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APPLICATION OF HYBRID ALGORITHMS ON COURSE SCHEDULING

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Abstract. *Course scheduling is a difficult issue that involves resources distribution and each scheduling task has its corresponding problems, needs and conditions. Thus, a good scheduling is to distribute manpower and space to the required time and position in order to achieve a balance. With rapid development of the modern computer industry, computers have been used for scheduling and developed a set of algorithms for problem-solving based on the corresponding problems, needs and conditions. In this study we proposed a hybrid algorithm which combines genetic and heuristic algorithm to solve course scheduling and designed a user-friendly human-machine interface by LabView and Excel.*

Keywords: Genetic algorithm, Heuristic algorithm, Scheduling, Course scheduling

1. Introduction.

1.1. Course scheduling.

In course scheduling, NP-Complete is a common problem [1]. Currently, there is no general and effective approach to solving the problem. In [1-6], the most difficult problem in course scheduling is resource distribution and the restrictive conditions are numerous and complex. For example, course scheduling is related to classroom resource, equipment and the resources needed by each teacher may vary. Moreover, the time of courses for each school is different and then the restrictive conditions also change. The above-mentioned is the simple resource distribution; in universities, if the courses are scheduled based on the time slots desired by the professors, there would be more difficulty on course scheduling. In sum, merely using scheduling concept cannot achieve significant result for scheduling. Thus, the best-fit algorithm and introduction of matrix dimensions should be found to solve those problems.

1.2. Genetic algorithm with heuristic algorithm.

The basic concept of genetic algorithm is constructed based on Darwin's "survival of the fittest in natural selection" and the optimal solution can be found by simulating the selection, crossover and mutation processes in the evolutionary process and highly parallel search is used [3,4]. The highly parallel search should be considered to avoid local solutions. Heuristic algorithm is an optimal theory, which is used to solve problem under a lot of conditions and it will start on initial solution that the solution will be improved until algorithm ends or cannot be improved [5,6]. The genetic & heuristic algorithm process in this paper is shown in Figure 1.

As shown in Figure 1, the initial solution will be funded by heuristic algorithm and adaptive value of each chromosome is re-evaluated after generating a new population.

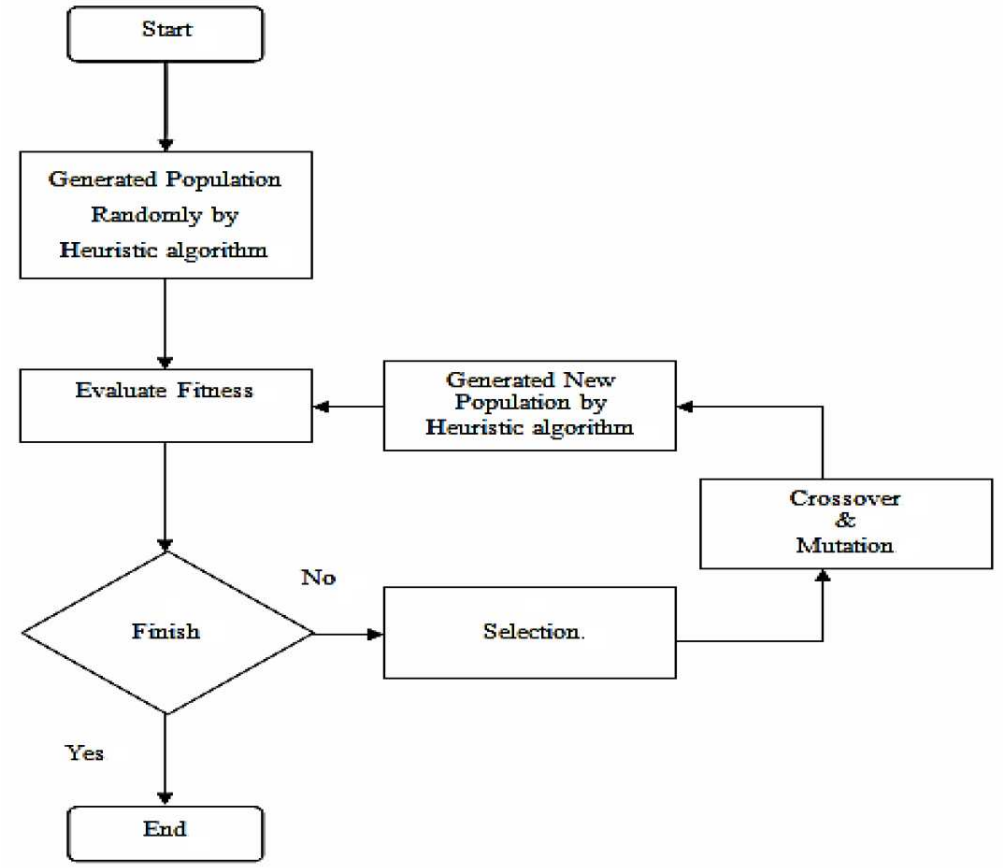


FIGURE 1. Genetic & heuristic algorithm operation process

Before terminal condition is met, the algorithm is repeated until the termination condition is satisfied. The selection mechanism selects chromosome with the better adaptive value for crossover in the mating pool. Thus, better genes can be reserved for the next generation. Crossover uses parent generation to generate the new filial generation and inherit the part of genes in the parent generation. The common crossover methods include single-point, double-point and uniform. The mutation selects part of genes in the chromosome for change to create new genes. Before filling in next generation, the new genes have to be adjusted by heuristic algorithm when it is illegal [7].

