Optimization of Genetic Algorithm for Urban Traffic Light Schedule Problem

Sartikha[1], Noper Ardi[2], Ahmadi Irmansyah Lubis[3]

{sartikha@polibatam.ac.id[1], noperardi@polibatam.ac.id[2], ahmadi@polibatam.ac.id}

[123]Department of Informatics Engineering, Politeknik Negeri Batam, Batam, Indonesia

Abstract. Congestion is a major problem at urban traffic light intersections. One of the problems is the uneven distribution of vehicles at traffic light intersections, even though the portion of green duration at traffic light intersections is the same. Must present an adjusted deduction based on the number of vehicles at each intersection. In addition to optimizing the green duration, if you only consider one intersection, it will cause other problems such as congestion at the next connected intersection so that the required parameters are used for coordination between the initial intersection and the next connected intersection. In this research, optimization was carried out by giving weight to each parameter based on real vehicle data passing through the route at 11 intersections in Yogyakarta. At 11 intersections, 9 traffic light intersections were taken which will make the optimal green duration based on the parameters of the initial flow, destination flow and trip duration for traffic light coordination between the initial traffic light intersection and the next connected traffic light intersection. Next, the fitness function is formulated and then processed using a genetic algorithm. In the Genetic Algorithm optimization process, chromosomes are the green duration of 9 traffic light intersections which will then be processed with the genetic algorithm stages. The result is 9 optimal green durations based on the initial flow, the destination flow and the duration of the trip. The green duration adjusts the weights with maximum accuracy and reduces the vehicle travel duration from 44-64 seconds per one traffic light and a total of 419 seconds at 9 traffic intersections from the optimized data.

Keywords: Optimization, Genetic Algorithm, fitness, Selection Probabilities, Traffic light signal.

1 Introduction

Congestion in Indonesia is increasing every year. In 2015 Indonesia was ranked 11th just below Brazil and Argentina as the most congested country in the world with an estimated average time index when traffic jams reached 40.58 minutes. In 2017, the ranking increased, namely 2nd place with a time index of 49.44 minutes. (www.numbeo.com). One of the points of urban traffic congestion occurs at a red light intersection. The urban traffic network consists of roads that connect to each other through intersections or from a number of intersections[1][2]. In Indonesia, every urban intersection usually uses a traffic signaling device in the form of an electronic device that uses light signals that can be equipped with sound signals to regulate traffic. Traffic is the

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movement of vehicles and people in the road traffic room[3]. The mechanism at every intersection road users will stop if the light signal is red and will continue the journey if the light signal is green. This mechanism will continue to repeat at each intersection. Metaheuristics is a method used to solve complex optimizations which is an extension of the approximate search method[4][5][6]. Harmony Search is a relatively new metaheuristic algorithm developed by previous researchers[7][8]. Another approach taken by the researcher is to change the fixed time signal controller to an adaptive time signal control, then use a Genetic Algorithm which is one of the metaheuristics to get the optimal green signal time. Genetic algorithms were also used to optimize the placement of traffic signs based on the comprehensive traffic model of the Department of Public Works, Malaysia. This study succeeded in maximizing the green time to 55 seconds[9][10]. Other researchers use Genetic Algorithm for traffic green light optimization by considering the number of vehicles. The optimization result is an extension of the green light duration which will be added to the previous fixed green light and applied to the emulator[11][12]. Using a genetic algorithm with pedestrian queue parameters was also added to get the optimal green duration optimization[13].

