x$ in the population; Perform mutation operation on individuals $x$ to generate new individuals $x'$; Replace $x$, if $x'$ is better than $x$, otherwise it doesn't change $x$.

Through the above operation, the search of excellent individuals in the population is strengthened, which is conducive to improving the efficiency of genetic algorithm and obtaining better solutions. The replication operation is selected by roulette. The stopping condition is max_it, which is maximum number of objective function evaluations.

4 Simulation Test
In order to effectively test the solving efficiency of IGA at different scales, this paper randomly generates 24 groups of examples, where $m = \{2, 4, 6\}$, $n = \{40, 80, 120, 150\}$, two groups of examples are generated for each scale $m \times n$, where $p_i \sim [1, 99]$ (minutes), $T_j \sim [1, 99]$ (minutes), $w_i = (1 + \beta)\max \{p_i\}$ (minutes), where $\beta$ is the random number between 0 and 1.

As stated above, there is no algorithm known to solve the same problem and there are no existing comparative algorithms. In this study, we compare IGA with simulated annealing (SA [13]) and hybrid particle swarm optimization and genetic algorithm (HPSOGA [14]). SA can be directly applied to solve universities students' career planning resources scheduling problem by considering rest time of teachers in decoding process.

Table 1. Comparisons among IGA, SA and HPSOGA on AVG

| Scale     | IGA   | SA    | $\Delta$ | HPSOGA | $\Delta$ |
|-----------|-------|-------|----------|--------|----------|
| 2 $\times$ 40(1) | 837.64 | 847.00 | -9.36    | 844.58 | -6.94    |
| 2 $\times$ 40(2) | 745.34 | 757.93 | -12.59   | 764.29 | -18.95   |
| 2 $\times$ 80(1) | 1876.23 | 1880.62 | -4.39    | 1889.75 | -13.52   |
| 2 $\times$ 80(2) | 1544.61 | 1559.87 | -15.26   | 1579.49 | -34.88   |
| 2 $\times$ 120(1) | 2202.96 | 2248.02 | -45.06   | 2284.97 | -82.01   |
| 2 $\times$ 120(2) | 2264.63 | 2296.63 | -32.00   | 2286.77 | -22.14   |
| 2 $\times$ 150(1) | 2416.60 | 2449.39 | -32.79   | 2454.37 | -37.77   |
| 2 $\times$ 150(2) | 3859.37 | 3933.55 | -74.18   | 3945.35 | -85.98   |
| 4 $\times$ 40(1) | 268.97  | 261.06  | 7.91     | 275.02  | -6.05    |
| 4 $\times$ 40(2) | 311.00  | 310.03  | 0.97     | 321.62  | -10.62   |
| 4 $\times$ 80(1) | 574.60  | 582.35  | -7.75    | 601.62  | -27.02   |
| 4 $\times$ 80(2) | 531.09  | 554.66  | -23.57   | 557.78  | -26.69   |
| 4 $\times$ 120(1) | 961.43  | 957.86  | 3.57     | 975.63  | -14.20   |
| 4 $\times$ 120(2) | 784.30  | 808.11  | -23.81   | 806.57  | -22.27   |
| 4 $\times$ 150(1) | 1077.79 | 1088.67 | -10.88   | 1105.63 | -27.84   |
| 4 $\times$ 150(2) | 1096.01 | 1114.92 | -18.91   | 1113.81 | -17.80   |
| 6 $\times$ 40(1) | 133.93  | 153.21  | -19.28   | 151.87  | -17.94   |
| 6 $\times$ 40(2) | 163.35  | 171.51  | -8.16    | 168.80  | -5.45    |
| 6 $\times$ 80(1) | 321.01  | 329.56  | -8.55    | 349.30  | -28.29   |
| 6 $\times$ 80(2) | 280.16  | 275.99  | 4.17     | 298.53  | -18.37   |
| 6 $\times$ 120(1) | 556.17  | 581.47  | -25.30   | 599.42  | -43.25   |
| 6 $\times$ 120(2) | 438.69  | 466.85  | -28.16   | 467.15  | -28.46   |
| 6 $\times$ 150(1) | 561.50  | 601.76  | -40.26   | 594.83  | -33.33   |
| 6 $\times$ 150(2) | 616.93  | 687.65  | -70.72   | 690.01  | -73.08   |

As shown in Table 1, when the average solutions of three algorithms are compared, it can be found that average of IGA is better than that of SA and HPSOGA on 21 of 24 instances. So we can conclude that new IGA performs better than its comparative algorithms in stability. Thus, IGA can get better results than other two algorithms on most of instances and has promising advantages in universities students' career planning resources scheduling problem.
Conclusion
Aiming at the shortage of teachers in the career planning education for junior college students, this paper puts forward an improved genetic algorithm based on the characteristics of the problem, so as to make more reasonable arrangements for the limited consulting resources. This scheduling algorithm adopts double-string coding, and selects different crossover operators and mutation operators for each string, so as to ensure that the individual after crossover is a feasible individual, and conducts partial perturbation to the individual, which is conducive to the algorithm jumping out of the local optimal solution. Compared with the SA and HPSOGA, it can be concluded that the IGA has better solution accuracy and stability than SA and HPSOGA, and is a feasible and reasonable allocation of consulting resources, which can effectively improve consultation efficiency.

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