Based on the above literature, the advantages and disadvantages of the genetic algorithm are summarized as follows:

(1) Advantages

a) Only need appropriate adaptive functions and no complicated mathematical derivation is needed.
b) Use codes, instead of original parameters for calculation.
c) If the original parameters can be encoded then it can be applicable to different types of problems.

(2) Disadvantages

a) Problem coding must be pertinent, and the coding method would affect results of calculation.
b) The calculation method is synchronous (chromosome and gene length from coding would affect the calculation rate).
c) Optimal solution cannot be ensured unless there is optimal reference solution.

2. **Construction and Operation of the System.** Based on previous literature, this study employed both genetic algorithm and heuristic algorithm. Furthermore, the initial data were read using Excel. The results from the algorithm were exported from Excel.

2.1. **Coding methods.** The chromosome structure is shown in Figure 2. Each chromosome consists of genes of n teachers. Each gene is formed based on the teachers' timetables.

Teacher A	Teacher B			Teacher n
Teacher A's course timetable	Teacher B's course timetable	.....	.....	Teacher n's course timetable

FIGURE 2. Chromosome structure

The teachers' timetables can be represented by one-dimensional matrix in the program, such as Num [4] = {351}, where 4 denotes Thursday, 3 denotes 3 credits, 5 denotes the fifth class and 1 denotes course code. The number of courses by each teacher is represented by two-dimensional matrix, as shown in Figure 3. The first teacher offers 2 courses that have two credits and three credits. Respectively, the second teacher and the third teacher each offer one course and the credits are 2 and 3. The original data are imported to LabView using Excel.

	A	B	C
1	2	2	3
2	3		

FIGURE 3. The number of courses and credits

2.2. **System model.**

- Adaptive function

The function is defined by restrictive conditions and elasticity conditions. The adaptive function adopts score deduction system and the total score is 100. Thus, more score is deducted if more conditions are violated then the adaptive function will be lower. The adaptive function is presented in (1).

$$Fit = 100 - \sum_{i=1}^{m} Cost_i \tag{1}$$

Using heuristic algorithm with restrictive condition and elasticity condition to generate the initial feasible solutions is as follows.

1) Restrictive condition: this condition must be satisfied.

Initial condition can be produced by the restrictive condition and the description is as follows.

a) The time specified by schools to be excluded for course scheduling

For example, the general education courses offered in universities of Taiwan are to be attended by all students; thus course scheduling should avoid those time slots.

b) Overlapping of course time should be avoided.

This is the basic condition of scheduling and this rule is to protect the rights of the students.

In sum, the score is 100 in the deduction system and the condition shall not be breached.

2) Elasticity condition: as compared with restrictive conditions, this condition should be satisfied as much as possible.

a) The courses should be scheduled according to the available time of the teachers.

Course scheduling should consider the available time of teachers because professors have other works, such as research and lab work. Thus, the penalty function is shown in (2).

$$Cost_1 = \sum_{i=1}^{n} \sum_{j=1}^{m} C_{ij} \tag{2}$$

Equation (2) represents the ith teacher and violates the $b-1$ condition for j times.

The preferred time is compiled in Excel, as shown in Figure 4, where 2 denotes the most favorable time, 1 denotes the acceptable time frame and 0 denotes the unaccepted time.

	A	B	C	D	E
1	2	1	0	2	2
2	2	1	0	2	2
3	2	2	2	2	2
4	2	2	2	2	2
5	0	0	0	1	2
6	0	0	0	1	2
7	0	1	2	1	0
8	0	1	2	1	0

FIGURE 4. Preferred time

b) $b-2$. Course time during the lunch hours should be avoided. The penalty function is shown in (3).

$$Cost_2 = \sum_{i=1}^{n} \sum_{j=1}^{m} C_{ij} \tag{3}$$

Equation (3) represents the timetable of the ith teacher and violates $b-2$ condition for j times. This rule is common in most universities in Taiwan.

3. Experimental Results.

3.1. **System description.** The main operation menu of the system is as shown in Figure 5. Block A shows the initial number of teachers, number of courses and credits. Block B shows the display window of optimal adaptive value and iteration times. Block C is the input initial condition and Pc and Pm represent the crossover rate and mutation rate, respectively. Morning and Afternoon are represented by numbers, i.e., 1 in Morning means no course should be scheduled on Monday morning, while 3 in Afternoon means no course should be scheduled on Wednesday afternoon.

3.2. **System parameters.** Before system execution, the initial parameters are required. The initial parameters required for the system are imported by Excel, including preferred time slots of the teachers, as shown in Figure 6 (Teacher A). The number of teachers, number of classes and credits are shown in Figure 7. As seen, Teacher A offers two courses, A1 (4 credits) and A2 (3 credits).

