The Application of Genetic Algorithms as an Optimization Step in The Case of Nurse Scheduling at the Bringkoning Community Health Center

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Abstract. Scheduling is an important activity that must be done in every job. In scheduling, there must be some rules that can minimize the occurrence of conflicts or gaps between schedules. In this study, applied a genetic algorithm to solve the problem of scheduling nurses in Bringkoning community health center. In the process of genetic algorithm, there are several processes that must exist until the creation of a result is a schedule. The number of nurses, population length, Cr and Mr values, and also number of iterations along with the number of days determined by input. The crossover method used is one cut-point crossover, Random mutation method and selected with elitism selection. Thereby, the analysis gained, is the value of the parameter genetic algorithm affects the optimization results. The small parameter size will cause the search area of the genetic algorithm to be narrower, whereas if the parameter size is too large it will require longer computing time and does not guarantee it will result in an optimal value for some of those variables. So, it depends on number of days in the input to get optimal result of the schedule for nursing care in the room of the emergency unit.

1. Introduction

Scheduling is an important activity that must be done in every job. In scheduling, there must be some rules that can minimize the occurrence of conflicts or gaps between schedules [1][2]. Scheduling is the allocation of time available to carry out each work in order to complete an activity to achieve optimal results by considering the existing limitations. Puskesmas (Community Health Centre) is a functional organizational unit that organizes comprehensive, integrated, equitable health efforts that are acceptable and affordable to the community with active community participation and use the results of the development of appropriate science and technology, with costs that can be funded by the government and the wider community to achieve optimal health status, without neglecting the quality of service to individuals. Bringkoning Health Center is one of the health centers in the district. Sampang on Madura Island, which has inpatient services and requires the availability of nurses at each shift. The problem of nurse scheduling is something to consider because the number of nurses is relatively limited compared to the number of patients and work shifts.

Some problem may happen during the process of making a schedule. As if one problem is solved, it turns out the other problem reappears. From these problems an algorithm is needed to solve a problem in solving a scheduling [3]. The large number of patients who need health services is in stark contrast to the number of nurses and doctors in the hospital. It resulted in the hospital that needs to
make efficient scheduling for every available human resource (including nurses and patients) so that all patients can be served well [4].

Genetic algorithm produces the best population from the initial population [5] [6]. While the advantage of Genetic Algorithms is the nature of the search method that is more optimal, without too much searching space. In compiling a Genetic Algorithm, several stages of the process are needed, namely the process of making the initial generation, genetic processes, selection processes, and repetition of processes. Genetic methods are used in several studies with complex problems. In this study, a nurse scheduling using genetic algorithm method by representing the number of chromosomes to produce an optimal solution.

2. Method
This chapter explains about the data used in research and how the genetic algorithm method works in optimizing nurse scheduling.

2.1. Data collection
The data used in this study came from the Emergency Unit of the Sampang Bringkoning Health Center which included nurse data, shift data, number of days and space data.

2.2. Genetic Algorithm
Evolution algorithm is a generic form of population-based meta-heuristic optimization algorithm that becomes a sub-set of evolutionary computing [7]. Genetic algorithm itself is very popular to be used to solve optimization problems that are complex in the fields of physics, biology, economics, sociology and others.

The process in genetic algorithms begins with initialization, which creates random individuals who have a particular set of chromosome genes. The initial population is built randomly, while the next population is the result of the evolution of chromosomes through an iteration called generational terms. In each generation, chromosomes will go through an evaluation stage using a measuring instrument called a fitness value. The fitness value of chromosomes shows the quality of chromosomes in the population. The process of reproduction produces the next generation known as offspring formed from a combination of 2 chromosomes of the current generation that act as parents using a crossover operator. In addition to the crossing operator, a chromosome is also modified using a mutation operator. Evaluation is used to calculate the fitness of each chromosome. The greater the fitness the better the chromosome is to be a potential solution. Selection is made to select individuals from the population and offspring groups that are maintained alive in the next generation. The probabilistic function is used to select individuals who are kept alive. Better individuals (having greater fitness value) have a greater chance of being selected. After passing through many times iteration (generation) will get the best individual. This best individual has a chromosome arrangement that can be converted into the best solution (at least close to optimum). From this it follows that the genetic algorithm produces an optimum solution by searching among optimum alternative points based on function.