Signalized intersections are one solution to various problems such as avoiding accidents such as collisions due to vehicles coming from the opposite direction, maintaining capacity in traffic conditions at peak hours due to traffic conflicts that cause congestion at intersections. Fixed time signal controllers are still used at several intersections in Yogyakarta, the fixed duration of the green light is 30 seconds. In fact, each side of the road at the connected intersection has parameter characters with different values, so that dividing the duration of traffic light time using the same distribution for all sides of the road becomes less than optimal, besides that other problems will arise when optimizing the green duration is only done at one intersection, for example one intersection is given a long green duration, it turns out that at the next intersection there is a severe buildup of vehicles. This study will use the metaheuristic method to optimize the green light to be more optimal. In the algorithm studied from previous research, the Bee Colony and Discrete Harmony algorithms are used to change the direction based on the input parameter information with a predetermined time duration. Meanwhile, to optimize the green duration, the previous researchers used the Genetic Algorithm, one of the reasons is because the Genetic Algorithm. It only requires information about the quality of the solution generated by each set of variables. Some optimization methods require derived information or even need to have a complete understanding of the structure of matter and variables. Genetic Algorithm does not require specific information about a problem so it is more flexible[13][14]. It's just that in previous studies the genetic algorithm only considers the parameters for each intersection and has not considered the coordination between traffic intersections. Though the possibility of other problems will arise if you do not consider this. For example, regarding the number of vehicles to reduce vehicles at one intersection, the intersection is given a long green duration even though at the destination intersection there is an accumulation of vehicles. This allows solving a congestion problem on the one hand but adding to congestion on the other. So that this study will use a genetic algorithm to optimize the duration of the green traffic light will consider the parameters of the initial flow or the number of vehicles at the signalized intersection for traffic light control on the duration of the green and consider the duration of the trip and the destination flow for coordination between traffic intersections. The parameters of the initial flow, the destination flow and the duration of the trip will be entered into the fitness of the genetic algorithm to get the optimal green duration.

2 Material and Methods

2.1 Genetic Algorithm

Genetic algorithm is an algorithm that is commonly used to solve the search for values in an optimization problem. The genetic algorithm looks for individuals with the highest fitness values. Fitness value is a measure of whether or not an individual is used as a reference in the genetic algorithm to find the optimal value[15][16][11]. For example, in the case of minimizing the distance, the fitness value is the inverse of the total distance from the route obtained. The trick can be using the formula 1/x, x is the total distance from the path obtained. In genetic algorithms, we recognize definitions that will be used in the optimization process, namely: Individuals are one of the possible solutions to the problems raised. Individuals in the genetic algorithm are a collection of genes that can be said to be the same as chromosomes, the combination of genes will form a certain value[9][17]. Genes can consist of float, combitional and binary, the value of the gene is called allele. One cycle of the evolutionary process or one iteration in the genetic algorithm is called Generation. Population is a group of individuals that will be processed together in an evolutionary cycle to generate an initial population that is carried out randomly. The main components in applying genetic algorithms are:

1. Coding Technique

Coding technique is a way of encoding a gene that is part of a chromosome, a gene will usually represent one variable. Data types to represent chromosomes using bit strings, arrays of real numbers, permutation elements, rule lists, program elements and other structures.

2. Generating Initial Population

The initial population is generated by generating a number of individuals randomly through a certain procedure. The size of the population depends on the problem to be solved and the type of genetic operator to be applied. The initial population generation is carried out after the population size is determined, for the generation of each individual must pay attention to the conditions that indicate a solution must be met.

3. Chromosome Evaluation

Chromosome evaluation is done with an objective function, the value of the variable that has certain rules will be converted into an equation. For example, what you want to solve is the value of x, y and z, these values must meet the equation $x+2y+3z=200$, then the objective function that can be used to get the solution of the objective function (chromosomes)$=|(x+2y+3z)-200|$. The objective function is calculated by entering a randomized value.

4. Selection

The next process is selection which is used to select individuals for further crossbreeding and mutation processes. Selection is done to find a good parent candidate so that a good parent can produce good offspring. The first step in making a selection is to find a fitness value to be used in the next selection stage. Each individual in the selection container will receive a reproduction probability that depends on his own objective value against the objective value of all individuals in the selection container. The selection process is carried out by making chromosomes that have a small objective function with a high probability of being selected or with a high probability.

5. Crossover Process

Crossover is the operator of the genetic algorithm for the formation of new chromosomes involving two parents. Crossover generates new points in the search space that are ready to be tested. Individuals are randomly selected for crossing with a crossover probability between 0.5 to 0.95. If crossing over is not done then the value of the parent will be passed on to the offspring. The principle of this crossover is to perform operations on the genes of the two parents to produce new individuals.

f. Mutation Process

Gene mutation is the next operator in the genetic algorithm whose role is to replace genes that are lost from the population due to the selection process, genes that do not appear on initialization are likely to reappear. The daughter chromosomes are mutated by adding a very small random value and with low probability[18]. The probability of mutation (probability) is defined as the percentage of the total number of genes in the population that are mutated. Mutation probabilities control the number of new genes that emerge for evaluation.