3.3. **System execution.** System execution is conducted twice to observe the stability. The double-point crossover rate and mutation rate are Pc = 0.7, Pm = 0.01 [8] and there are 100 iterations. The execution results of the first round are shown in Figure 8 and no course is scheduled on Morning afternoon. The execution results of the second round are shown in Figure 9 and no course is scheduled in Tuesday afternoon. Ax represents the course scheduling for Teacher A.

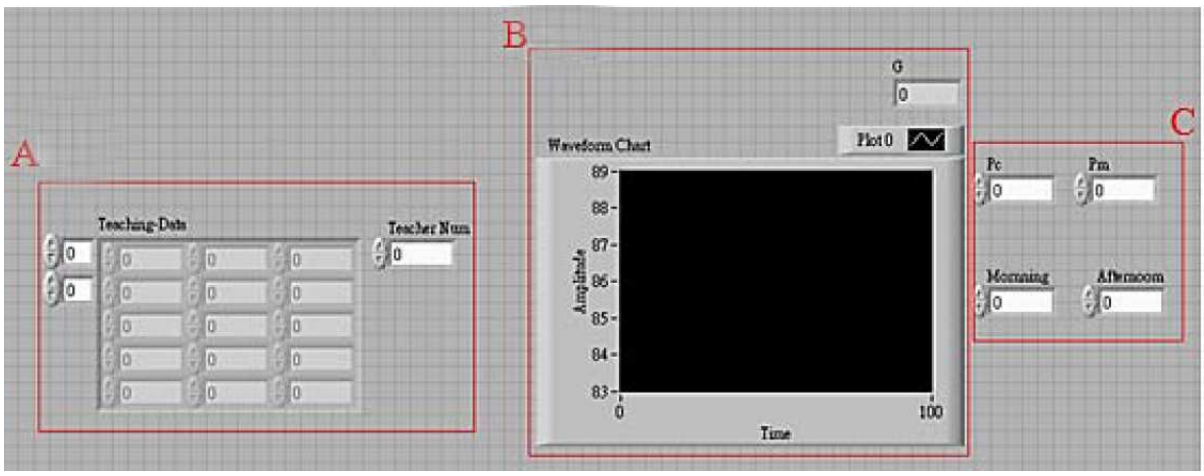


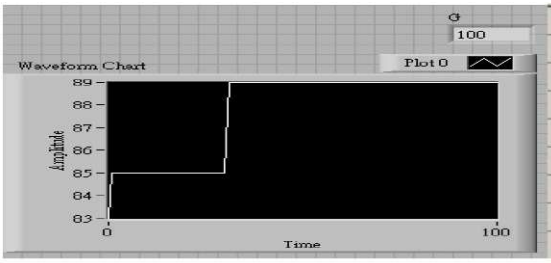
FIGURE 5. Initial operation interface of the system

	A	B	C	D	E
1	0	1	0	2	2
2	0	1	0	2	2
3	0	2	2	2	2
4	0	2	2	2	2
5	0	0	0	1	2
6	0	0	0	1	2
7	0	1	2	1	2
8	0	1	2	1	2

FIGURE 6. Preferred time slots of Teacher A

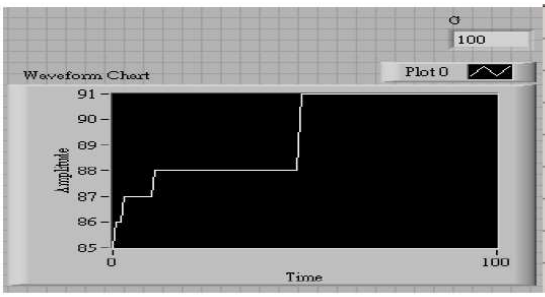
	A	B	C	D	E
1	4	3	3	3	3
2	3		3	4	

FIGURE 7. Number of teachers, classes and credits



	A	B	C	D	E
1	D2	A1		A2	C1
2	D2	A1	B3	A2	C1
3	D2	A1	B3	A2	C1
4	D2	A1	B3		
5		C2		D1	
6		C2		D1	E1
7		C2		D1	E1
8					E1

FIGURE 8. Output screen and fitness fig for execution result A and fitness is 89.



	A	B	C	D	E
1		A2	C1		D2
2	D1	A2	C1	E1	D2
3	D1	A2	C1	E1	D2
4	D1			E1	D2
5				B1	A1
6			C2	B1	A1
7			C2	B1	A1
8			C2		A1

FIGURE 9. Output screen and fitness fig for execution result B and fitness is 91.

4. **Conclusions and Future Studies.** In this study, genetic algorithms and heuristic algorithm have been successfully applied in course scheduling to increase working efficiency, and the system is constructed by two restrictive conditions and two elastic conditions to enhance flexibility and reasonability. As NP-Complete problems may produce various restrictions due to different environments, resources and conditions, future studies can focus on developing generalized algorithm.

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