Chromosomes in this study are permutation representations with 63 genes. Integer numbers indicate nurse numbers. Every 3 columns shows shift, so the first 4 columns show shift 1, the second 3 columns show shift 2, the third 3 columns show shift 3 and so 9 columns show the nurses' needs in one day onward until the 7th day and number 63. Chromosome representation is described in Figure 1 follows:
Penalties are violation values that do not comply with the rules [8]. The value of the violation is calculated based on the appearance of the violation on the chromosome. Every occurrence is counted 1 violation type limit and its value in this study can be seen in the following Table 1:

| The number of violations | Details | Types of Violations | Violations Constancy | Violations Value |
|--------------------------|---------|---------------------|----------------------|-----------------|
| P1                       | There can’t be one nurse in one day | soft constraint. | 5                     | 1                |
| P2                       | A nurse must have time off 2 times a week | Soft constraint. | 5                     | 1                |
| P3                       | A nurse may not get the morning shift after getting the night shift | hard constraint. | 20                    | 1                |

To determine the weight of each individual fitness value calculation is performed. This fitness value shows the quality of each individual. The results of the fitness calculation are then used to input into the selection process in finding the best individual who will be the solution to solving the problem. To calculate the value of fitness used the equation

\[ \text{Fitness} = \frac{1}{1 + (\text{number of errors}_1 + \text{number of errors}_2 + \text{number of errors}_3 + \ldots)} \]  

The selection process is done using the elitism method. The selection process is carried out to filter all individual results of the genetic algorithm to form a new generation. The selection process uses the elitism selection method by selecting the chromosomes with the greatest fitness value as much as predetermined popsize.

In this process the crossover method used is single-point crossover. Steps to the one cut-point crossover method:
1. Choose a parent randomly
2. Pairing the selected chromosome into the parent to do the crossover process.
3. Determine the crossover cut point randomly.
4. After determining the crossover point then exchange genes between 2 parent chromosomes to produce offspring.

The mutation method used is random mutation. The steps of the mutation method are as follows:
1. Choose a parent randomly
2. Randomly selecting two genes on a chromosome then swapping the value of that gene. Process Mutation (Random <Mr)

3. Result and Discussion
Tests conducted are testing the size of the generation of the value of fitness. The generation size test is used to determine the best generation for the best solution. In this generation trial 100 population size is used which is obtained from the results of population size trials that have been done previously which are considered to be able to produce the best average fitness value. The graph of the test results can be seen in figure 2.
Based on the test results on the graphic image above, the greater the size of the generation, the average fitness produced tends to be even greater. At a population size of 1000 individuals has the smallest average fitness value of 0.92 while at a population size of 10000 individuals, the average fitness value reaches a value of 0.952. The maximum generation of this test is 10000. The results of this test prove that if the number of generations is too small then the algorithm search area becomes narrower, so the solution is less than optimal.

Population size testing is used to determine the best population size to produce the best solution.

\[
\text{pops} \text{size:} \\
10 = 0.65079 \\
20 = 0.659 \\
50 = 0.66189 \\
100 = 0.75
\]

Based on testing with these data, the more population, the better the fitness value produced. Based on the test results, the greater the size of the population, the average fitness produced tends to be even greater. From the picture above also shows that the more iterations or generations, the fitness value obtained will be more optimal.

\[
\text{iterasi:} \\
10 = 0.626 \\
20 = 0.637 \\
50 = 0.657 \\
100 = 0.668
\]

Trials based on crossover rate (cr) and mutation rate (mr) are conducted to find out the best combination of cr and mr to produce the best fitness.
Obtained results as in the picture, performed a number of tests and the best fitness value is when \( cr = 0.7 \) and \( mr = 0.3 \).

4. Conclusions

Based on the results of implementation and testing in the application of genetic algorithms for nurse scheduling, several conclusions can be drawn as follows:

a. In this case the genetic algorithm is represented by a permutation based on the nurse's code. The form of chromosome representation used has the length of the chromosome according to the input of the user whose chromosome generation is random.

b. The crossover method used is one-cut point and for the mutation process uses the random mutation method. While the selection method used is elitism which produces the most optimal fitness value.

c. In determining the parameters of the genetic algorithm used in scheduling nurses, testing of parameters consisting of generation size, population size (popsize) and a combination of crossover rate and mutation rate is carried out. The results of the test are the parameters with the highest average fitness value from the experiments conducted several times.

d. Based on the test results, it can be concluded that the genetic algorithm parameter values affect the optimization results. The small parameter size will cause the genetic algorithm search area to get narrower whereas if the parameter size is too large it will take longer computational time and does not guarantee it will produce an optimal value.

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