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The Adaptive Traffic Light Timer Design Using Fuzzy Logic Control(A Case Study At The Bridge Of Soekarno Hatta Crossroad Malang)

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Abstract : *A conventional traffic light timer usually uses fixed timer control system. It is considered necessary to develop such an adaptive traffic light controller in which its systems operate under three fuzzy logics. First, determining the phases order based on vehicles queuing length (m/meters); second, determining the green light signal duration (s/ seconds) based on the length of vehicles queuing inputs and the vehicles traffic volume (passenger car units/ 5 minutes); third, determining the decision whether to continue or halt the green light signal duration based on the remaining numbers of vehicles queuing at the intersection of Soekarno Hatta Street. There were three membership functions, namely the input membership function which was defined as the vehicles queuing length and the volume of vehicles traffic. Meanwhile, the output membership function was the green light signal duration. Each membership function was established by classifying the fuzzy set inputs and outputs using Mamdani method. The assembled design was simulated in order to observe the green light signal duration, the traffic volume, and the vehicles traffic volumes passing the said intersection using a Processing Software. This article aims to optimize the green light signal duration in order to increase the vehicles traffic volume passing the said intersection. The result of the study shows that the traffic light which uses Fuzzy Logic could operate adaptively and the passing vehicles traffic volume is greater compared to the conventional system.*

Keywords –*traffic light, fuzzy logic, mamdani method, intersections, phase order*

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I. INTRODUCTION

Intersections often become centers of traffic congestions, since the volume of coming vehicles traffic is bigger than the one leaving the intersections. Traffic congestions could precipitate exhaustion, lead to inefficient use of fuel, worsen the air pollution, cause accidents, and even trigger particular acts of crime [1]. Traffic lights have taken parts in expediting the traffic congestions and flows; however, current traffic light systems are still operated under a conventional system which involves fixed timer system. The conventional system is considered inefficient because it couldn't notice current traffic flows. Hence, it is necessary to develop such an adaptive traffic light timer system in order to adjust the green light signal duration to the current traffic flows.

An adaptive traffic light timer controller system has been developed in order to expedite traffic congestions; one of which is by employing a Fuzzy Logic using Mamdani method to adjust the green light signal duration [2] [3]. The adaptive traffic light controller system based on fluctuate number of traffic volume are the number of coming vehicles and the number of queuing vehicles served as a logic input [4]; Meanwhile, a controller's design with vehicles queuing input and vehicles traffic flow were also made to adjust the duration [5]. In addition, there were to phases used to determine the phases order and the green light signal durations [6][7].

Based on the previous explanation, the traffic light system will examine the changing and flow of certain roads' traffic. This article is going to explain three phases, namely determining the phase orders, the duration of the green light signal durations, and the decision to continue or halt the green light signal durations. First of all, the phase orders were determined based on the vehicles queuing lengths. Second of all, the vehicles queuing lengths and the coming vehicles traffic volume were set as the Fuzzy Logic inputs to determine the green light signal durations. Third of all, the remaining numbers of vehicles traffic volume were used to make a decision whether to continue or halt the green light signal duration. The data of the vehicles traffic volume were based on the road traffic flows at the intersection by the bridge of Jl. Soekarno Hatta Malang at that moment. These data were taken from the observation data of the Laboratory of Transportation and Remote Sensing, Civil Engineering Department, Faculty of Engineering, Brawijaya University.

This study uses Processing software to do the simulation process. This study aims to compare the conventional system and the adaptive system using the Mamdani type from the Fuzzy Logic. It is hoped that the adaptive system could optimize the green light signal durations, thus it could increase the vehicles traffic volume passing the intersections. The system's performances from this study could be observed from the duration of the green light signal durations and the vehicles traffic volume passing a particular road compared to the conventional system.

II. TRAFFIC LIGHTS CONTROLLER SYSTEM

2.1. Fixed time controller system

Most of traffic lights controller systems in Indonesia use conventional fixed time controller. These traffic lights operate based on fixed time without considering any changes of traffic flows at any intersections. The time is set based on a statistic measurement from the traffic observations.

2.2 Adaptive traffic lights controller system

An adaptive traffic lights controller system could adjust the green light signal durations following any changes on traffic flows. One of the methods used in this system is a Fuzzy Logic. The Fuzzy Logic is used as a 'decision maker' of the traffic lights controller server, thus it could result on expediting traffic congestions. The decision making is based on certain rules. This study uses three phases of decision making, namely green light signal durations and decisions to continue or halt the green light signal durations.

