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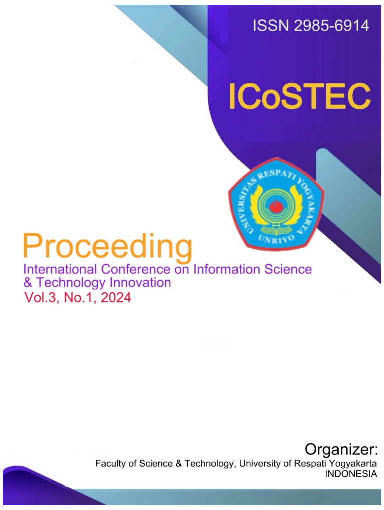

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Leveraging a Hybrid Genetic Algorithm for the Optimal Teacher Placement

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***Abstract*— The teacher placement problem is a hard problem or a Non-Polynomial Algorithm with factorial complexity. One way to solve this kind of problem is by using Genetic Algorithm. The performance of this Genetic Algorithm can be improved by trying various sub algorithms in generating new chromosomes such as crossbreeding and mutation. In addition, this Genetic Algorithm can also be improved by inserting another algorithm in the middle of the process known as the Hybrid Genetic Algorithm with the intention of preventing the condition of the solution trapped in the local optimum. In this research, a Hybrid Genetic Algorithm is used by using the single point crossover method as the crossover operator and insertion mutation as the mutation operator, and inserting a local search algorithm in the middle. The data used came from the Magelang District Education Office, with a total of 636 teachers and 106 schools. This study found that the Hybrid Genetic Algorithm could always produce better results than the Pure Genetic Algorithm using the population size parameter (20 and 40) and the probability of mutation/crossover (1:100 and 1:200). Using the Hybrid Genetic Algorithm, the shortest total distance is 11,286.908 km, while using the Pure Genetic Algorithm, the shortest distance is 11,562.830 km with the same number of iterations.**

***Keywords*: single point crossover, insertion mutation, teacher placement, hybrid genetic algorithm, local search algorithm.**

I. Introduction

In assigning elementary school teachers to schools, the Magelang District Education Office has not taken into account the distance between teachers and schools. The distance between a teacher's residence and school is one of the factors that determine teacher performance. The longer the journey from home to school, the more it will affect the teacher's fitness and in turn will affect the teacher's performance at school. For this reason, teacher placement should also take into account the distance between the teacher's residence and the school, meaning that the total distance between the teacher and the school should be as short as possible [1]. The teacher placement problem is similar to the Traveling Salesman Problem, which is a non-polynomial complexity problem. For this reason, it would be more suitable if this problem is solved in a non-deterministic way or it can be said that it is better solved using a probabilistic algorithm.

In previous studies, this teacher placement problem has been solved using ordinary genetic algorithms with various variations of crossover and mutation methods. [2], [3]. Gen & Cheng [4] said that genetic algorithms use only a few mathematical calculations in solving a problem, and are effective in global search, and have high flexibility to be hybridized with other search methods to be more effective. The genetic algorithm can perform a global search in the entire space, but does not have the ability for local search around the convergence region. Hybridizing genetic algorithms with local search techniques can improve the performance of genetic algorithms by adding new best individuals in the genetic algorithm cycle. [5].

In this research, a solution model will be created with a hybrid genetic algorithm to solve the teacher placement problem. Hybrid genetic algorithm is a form of population-based genetic algorithm hybridized with individual learning procedures capable of improving global search, so that the quality of the resulting solution is better, more efficient, and guarantees a more feasible solution. In this research, the single point crossover method will be used as the crossover operator and the insertion mutation method as the mutation operator and by adding the insert-based local search operator as the local search procedure.

II. Literature Review

This section specifically discusses pure genetic algorithms and hybrid genetic algorithms.

A. Genetic Algorithm

Genetic algorithm is a heuristic optimization inspired by natural selection and genetics. It was developed by Holland [7] and Goldberg (8). In genetic algorithms, the population of potential solutions is referred to as a set of chromosomes or population. Chromosomes or individuals evolve successively from generation to generation using a set of genetic operators, namely selection, crossover and mutation. The process of reproduction of new individuals is created through the application of these operators. A large number of operators have been developed to improve the performance of genetic algorithms, as the performance of these genetic algorithms depends, among other things, on the capabilities of the operators. Selection operators are used to select chromosomes to be produced into new individuals. Interbreeding operators are used to combine genetic information between chromosomes to explore the search space. Meanwhile, the mutation operator is used to maintain a population with sufficient chromosome diversity and avoid premature convergence or prevent local optimum.

