



Traffic light regulating system simulation at Surakarta city using decision table

Heribertus Ary Setyadi¹, Yusuf Sutanto²

¹Department of Information System, Bina Sarana Informatika University, Indonesia

²Department of Information Management, Dharma AUB University, Indonesia

ARTICLE INFO

Article history:

Received Jan 30, 2023
Revised Feb 18, 2023
Accepted Feb 28, 2023

Keywords:

Decision table
Simulating
Surakarta
Traffic light

ABSTRACT

The effectiveness of a transportation system depends on its ability to support the reliable movement of people, goods, and vehicles from one place to another. An urban traffic system is an important yet complex transportation system composed of vehicles, pedestrians, traffic lights, and a traffic network structure. Existing traffic lights are usually configured with a fixed cycle, and do not take into account specific traffic conditions. Such a configuration is very inefficient. When a large event is held during rush hours, it inevitably gives rise to traffic congestions. The purpose of this research is to produce a system for simulating traffic lights base on predetermined four criterias in order to reduce coongestion. The four criterias are intersections amount, vehicle density in a certain period of time, road width and one way street. Output of this system are engineering simulation and traffic light regulation at the intersection. The problem discussed and worked on in this research is set the time of traffic lights or the time of the red lights and green lights which are at the three intersection and four intersection. The analysis phase is to analyze the process at Surakarta Transportation and Information Agency in traffic lights. The next step is to analyze the weaknesses of the system and analyze the needs of the system being developed. The developed system can produce traffic light simulations and traffic engineering at intersections that includes setting the time the lights are red and green, the green lights are on at the same time and the rules for turn left may go.

This is an open access article under the [CC BY-NC](https://creativecommons.org/licenses/by-nc/4.0/) license.



Corresponding Author:

Heribertus Ary Setyadi,
Department of Information System,
Bina Sarana Informatika University,
Letjen Sutoyo No.43 Road, Surakarta, 57135, Indonesia.
Email : heribertus.hbs@bsi.ac.id

1. INTRODUCTION

Modern lifestyle consists of fast and rapid transport mediums which play a vital role in economic development for any nation. All developed nations have a well-developed transportations system with efficient traffic control on road, rail and air. Transportation of goods, industrial products, manpower and machinery are the key factors which influence the industrial development of any country (Sunı & Thuleswar, 2018). Advances in vehicle technology have provided people with convenient and safe transport. However, the rapid increase in the number of vehicles has

intensified traffic congestion and physical solutions such as road extension are no longer a good solution (Jang, 2018). The effectiveness of a transportation system depends on its ability to support the reliable movement of people, goods, and vehicles from one place to another. An urban traffic system is an important yet complex transportation system composed of vehicles, pedestrians, traffic lights, and a traffic network structure.

Existing traffic lights are usually configured with a fixed cycle, and do not take into account specific traffic conditions. Such a configuration is very inefficient. When a large event is held during rush hours, it inevitably gives rise to traffic congestions. In the past, in order to solve these problems of traffic congestion, traffic officers could help relieve traffic congestion. However, this approach would lead to an increased manpower burden and cause unnecessary risk to these traffic officers (Chu, et al., 2019). In recent years, with the continuous improvement of Indonesia's economic level, road transportation has developed rapidly, and the car parc of residents has been increasing continuously. Although the facilities for road signs and traffic light arrangements have been improved, congestion is still increasing from year to year (Xiaoxia, 2020). Traffic regulation using traffic lights is intended to regulate the movement of vehicles from every direction in order to remain orderly and avoid potential congestion. Most of the traffic light regulations in Indonesia have not worked well. Setting up same green light duration for all intersections is one of the biggest causes of congestion (Siti & Evelyn, 2021).

Problems related to urban traffic is increasingly important, and many researchers are trying hard to solve them. The research entitled Design and Simulation of Adaptive Traffic Light Controller Using Fuzzy Logic Control Sugeno Method aims to reduce the number of queues and increase the number of vehicles passing through the intersection. Randomly given inputs can be responded to by the fuzzy system and produce varying green time output. Traffic light control systems that use fuzzy logic control and fixed time control have different results in performance. Judging from the waiting time, the system proposed in this study has a lower performance than the fixed time based traffic light control system, because it has a longer waiting time than the fixed time based traffic light control system (Ria, et al., 2020).

