A Genetic Algorithm to Determine Research Consultation Schedules in Campus Environment

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Abstract. Scheduling algorithm is one of computation problem with high complexity. One of the problems is a difficulty to determine an optimal scheduling alternative that is adjusted with the constraints needed. This study aims to test whether the Genetic Algorithm (GA) program that was built was successful for maximizing the value of fitness. The data used in this study is data simulation from the GA Program. Based on the result of this study, we can concluded that the GA program can be used for scheduling because it has good accuracy. This can be seen from the fitness value of 1 and there is no clash between one schedule and another schedule and there are no restrictions that are violated.

1. Introduction
Scheduling algorithm is one of computation problem with high complexity [1]. One of the problems is a difficulty to determine an optimal scheduling alternative that is adjusted with the constraints needed, resulting in almost impossible task to solve with normal mathematics calculation.

Scheduling process needs a wide searching space and some parameter with various condition [1]. Multiple kinds of condition during the process result in calculation and determination difficulty. This is

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due to the conditional constraints with high variety and complexity [2]. For example, in class scheduling process, there are instructors who are only available to teach at certain days and times, followed by minimal number and capacity of the classroom. These conditions make scheduling process becoming ineffective in providing optimal scheduling alternatives.

One of the solutions to determine the suitable scheduling is by exploiting the advantages of Genetic Algorithm (GA). As one of its the advantages, GA is widely used for the best random searching by trying some random solutions while recording the best solution [3]. GA can also be used to search non-linear big solution space that is hardly to be encoded [4].

This algorithm is widely used by the researcher to solve the scheduling process. Sapru et. al. used GA to determine the time table scheduling for employing guided mutation. They exploited selection scheme based on ranks to ensure that the produced timetable schedule is optimal and proper compared to stagnant solution configuration related to the roulette selection scheme [4]. Reddy et. al. used GA to determine fast, suitable, and easy to use train time scheduling [3]. Kristiadi & Hartanto [5] used GA to determine lecturing scheduling optimization. They built a library with GA concept, arranged with several operators such as Tournament Selection, Uniform Crossover, Weak Parent Replacement, and two mutation method which are Interchanging Mutation dan Violated Directed Mutation. The library is designed to be able to define custom constraint or scheduling conditions which have not been accommodated in the library’s core modification program [5].

In university, schedule in research guidance is generally about adjusting lecture and the students, as well as placing them at the specific time in the class. But there are several problems such as different schedules of the adviser (the lecturer) and the student, as well as the number of class and overlapping schedules.

In this study, research guidance schedule problems in the university will be solved. As mentioned in the second paragraph, the most effective approach to solve schedule problems is by using GA. GA is the most popular algorithm and mostly used to solve schedule problems. The programming language used to solve this problem is Perl.

2. Literature Review

2.1 Genetic Algorithm

GA is a powerful optimizing and heuristic algorithm with the principles of evolution as its basis [6]. Importantly, GA is based on Darwin’s theory on Survival of The Fittest [7,8]. Processes in GA include selection, crossover, mutation, and elitism repeated until the conditions are met [5]. GA can be done with complete operation process or by combining it with several computation methods [9,10]. Using GA in scheduling can optimize the results effectively [2,6,9,11]. GA has successfully used in several cases of research guidance schedule. Corne et al. used conventional method where each gene represents time where particular guidance happened with crossover and mutation operator. This system has been used in the University of Edinburgh with enhanced time-saving. While Paechter took different methods where the genes for each guidance do not only determine when the time it should be used but also how to search a new period if, after crossover, the schedule conflict occurs. If the research guidance could not be included in one period, it would be left as unscheduled, this is different from previous system which enables unfit schedule [6]. GA flowchart in this study can be seen in Figure 1.
2.2 Problem Definition
The definitions in this study include:

\[ D = d_1, d_2, d_3, ..., d_n \]
\[ H = h_1, h_2, h_3, ..., h_n \]
\[ R = r_1, r_2, r_3, ..., r_n \]
\[ J = j_1, j_2, j_3, ..., j_n \]