III. THE ADAPTIVE TRAFFIC LIGHTS DESIGN AND THE FUZZY LOGIC

The adaptive traffic lights design in this study uses three phases of decision making. First of all, determining phases order which are based on vehicles queuing lengths. Second of all, vehicles queuing lengths and the coming vehicles traffic volume to determine the duration of green light signal based on the established Fuzzy rules. Third of all, determining whether to continue or halt the durations of the green light signal based on the remaining vehicles traffic volume at the intersections; if there are not any vehicles passing the intersections while the signal is green, the green light signal will be halted and changed into following phase order.

Fuzzy system was firstly invented by Lotfi Zadeh, a professor at the University of California, in the middle of 1960's. The Fuzzy system is a proper means to map certain input spaces to particular output spaces. Professor Ebrahim Mamdani led the implementations of fuzzy set among controlling fields. The development of Fuzzy Logic theory has captured many expertise's attentions to use it to control certain system in a form of automatic algorithm. This algorithm could also be applied on traffic lights controllers, automatic transmission systems, and other industries. The inputs used in this study were the vehicles queuing lengths and the coming vehicles traffic volume. Meanwhile, the outputs were the green light signal durations.

This study employs Fuzzy Inference System using Mamdani method or often called as MAX-MIN method. This is chosen because the functional implication used in this study is MIN while the compositional rule is MAX. In order to get such an output of green light signal durations, there are several measures to follow (see Fig. 1).

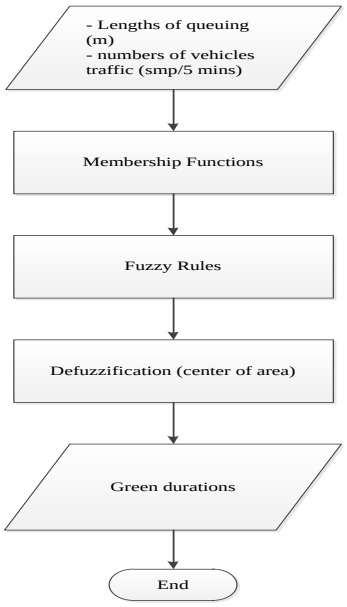

Figure 1

This Fuzzy Logic controller is constructed using 16 rules in order to allow decision making and all the rules are connected with AND operators. The rules are presented in Table 1.

Table 1The Fuzzy Logic System Rules

Lengths of queue	Vehicles traffic volume			
	VL	L	M	H
VL	VL	L	M	M
L	VL	L	M	M
M	L	M	M	H
H	M	M	H	H

notes:
VL: *Very Low*; L: *Low*; M: *Medium*; H: *High*

IV. SIMULATION

Simulation process of this study was operated using Processing software and was applied for both traffic lights controller systems namely the fixed timer and the Fuzzy Logic. The system performances could be seen based on the green durations when the vehicles traffic volumes changed (see Table 2).

Figure 2 The Traffic Lights Controller Simulations

Table2 The Controller Systems Performances based on the Green Durations and Number of Vehicles Traffic Volume

The Kind of The Vehicle	Green Durations of Each Street (s)			
	MT. Haryono	Soekarno Hatta	M. Panjaitan	Gate UB
Motorcycle	15	20	15	14
Car	29	33	28	26
All kinds	37	43	37	36

There are 3 kinds of control system tested, the first is the conventional system-1 ie the system timer remains as in the circumstances at the location. On the green duration system of segment 1, segment 2, segment 3, and segment 4 respectively by 30 seconds, 45 seconds, 15 seconds and 9 seconds. The conventional system-2 on segment 4 the green duration will light up after segment 3 run for 9 seconds. Both of system use phase sequence clockwise. While the third system is adaptive system in this research. The simulation process was conducted in 3600 seconds and Table 3 shows the performance of the traffic lights controller systems based on the vehicles traffic volume passing particular traffic lights.

Table 3 The Result of the Traffic Lights Controller Systems Performance Test

Performance	Street	Controller systems		
		Conventional 1	Conventional 2	Adaptive
Volume of the vehicle passed (smp/hour)	1	295	283	368
	2	565	544	546
	3	149	113	308
	4	224	203	377
	Total	1233	1143	1599
	Average	308.25	285.75	399.75

V. CONCLUSION

This article presents the adaptive traffic lights timer system using the Fuzzy Logic. Utilizing the Processing Software, the simulation process was conducted in 3600 seconds. Based on the simulation experiment, the proposed adaptive traffic lights timer system could result on optimum green light signal durations; thus, the vehicles traffic volume passing the intersection was greater in number. Hence, the adaptive traffic lights timer system could be operated and served as an alternative way to overcome traffic congestions as it could examine real time traffic flows and situations.

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