Research by designing and evaluating a new intersection model using VISSIM software aims to introduce the application of the VISSIM program, designed for road traffic microsimulations, in the design and testing of the traffic-light-controlled intersection model. The traffic on the selected problematic congested intersection was modelled and simulated first for the current state, then for two models with modifications that were to increase the throughput of the intersection. The first modification of the intersection was the addition of a separate lane in the most exposed direction, while maintaining the current intersection control conditions by light signals. The second modification of the intersection represented except additional separate lane also adjustment of the traffic lights. Both adjustments have led to a significant reduction of the number of vehicles waiting in direction of the greatest congestions (Jana, et al., 2020).

Simulation research to optimize traffic flow at intersections aim to created a traffic flow model using the AnyLogic simulation software with a case study in Persiaran Kayangan and Persiaran Permai Intersection, Section 7, Shah Alam. In this study the aim is to evaluate the traffic flow at the intersection using a simulation approach and determine the best time for traffic lights to reduce congestion during peak hours. The simulation model was run for one hour to determine the average green light time at each intersection. Simulation produces the best duration traffic green light for intersections that minimize the average waiting time and maximum traffic flow of 120 seconds for Section 2, 75 seconds for Padang Jawa, 130 seconds for i-City, and 100 seconds for UiTM. This duration is expected to reduce significant traffic congestion (Muhammad, et al., 2019). Muhammad Aria developed Fuzzy Logic System for Coordinated Traffic Signal Control with Dynamic Phase Selection. The Fuzzy System consists of three main modules, they are red signal phase module, green signal phase module and the signal change decision module. This system will determine which path will get the green phase and how long the green phase will be given (Muhammad, 2018).

Seeing the importance of the role of traffic in traffic management, a system engineering is needed to control traffic lights. A good traffic control system will automatically adjust to the density of traffic flow on the regulated lane (Wu, et al., 2019). In this research, a simulation and design of

traffic lights and traffic signs at the intersection will be designed and built to minimize congestion. The system created is used to set the time of traffic lights or time of red lights and green lights by using the criteria of the number of deviations, the density of vehicles in a certain period of time, road width, one way street. Traffic lights simulation and traffic engineering at the intersection which includes setting the red and green lights for a long time, the green lights on at the same time and turning left is allowed. That discussed in this study only three and four intersections.

2. RESEARCH METHOD

This research was conducted at the Surakarta Department of Transportation, the materials used are criteria data such as vehicle density, road width and traffic flow also traffic density statistics at the Surakarta Department of Transportation.

2.1. Types And Data Sources

The type of data used in this study is qualitative data. Secondary data needed are transportation service rules to determine the type of vehicle, road width, traffic density, distribution of traffic lights. The primary data in this study are data at several intersections, including: road width, vehicle density, number of vehicles passing through an intersection based on type. Vehicle density is calculated based on the type of vehicle and the intended direction (turn right, left or straight). Those data is used to determine the duration of the traffic lights, the green lights go on at the same time, turn left to go and determine go straight on.

2.2. Systems Development Method

Identification of Problems

There is a traffic congestion or density of vehicles at several intersections, especially during peak hours. Congestion occurs due to improper timing of traffic lights. Turning on the green light is also considered inappropriate to cause a queue in the middle of intersection. The signs for turn left can go or go straight on also feel less than the maximum.

System Requirement Analysis

Input: criterion data used and data obtained at the intersection in accordance with existing criteria. Process: calculation of the data obtained for each criterion and making a decision table. Output: simulation of traffic signs at an intersection that includes traffic lights and turn left or straight signs can go on.

System Design

Conducted at this stage is to translate the analysis into interface design, database design, and Unified Modeling Language (UML) diagrams that help in making system design. This stage aims to provide an overview of what should be done and how the traffic control simulation will look like.

Coding a Program

The results of system design will be converted into a format that is understood by the machine into the programming language that has been determined through the process of writing the program. In this research use visual basic programming language.

2.3. Developed System Flowchart

There are two actors in this system: field officer and office clerk. Start from field officer who input road width data base on vehicles maximum number and how long of red light is on. Intersection data inputted and recrded by office clerk. Intersection and vehicles density data inputted by field officer. System flowchart figure shown as figure 1.