2.2 Signal Intersection

Signalized intersections are part of a fixed time control system with three colors of lights, namely red, yellow and green lights to separate traffic movements from opposite directions that intersect at the intersection. So that it can avoid accidents such as collisions due to vehicles coming from the opposite direction, maintain capacity in traffic conditions at peak hours due to the flow of traffic conflicts that cause congestion at intersections. The red light means the vehicle is stopped, the green light is the vehicle may pass while the yellow light is the time between green and red. Yellow time is used as a warning that the phase has ended, giving time for the last vehicle in the green phase to complete its journey through the conflict area. The preset red, yellow and green signal times that do not change during operation are called fixed signal control.

In urban traffic lights one intersection connects another intersection in a horizontal direction and a vertical direction. Changing traffic lights at one intersection can change the order of connected vehicles, reducing the number of vehicle discharges on each side of the road and affecting the traffic lights of neighboring intersections, even significantly affecting destination function. For the same intersection, changing traffic lights in different time intervals will also affect the objective function.

2.3 Data Preparation

This study uses real data from Iqbal, M[19] research of 11 intersection points whose routes have been determined with two T-junctions and one traffic light intersection in Yogyakarta, the intersection route data will be optimized for the green light. The intersection has the same fixed green time of about 30 seconds per side of the road, 90 seconds of red time and about 2 seconds of amber light. 16 routes with 9 traffic light intersections, the green time will be optimized with a predetermined Genetic Algorithm and connected to the next traffic light intersection can be seen in Table 1, while the route map is in Figure 1. The data that will be used to optimize the green light with the genetic algorithm are as follows:

Fig.1 Intersection data map

The map above is a traffic intersection that will optimize the duration of the green. Each intersection is coded with P1 to P9, P1 Unity Street, P2 Terban Street, P3 Cik Ditiro Street, P4 Suroto Street, P5 Sardjito Street, P6 Colombo Street, P7 Kahar Muzakir Street, P8 Simanjuntak Street, P9 Sudirman Street, P10 Sudirman Street(one way), and P11 Jalan Pancasila.

Table 1 intersection code and traveling time

Intersection code	Travel duration to the next signalized intersection	Destination Intersection code
P1	180	P3
P2	0	0
P3	120	P9
P4	60	P2
P5	180	P3
P6	180	P3
P8	0	0
P9	180	P2
P10	180	P2

3 Experimental Design

The research flow contains research stages, the stages begin with conducting a literature study on metaheuristic algorithms used to solve urban traffic congestion problems.

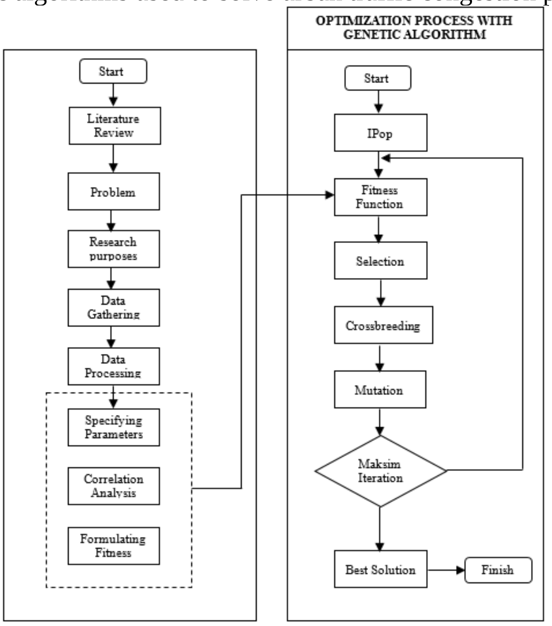

Fig.2 Research Flowchart

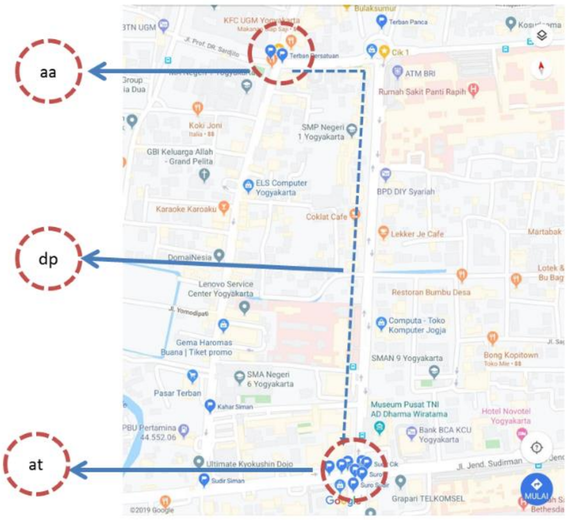

Fig.3 traffic map

In Figure 2 the traffic map 3 parameters that will be used for optimization are the initial flow (aa), the destination flow (at) and the duration of the trip (dp).