The steps in Genetic Algorithm are as follows:

1. [Initialize parameters such as population size (n), mutation: crossover probability, and number of iterations.
2. [Initial Population] Generate an initial population of n chromosomes.
3. [New Population] Repeats the following steps to create a new population.
    a. [Fitness] Calculates the fitness value of each chromosome in the population.
    b. [Selection] Selects the parent chromosome for reproduction.
    c. [Regeneration] Perform crossover or mutation process
    d. [Offspring evaluation] Placing a new offspring into the population if the fitness value of the offspring is greater than the fitness in the current population.
4. [Population switch] Using the new population for the next genetic process.
5. [Stop check] If the stop condition is reached, the genetic process ends.
6. [Recursion] If the condition in step 5 is not met, then go back to step 3.

B. *Hybrid Genetic Algorithm*

Hybridization is an effective way to improve the performance and efficiency of genetic algorithms. One form of hybridization that is often used is the combination of genetic algorithms with local search algorithms. Local search is the exchange of information carried by genes on child chromosomes. In a hybrid genetic algorithm, the main role of the genetic algorithm is to explore the search space to find the global optimum, while the local search algorithm uses the information gathered by the genetic algorithm to solve the local optimum [9].

The following are the steps for the hybrid genetic algorithm proposed by Wan and Birch [10]:

1. Define the fitness function and set the GA operators (such as population size, number of generations, selection method, mutation probability, crossover).
2. Randomly generate an initial population and make it the current parent population.
3. Evaluate the objective function for each individual in the initial population.
4. Generate the child population using GA operators (such as parent selection, crossover, and mutation).
5. Evaluate the fitness of the children.
6. Is the child the best among the other children and the best of the current parent population?
7. If not, do step 9. No local search occurs in this generation.
8. If yes, then perform local search on the best child chromosome. Find the best locally improved solution and replace the best offspring with it.
9. Decide which chromosome to include in the next population. This step is referred to as "replacement" where the chromosomes of the current parent population are "replaced" by a new population consisting of the chromosomes of the child and/or parent populations.
10. If the number of stopping conditions is met, then the looping process is stopped. Otherwise, proceed to step 3.

III. METHODS

A. *Research Data*

Data was obtained from the Magelang District Education Office in the form of teacher data and elementary school data. Teacher data consists of 636 data consisting of id_teacher, name, and coordinates of the house where they live. Meanwhile, school data includes id_school, school name and coordinates. It is assumed that each school has 6 study groups. From the data above, the distance between the teacher's house and school is calculated using the Haversine formula. [6]

B. *Chromosome Representation*

The chromosome expresses a solution, namely how to place teachers in schools so that the total distance is minimal. In order for the chromosome to be subjected to the genetic algorithm operator, in this case the chromosome is expressed in the form of an array of 636 length where the contents are in the form of characters representing the identity of the teacher. while the array represents school classes, where each school consists of 6 classes. This can be described as shown in Fig. 1

S1	S2	S3	S4	S5	S6				Sm
T1	T2	T3	T4	T5	T6	…	…	…	Tn

Figure 1. Representation of chromosome

C. *Fitness Function*

The goodness of a chromosome or solution is determined by calculating its fitness function. In this case the fitness function is the total distance from each teacher to their respective schools. This fitness function can be calculated because all distances between teachers to schools are known using the Haversine formula.

D. *Selection Method*

The process of selecting chromosomes for crossover or mutation is done using the *roulette wheel method*, where the probability of a chromosome being selected for crossover or mutation is proportional to its own fitness value. The higher the fitness score, the higher the probability of selection. [11]

E. *Crossover*

In this research, the crossovering method used is single-point crossover. In the single point crossover method (SPX), there is only one crossing point with a randomly generated position. The crossing point is determined by generating a random number in the range of 1 to the length of the chromosome. For example, as shown in Fig. 2., there are two chromosomes, parent 1 and parent 2 with a chromosome length of 6, and the random number as a crossing point generated is 3, so genes 1 to 3 will be cut with

4 to 6. Furthermore, genes 1 to 3 in the first chromosome will be crossed with genes 4 to 6 in the second chromosome, to become the children and vice versa. [12], [13]

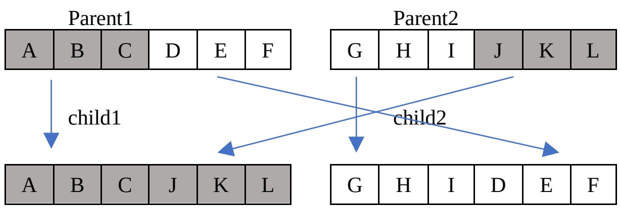


Figure 2. Single Point X-Over

F. *Mutation*

In this research, the mutation operator used is swap mutation as seen on Fig 3. The first step is to randomly select two gene positions in the parent chromosome. Then the two genes are swapped to become new generation. [14]