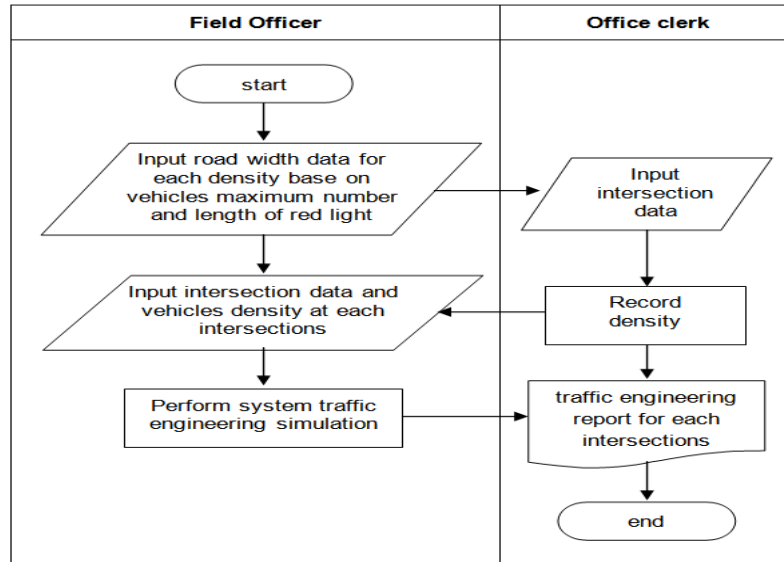


Figure 1. Developed System Flowchart

3. RESULTS AND DISCUSSIONS

Decision table is a table that is used as a tool to solve logic in programs. Decision tables are very effective when the conditions to be selected in the program are quite large and complex (Tin, et al., 2019). In this research a decision table is made to determine the duration of traffic lights, red and green lights that are lit at the same time, turn left and keep going also go straight ahead.

3.1. Determine Traffic Light Duration

To determine length of the green and red lights there are several conditions that must be met. The conditions needed to determine the duration of the traffic light can be seen in table 1.

Table 1. Decision Table

Code	SM	KK	KB	TB	LLM	LLH
Sn	> JSMSn	> JKKSn	> JKBSn	> JTBSn	LLMS	LLHS
Pn	> JSMPn	> JKPPn	> JKBPn	> JTBPn	LLMP	LLHP
En	> JSME n	> JKKE n	> JKBE n	> JTBE n	LLME	LLHE
Ln	> JSMLn	> JKKLn	> JKBLn	> JTBLn	LLML	LLHL

Description:

n : road width

S : very congested code, P : congested, E : middle, L : quiet conditions

SM : column to collect data on the number of motorbikes at certain density conditions in accordance with the code on the left.

JSMSn : amount of motorbikes (SM) when conditions are very crowded (S) on wide roads n.

JKKPn : amount of small vehicles (KK) when conditions are congested (P) on a wide road n.

JKBPn : amount of big vehicles (KB) when conditions are congested (P) on a wide road n.

JTBE n : amount of non-motorized vehicles (TB) when the density is moderate (E) on a wide road n.

LLM : value of length the red light for the conditions contained in the code column.

LLH : value of length the green light for the conditions contained in the code column.

The number of each vehicle category for a very dense density in the morning is entered as follows.

SM : > 2500 KK : > 1000 KB : > 100 TB : > 200

At four intersection determined amount of vehicles originating from the road at that intersection. For example, the Ngemplak junction has a main road, A. Yani street and two other roads as Letjen.Sutoyo street and DI. Panjaitan street. From each road amount of each vehicle category that turns into a particular road is entered. The picture of Ngemplak intersection can be seen in Figure 2. Vehicle data simulation at the Ngemplak intersection in the morning can be seen in table 2.

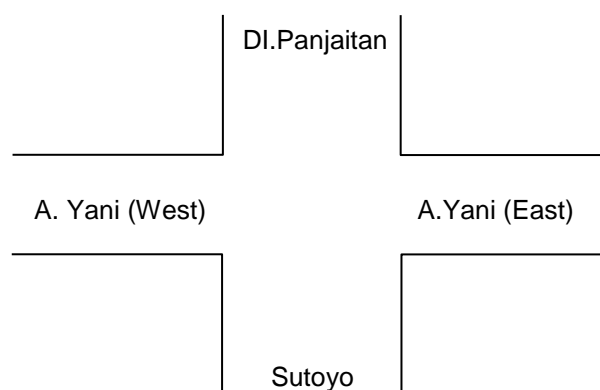


Figure 2. Ngemplak Four Intersection

Table 2. Traffic Density at Ngemplak Intersection In The Morning

From	To	SM	KK	KB	TB
East A.Yani	West A.Yani	P	S	E	L
East A.Yani	Letjen.Sutoyo	S	S	L	L
East A.Yani	DI.Panjaitan	P	P	L	L
West A.Yani	East A.Yani	E	P	P	L
West A.Yani	Letjen.Sutoyo	P	E	L	L
West A.Yani	DI.Panjaitan	E	E	L	L
Letjen.Sutoyo	West A.Yani	E	E	L	L
Letjen.Sutoyo	East A.Yani	L	E	E	L
Letjen.Sutoyo	DI.Panjaitan	S	S	L	L
DI.Panjaitan	West A.Yani	E	L	L	L
DI.Panjaitan	East A.Yani	E	L	L	L
DI.Panjaitan	Letjen.Sutoyo	S	P	L	L