3.1 Define parameters

There are 3 parameters that will be used for this research, namely the initial flow, the destination flow and the duration of the trip. The initial flow is obtained from the total number of vehicles at the initial intersection, the destination flow is obtained from the total number of vehicles that will pass through the next signalized intersection route that is connected and stops due to traffic lights. Furthermore, the travel duration parameter is the distance between one intersection and the next connected signalized intersection.

The initial current value is the total number of vehicles at the starting point of the intersection. The initial flow value of P1 is the total sum of the number of vehicles on routes number 1,4 and 16. The total number of vehicles from each route is 390,282 and 510. So the total value of P1 is 1182. In addition, the initial flow for intersections that are not at the point At the beginning of the route, the initial flow value will be taken from the number of vehicles that will pass through the intersection. An example for the initial flow value on P2 is the total number of vehicles on routes number 7 and 8. The total number of vehicles from each route is 343 and 955. So the total value of P2 is 1298. The sum of the initial flows at all intersections will be optimized.

1. Formulate Fitness

Finding the fitness value is calculated based on the minimize formula, the value if x+2y+3z=200 then to find the x,y and z values which are genes in the genetic algorithm, the following formula is used x+2y+3z-200.

The best value is the value that has the least difference with a value of 200. In this study, the stages of formulating fitness refer to the formula with the following stages:

a. The minimized function is the total green duration value of 9 gene junctions consisting of P1, P2, P3, P4, P5, P6, P7, P8, and P9.
b. Before entering the minimal function, the total cycle or total green duration is calculated and multiplied by the weight of the 3 parameters to get the green duration based on the weight. The formula is as follows, the value of c is the total number of green durations from P1, P1, P2, P3, P4, P5, P6, P7, P8, P9 which are randomized by genetic algorithms.
c. Next, look for the difference in value between the optimal green value that has been processed with the weight of the 3 parameters (g A(i)) and the green duration that has not been processed with the weight (g(i))
d. The total value of the difference between each optimal green duration (P(i)) with the following formula:

$$F(x) = P1 + P2 + P3 + P4 + P5 + P6 + P7 + P8 + P9 \quad (1)$$

3.2 Optimization Process

The optimization process with the genetic algorithm as seen in flowchart (figure 2) begins by initializing the initial population. The initial value is the value taken from a predetermined random value.

Table 2. Genetic Algorithm Parameters

Detail	Parameter	Value
Total Population	nPop	400

Maximum Repetition	MaxIT	50
Green (Min and Maks)	gMin-gMax	10-30 Second
Probability *Crossover*	Pc	0.5
Mutation Probability	Pm	0.02
Maximum Cycle	C	270 Second

To determine the initial population and calculate the fitness value, the following rules are used. Chromosomes (K) consist of 9 signaled intersections, namely P1, P2, P3, P4, P5, P6, P8, P9, and P10. The gene value is the duration of the green light that will be randomized and limited to a minimum value of green and a maximum of green. Then the randomized value will be calculated its fitness. The best fitness will be used as the initial population.

$$F(x) = P1 + P2 + P3 + P4 + P5 + P6 + P7 + P8 + P9 \quad (1)$$

$$P(i) = abs(gA(i) - g(i)) \quad (2)$$

$$gA(i) = \left(\frac{\frac{aa}{\sum aa}+\frac{at}{\sum at}+\frac{dp}{\sum dp}}{3}\right) x\ c \quad (3)$$

Information:
aa = initial current number of vehicles
at = destination flow number of vehicles
dp= duration of travel between intersections
P = fitness value of each intersection
F= Fitness value of all intersections
g= duration of vehicle green value
gA= weight duration based on cycle
c= total cycle duration optimal green
i= intersection index