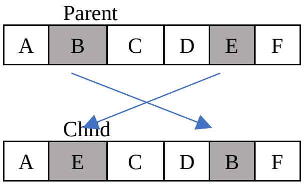


Figure 3. Swap Mutation

G. *Local Search*

The exploration capability of genetic algorithms can be further enhanced by utilizing local search. Local search is performed by changing the genetic makeup of the child chromosomes without affecting the quality of the previous chromosomes. Local search is performed to find better solutions in the neighbourhood of offspring, and increase population diversity, especially when the resulting offspring are similar to the population. Basically, local search is expected to provide another better solution around the local optima given by the genetic algorithm. The local search operator used here is the insert operator. This insert local search procedure is performed by randomly selecting two gene positions, namely positions 1 and 2 in the parent chromosome, where position 1 cannot be the same as position 2, then insert the gene at position 2 in position 1 and shift to the right all genes to the right of the insertion location, as shown in Fig.4. [15]

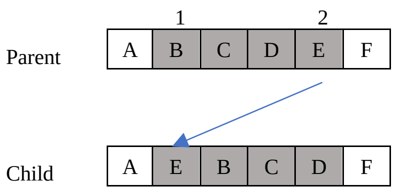


Figure 4. Insertion

IV. RESULT

In this study, the program was created using the Python programming language, then the program was run many times by varying the number of chromosomes in the initial population, the mutation/crossover probability (pm) while the number of iterations was limited to a maximum of 1,000 iterations. The input of this program is data obtained from the Magelang District Education Office, in the form of distance data between schools and teachers, where the number of schools is 106 while the number of teachers is 636 people. From the experiments conducted, the following results were obtained as shown in Table 1 and Table 2:

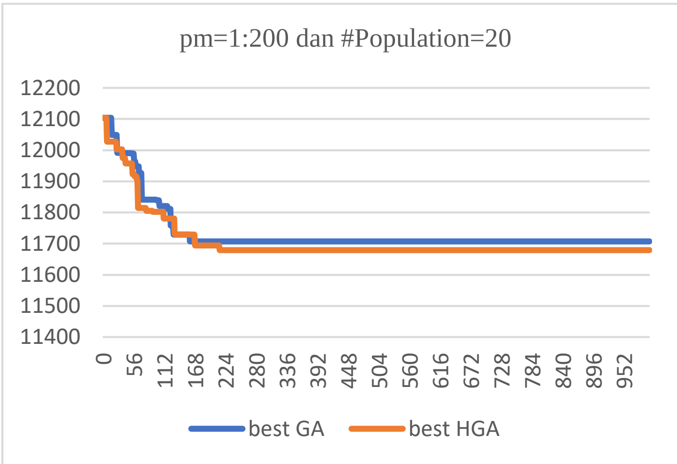
Table 1. Result of Pure GA

#Population	pm	Total Distance
20	1:100	11,802.2091 km
20	1:200	11,707.2259 km
40	1:100	11,563.0078 km
40	1:200	11,563.8300 km

Table 1. Result of Hybrid GA

#Population	pm	Total Distance
20	1:100	11,654.55845 km
20	1:200	11,679.21755 km
40	1:100	11,292.26081 km
40	1:200	11,286.90802 km

The graph below (Fig. 4) shows the change in fitness value of the pure genetic algorithm (GA) and the hybrid genetic algorithm (HGA), where it is visually apparent that the hybrid genetic algorithm is always better than the pure genetic algorithm.



V. Discussion

From the experiments conducted, it can be seen that changing the mutation/crossover probability has no effect on the results obtained. On the other hand, increasing the number of initial populations has a significant effect on the results obtained, namely better or shorter results, both for pure genetic algorithms and for hybrid genetic algorithms. When these two algorithms are compared, overall for each experimental parameter, it turns out that the hybrid genetic algorithm is able to produce results that are always better than the pure genetic algorithm. This shows that hybridization of genetic algorithms can indeed produce new offspring that are better than pure genetic algorithms. This is because the hybrid genetic algorithm can produce a variety of new offspring from the results of the pure genetic algorithm, and the probability of getting better offspring can arise from there. From the graph of experimental results, it can be seen that for pm = 1:200 and population of 20, starting from the 165th iteration, the results of the hybrid genetic algorithm always outperform the results of the pure genetic algorithm. Genetic algorithm hybridization cannot only use the insertion method, there are other methods that can be used such as the swap or scramble method or others. These other hybrid methods are worth trying as they also give hope for more varied offspring.

VI. Conclusion

The findings of this study can be summarized as follows:

1. Hybrid Genetic Algorithm using Local Search shows better performance than Pure Genetic Algorithm.
2. The shortest total distance produced by the pure Genetic Algorithm is 11,562.83011 km while the Hybrid Genetic Algorithm produces 11,286.90802 km.
3. At the 165th iteration the Hybrid Genetic Algorithm has started to outperform the Pure Genetic Algorithm, so there is no need to do large iterations.

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