\( D \) represents Lecturer while \( d_1, d_2, ..., d_n \) represents the name of \( D \). \( T \) represents Day while \( t_1, t_2, ..., t_n \) represents the name of Days. \( R \) represents Room while \( r_1, r_2, ..., r_n \) represents the name of the Room. And \( J \) represents Time while \( j_1, j_2, ..., j_n \) represents the name of Time. In this study, there are 20 Lecturers, 5 Days, 1 Room, dan 4 Times used, and can be seen in Table 1-3.

| Schedule | Day    | Time | Room |
|----------|--------|------|------|
| J1       | Monday | T1   | R1   |
| J2       | Monday | T2   | R1   |
| J3       | Monday | T3   | R1   |
| J4       | Monday | T4   | R1   |
| J5       | Monday | T1   | R1   |
| J6       | Tuesday| T2   | R1   |
| J7       | Monday | T3   | R1   |
| J8       | Monday | T4   | R1   |
| J9       | Wednesday| T1 | R1  |
| J10      | Wednesday| T2 | R1  |
| J11      | Wednesday| T3 | R1  |
| J12      | Wednesday| T4 | R1  |
| J13      | Thursday| T1  | R1  |

Figure 1. Genetic algorithm stages.
Table 2. Time Table.

| Code | Time       |
|------|------------|
| T1   | 08.00-10.00|
| T2   | 10.00-12.00|
| T3   | 14.00-16.00|
| T4   | 16.00-18.00|

Table 3. Lecturers Table.

| No | Lecturer |
|----|----------|
| 1  | D1       |
| 2  | D2       |
| 3  | D3       |
| 4  | D4       |
| 5  | D5       |
| 6  | D6       |
| 7  | D7       |
| 8  | D8       |
| 9  | D9       |
| 10 | D10      |
| 11 | D11      |
| 12 | D12      |
| 13 | D13      |
| 14 | D14      |
| 15 | D15      |
| 16 | D16      |
| 17 | D17      |
| 18 | D18      |
| 19 | D19      |
| 20 | D20      |

2.3 Constraints

In this study, there are several rules required for the schedule determination so that the fitness function in GA can run properly, they are:
1. Only one room used for guidance
2. There is not any overlapping schedule among lectures
3. One lecturer for Each student

3. Methods

3.1 Data
To see if GA successfully runs, this study uses the generated data from the authors’ generated results which include 1 Room, 5 Days, 4 Times, dan 20 Lecturers.

3.2 Genetic Algorithm
For scheduling problems in this study, the supervisor/promotor/lecturer is determined by the head of the department and written in the guidance list slot, in order to make schedule table filled. If there is not an optimal solution, then GA algorithm will be used to provide an optimal schedule. Discussion about scheme encoding and GA operator used in this section will be discussed in this subsection

3.2.1 Chromosome Structure
Chromosome representation used is bit string. All information that might present should be inserted into the chromosome. The forming chromosomes genes are consisted of four components, which are lecturers D, Days H, Room R, dan Time J. Table 1 shows 20 possible combinations, therefore in this study a chromosome consists of 20 genes that describe occurred scheduling condition. The chromosomes structures used in this study is [9]:

\[ f : D \times H \times R \times J \{0,1\} \]

Chromosome representation used is bit string. In Equation (1) the value of \( f(d, h, r, j) \) are 1 if the lecturer, day, room, and time are available, and will be 0 if unavailable

3.2.2 Fitness Value
Fitness function used in this study is optimized fitness function (highest fitness value) so that will be no overlap among schedule, which is [9] :

\[ f = \frac{1}{1+\alpha} \]

Based on Equation (2) where \( \alpha = D + H + R + J \). D is lecturer, where it will give 0 if and only if d lecturer presents on the meeting date \( t \) in room \( r \) and at meeting time \( j \). In contrary, it will give 1 if the overlapping happens for meeting date \( t \), room \( r \), meeting time \( j \), or the overlapping between the lecturers. These conditions are applied for other criteria.