3.3 Selection Process

The selection process which is one of the operators in the Genetic Algorithm is one of the processes used to select the best chromosomes in a population so that it has a greater chance of being processed further. Good parents will produce good offspring too. In this process the chromosomes that are less likely to be removed are removed. The selection procedure is as follows:

a. Calculate the total fitness Fk , k is the number of population and Fk is the fitness value
b. Calculate the relative fitness of P for each chromosome with the formula and , The selection opportunity value (Ps) is obtained from the exponential of the selection value multiplied by the best fitness (Tk) divided by the worst fitness (Wk) then the P value is divided by the Total Number of Ps (TP).
c. Calculate the cumulative fitness for each chromosome Ci=Ps, c=cumulative Ps
d. Select the parent that is a candidate for crossbreeding:
   1) Generate random number r
   2) Choose a chromosome that satisfies the condition, the random value of r is less than or equal to the cumulative probability value (r<=c).

3.4 Crossover

After the selection process is carried out, then a crossover process is carried out, the crossover operator in the Genetic Algorithm is used to perform crossbreeding on the previously selected parents. This process will be carried out 50 times in 400 populations. The number of crossover population will be calculated based on the crossover probability (Pc). The crossover procedure in this study is as follows:

a. Determine the population to be crossover with the specified mutation probability
b. Select the parent to be crossover, namely p1 and p2.
c. Determine the crossover position by generating a random value of 1 until the length of the chromosome is reduced by 1. In this study, one chromosome contains 9 genes, namely P1, P2, P3, P4, P5, P6, P7, P8, and P9. Then do the crossover.
d. The chromosomes that have been crossed will have their fitness calculated and the best fitness and minimum and maximum green durations that meet the initial initialization will be taken. Then the next optimization process is carried out until the maximum iteration.

3.5 Mutation

The next optimization process is crossover, gene mutation is the next operator in the genetic algorithm whose role is to replace genes that are lost from the population due to the selection process, and genes that do not appear on initialization are likely to reappear. The daughter chromosomes are mutated by adding a very small random value and with low probability. The probability of mutation (probability) is defined as the percentage of the total number of genes in the population that are mutated. Then the gene is selected at random and replaced with another gene selected at random. The mutation procedure carried out in this study is as follows:

a. Determine the number of mutation population with mutation probability. The value of the probability of mutation in this study is 0.02
b. The process of selecting the position of the gene to be mutated by generating a random value. Then the mutation is carried out. The mutation value must meet the maximum cycle requirements and the minimum and maximum green duration limits that have been determined.
c. The fitness of the appropriate chromosome will be calculated and the best fitness will be taken. Then the next optimization process is carried out until the maximum iteration.

The new population resulting from the Genetic Algorithm optimization process, namely selection, crossover, and mutation, is combined and the best fitness value is taken and repeated until the maximum iteration. The last iteration value with the best fitness will be used as a new solution for the green duration of traffic lights at 9 intersections.

4 RESULT AND DISCUSSION

This study optimizes the duration of the green traffic light consisting of 3 intersections, 2 forks and 1 intersection. The green duration taken consists of 9 intersections that have traffic light signals from the 16 intersection data routes described in the previous section. The 9 intersections are coded with P1 to P9 for optimization by Genetic Algorithm. P1 Jalan Unity, P2 Jalan Terban, P3 Jalan Cik Ditiro, P4 Jalan Suroto, P5 Jalan Sardjito, P6 Jalan Colombo, P7 Jalan Simanjuntak, P8 Jalan Sudirman, P9 Jalan Sudirman (one way). The green duration at the

9 signalized intersections will be optimized by considering 3 parameters, namely the initial flow parameter, the destination current and the duration of the trip. The three parameters will be normalized to be used as weights and entered into the fitness formula. The fitness value based on the weights of the 3 parameters will be entered into the genetic algorithm optimization process. The best fitness value will be taken as the optimal green duration. In this section, we will explain the results of the optimization process for the green duration of traffic lights from 9 intersections.

Genetic algorithm is used to optimize the green light value based on the duration of the trip and the number of vehicles. The duration of the green light will be randomized and fitness is calculated based on the initial flow of the vehicle, the current destination and the duration of the trip. The number of initial population input is 400 which will then be selected using Roulette Whell, selected individuals whose random values are less than or equal to the cumulative value of the Selection Probability (Ps). Then the selected individuals will be cross-breeding and mutating. The probability of crossbreeding and mutation values are 0.5 and 0.02 so that the number of individuals interbreeding and mutating is 200, this value is obtained by the value of the crossbreeding and mutation probability multiplied by the initial population (nPop x P). nPop is the number of initial population and P is the probability value of interbreeding or mutation.