4. Result and Discussion
The results of this study were to test whether the GA program that was built was successful for maximizing the value of fitness. The first step was to change the representation data from the chromosome into a bit string.
The representation of the D value in binary encoding for Lecture was:

\[ D_1 = 00000, D_2 = 00001, D_3 = 00010, D_4 = 00011, \ldots \quad (3) \]

The representation of the H value in binary encoding for Days was:

\[ H_1 (Monday) = 000, H_2 (Tuesday) = 001, H_3 (Wednesday) = 010, H_4 (Thursday) = 100, H_5 (Friday) = 111 \quad (4) \]

The representation of the J value in binary encoding for Times was:

\[ T_1 = 0000, T_2 = 0010, T_3 = 0100, T_4 = 1000 \quad (5) \]

And the representation of the J value in binary encoding for Room was:

\[ R_1 = 00 \quad (6) \]

Based on equations 3-6, the chromosome sample that will be formed were:

\[ \{D_1, H_2, T_3, R_1\} \]

\[ D_1 = 00000 \]

\[ H_2 = 001 \]

\[ T_3 = 0100 \]

\[ R_1 = 00 \]

Chromosome = 0000001010000 → The total of gens in the chromosome was 14 gens

Table 4. The result of scheduling consultation.

| Time | Consultation \{Lecturers, Days, Times, Room\} | Fitness |
|------|-----------------------------------------------|---------|
| 1    | ([D1,H1,T2,R1],[D2,H1,T1,R1],[D3,H3,T3,R1],[D4,H2,T3,R1],[D5,H1,T4,R1],[D6,H2,T2,R1],[D7,H2,T1,R1],[D8,H3,T1,R1],[D9,H3,T2,R1],[D10,H4,T1,R1],[D11,H2,T4,R1],[D12,H4,T2,R1],[D13,H3,T4,R1],[D14,H3,T3,R1],[D15,H5,T3,R1],[D16,H5,T1,R1],[D17,H5,T2,R1],[D18,H5,T4,R1]) | 1.000   |
| 2    | ([D1,H1,T2,R1],[D2,H1,T2,R1],[D3,H1,T3,R1],[D4,H2,T3,R1],[D5,H1,T4,R1],[D6,H2,T2,R1],[D7,H2,T1,R1],[D8,H3,T1,R1],[D9,H3,T2,R1],[D10,H4,T1,R1],[D11,H2,T4,R1],[D12,H4,T2,R1],[D13,H3,T4,R1],[D14,H3,T3,R1],[D15,H5,T3,R1],[D16,H5,T1,R1],[D17,H5,T2,R1],[D18,H5,T4,R1]) | 0.5000  |
| 3    | ([D1,H1,T1,R1],[D2,H1,T1,R1],[D3,H1,T3,R1],[D4,H1,T3,R1]) | 0.3333  |
1) [[D8,H3,T1,R1],[D9,H3,T2,R1],[D10,H4,T1,R1],[D11,H4,T1,R1],[D12,H4,T2,R1],[D13,H3,T4,R1],[D14,H3,T3,R1],[D15,H5,T1,R1],[D16,H5,T1,R1],[D17,H5,T2,R1],[D18,H5,T2,R1]]

Table 4 was the result of the GA program which is based on the best fitness value. The result of GA programs showed that the best fitness value is 1,000. The number of iterations given was 10,000, but the iteration process in this study stopped at the 51st iteration with the total of chromosomes was ten chromosomes. The results of this study indicated that the combination of D×H×J×R would produce a schedule that does not conflict with other lecture schedules.

5. Conclusion
Based on the result of this study, we can concluded that the GA program can be used for scheduling because it has good accuracy. This can be seen from the fitness value of 1 and there is no clash between one schedule and another schedule and there are no restrictions that are violated.

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