4.1 Fitness Weighting Result

In this part will be explain about the results of the Genetic Algorithm Fitness Weighting on the parameters of the initial flow, the destination flow and the duration of the trip. The fitness value is the average weight of each intersection times the ratio of the randomized greens divided by the total duration of green at 9 intersections. The following weights are obtained based on the initial flow data, the destination flow and the duration of the trip described in the previous section. To find out the fitness performance with 3 parameters that are weighted with predetermined rules, namely by calculating the value of the entire cycle which is the total green duration of 9 intersections. The green duration value based on the weight will be compared with the green duration which is processed by the genetic algorithm. The green duration value based on the weight will be compared with the green duration which is processed by the genetic algorithm. The weight value is in the following table.

Table 3 weight calculation result

No	junction code	Initial current weight	Destination flow weight	Travel duration weight	Average Weight
1	P1	0.101311391	0.106253762	0.121621622	0.109728925
2	P2	0.111253964	0.16408601	0.135135135	0.136825036
3	P3	0.090683123	0.080483668	0.081081081	0.084082624
4	P4	0.215993829	0.093122504	0.040540541	0.116552291
5	P5	0.070369418	0.099469278	0.121621622	0.097153439
6	P6	0.111596812	0.106253762	0.121621622	0.113157398

7	P8	0.101911374	0.16408601	0.135135135	0.13371084
8	P9	0.131053398	0.093122504	0.121621622	0.115265841
9	P10	0.065826691	0.093122504	0.121621622	0.093523605
Total		1	1	1	1

4.2 Optimal Green Duration Results and Algorithm Performance Analysis

Figure 2 illustrates the trace of the fitness value in the Genetic Algorithm where in 9 genes consisting of 9 traffic light intersections. The fitness value converges at the 40-50 iteration. So that the optimal green duration value for the best fitness can be taken at the 40-50 iteration. The green duration on the fitness will be used as the optimal green duration.

Furthermore, the value of the optimal green duration based on the weight of the fitness value and the optimization used with the genetic algorithm will be compared to the level of accuracy. The total duration is the sum of the green durations at 9 intersections. Optimal green duration at 9 intersections obtained from random values in the Genetic Algorithm optimization process using matlab. The stages of the results of the green duration optimization process on the fitness value with the Genetic Algorithm are as follows:

1. The green duration of 9 intersections is calculated in total and then multiplied by the weight of each intersection.
2. The green duration of the 9 intersections randomized by the genetic algorithm process is compared with the total green duration based on point a.
3. Next, the value of the 2 green durations being compared is sought for the difference in value. The smallest value difference is the green duration value with the best fitness.

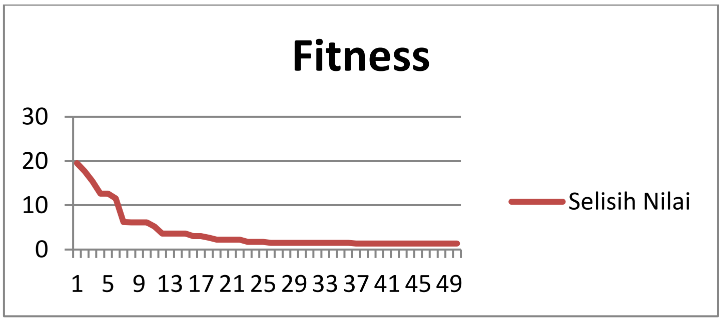

Fig.4 fitness value based on the number of iterations

In the diagram above, the more iterations, the smaller the difference in value or fitness. The best fitness is the most minimal fitness and the optimal green duration will be taken. The level of accuracy of the genetic algorithm on the best fitness reaches 99 percent. The results of the percentage of accuracy based on iteration can be seen in the diagram below.

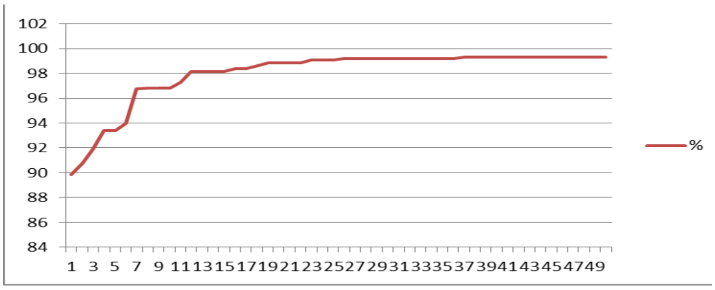

Fig.5 Optimal green duration accuracy percentage with genetic algorithm

The results of the green duration with the best fitness or optimal green duration for 9 P1-P9 intersections with a crossover probability value of 0.5 and a mutation of 0.02 in a total population of 400 and 50 repetitions are 22, 25, 15.4, 21.4, 18, 21, 24, 21, 17.

Table 4 Comparison of the difference between fixed green duration and optimal green duration

No	Difference between Fixed Green and Optimal Green with GA	Value
1	Fixed Green Value Difference	**87.2**
2	Fixed Green Value Difference with optimal duration	**21.9198591**
3	Optimal green duration difference with GA	**1.35823277**

To measure the performance of the fixed green duration value algorithm, the fixed green duration value with the optimal number of cycles and the optimal green duration value with the genetic algorithm will be compared. Then look for the difference in value between the 3 conditions. The result is that the green duration using the genetic algorithm only differs about 1.3 seconds while the green duration remains with a total cycle based on a random value having a time difference of 21 seconds. While the green remains which is the initial value of the traffic data has the largest time difference, namely 87 seconds.

4.3 Comparative analysis of travel duration between fixed green duration and optimal green duration

Green duration is considered good if the fitness value is getting smaller. In this study, the duration of the journey between the duration of the green is fixed and the duration of the green is optimal. The green duration is fixed with a duration of 30 seconds for 9 intersections and the green duration has been optimized by genetic algorithms. Comparisons are made on the route from the initial intersection to the traffic light destination intersection. The total duration of the trip of fixed duration (TDPt) and the total duration of the trip at the optimal green duration (TDPO) were obtained from the sum of the duration of the trip and the duration of waiting. Pa is the initial intersection and Pt is the destination intersection. Travel duration between intersections (Dp) is summed with the initial cycle (cTa) for a fixed green duration or (cOa) for optimal green duration and destination cycle (cTt) or (cOa) for optimal green duration cycles.

Furthermore, the duration of the trip at the fixed green duration and the travel duration at the optimal green duration were compared. The difference in the duration of the green trip is fixed and optimal reaches 419 seconds, the difference in the duration of the trip is the duration of the trip that has been successfully reduced in the traffic light cycle with the green duration optimized using the Genetic Algorithm.

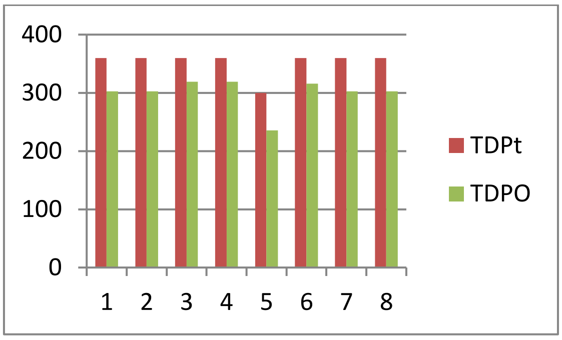

Fig. 6 Comparison of Fixed and Optimal Green Duration Trips

5 CONCLUSION

In this study, the authors carried out an optimization design for scheduling traffic lights at intersections. The optimization design uses the parameters of the initial flow, the destination flow and the duration of the trip from one intersection to the next connected traffic light intersection. The optimization method used is one of the metaheuristic methods, namely the genetic algorithm. The conclusion of this research is that it is successful in optimizing the green duration with Genetic Algorithm. Formulate fitness based on the parameters used for traffic light scheduling which consists of 3 parameters, namely initial flow, destination flow and trip duration, then the optimization process is carried out with genetic algorithms. Measuring the fixed and optimal green duration to validate the performance of the genetic algorithm against the previous fixed duration. The value of fixed duration or optimal duration is sought for the difference based on the previously calculated weight. The result is that the difference between the fixed green duration and the optimized green duration with the genetic algorithm is 86 seconds. The green duration successfully adjusts the weights with maximum accuracy and reduces the vehicle trip duration from 44 to 64 seconds per one traffic light and a total of 419 seconds at 9 traffic intersections from the optimized data.

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