3.2. Determining Green Light Turns On Together

If amount of vehicles that run straight and turn right the types of motorbikes and non-motorized vehicles are included in the medium category and amount of small vehicles as well as large vehicles is included in the quiet category, then the road facing will go together (green light).

Table 3. Concurrent Green Light On Decision Table

From	Count of vehicles that go straight and turn right				Green together
	SM	KK	KB	TB	
East A.Yani	E	E	L	E	Yes
West A.Yani	E	E	L	E	Yes
Sutoyo	E	E	L	E	Yes
DI.Panjaitan	E	E	L	E	Yes

3.3. Determining Turn Left Go On

To determine the regulation to allow turn left go on, there is a condition if amount of categories of motorcylce, small and non-motorized vehicles are straight and turn left in a medium density condition and the density of vehicles entering the left hand road is also in a moderate condition. Decision table to determine whether to turn left can continue can be seen in table 4.

Table 4. Table Decisions Of Turn Left Go On

From	To	SM	KK	KB	TB	Left Go On
East A.Yani	DI.Panjaitan	E	E	L	E	
East A.Yani	West A.Yani	E	E	L	E	Yes
West A.Yani	DI.Panjaitan	E	E	L	E	
DI.Panjaitan	DI.Panjaitan	E	E	L	E	
West A.Yani	Sutoyo	E	E	L	E	
West A.Yani	East A.Yani	E	E	L	E	Yes
East A.Yani	Sutoyo	E	E	L	E	
DI.Panjaitan	Sutoyo	E	E	L	E	
Sutoyo	East A.Yani	E	E	L	E	
Sutoyo	DI.Panjaitan	E	E	L	E	Yes
DI.Panjaitan	East A.Yani	E	E	L	E	
West A.Yani	East A.Yani	E	E	L	E	
DI.Panjaitan	West A.Yani	E	E	L	E	
DI.Panjaitan	Sutoyo	E	E	L	E	Yes
Sutoyo	West A.Yani	E	E	L	E	
East A.Yani	West A.Yani	E	E	L	E	

3.4. Determining Turn Left Go On

One of the criteria to determine the rules for a straight road is the type of intersection, which is a three intersection (T-junction) or an intersection that is prohibited from entering a street. If amount of vehicles heading to the T-junction is congested, there is a rule that straight go on when the road facing is on the road (green light). There are several conditions to determine the rules to go straight on or allowed straight while the red light is on at a certain time.

At the intersection of four in the west of Balekambang or A. Yani street, there is a crossroads to Letjen. Suprpto street and Husni Tamrin street. There is a prohibition on entering Husni Tamrin road other than motorbikes, so it is considered a fork or small intersection. Conditions like this can be applied straight ahead (green light) from the west A. Yani street while the east A. Yani is also lit with the green light. Vehicles that are about to turn right (Letjen. Suprpto) still stop (the red light on the right is on). This also applies to the case at the Kerten T-junction, vehicles from the east (Slamet Riyadi street) may continue when the road in front of them is lit with a green light while the vehicle that is about to turn right (A. Yani street) remains stopped (the right-hand red light is on).

3.5. Display Simulation System

The screenshot shows a software window titled 'manahan'. It contains a form for entering intersection data. The 'Intersection Name' is 'manahan' and 'Cunt of intersections' is '4'. Under 'Intersection Data', 'Intersection' is '2', 'Code' is '2man', 'Street Name' is 'Ahmad Dahlan', 'Width Road' is '8', 'Location' is 'North', and 'One Way' is 'No'. There are 'SAVE' and 'DELETE' buttons. Below the form is a table with columns: Kode, Nama Persimpangan, J.Simpang, No.Simp, and Nar.

Kode	Nama Persimpangan	J.Simpang	No.Simp	Nar
1ker	kerten	3	1	Slamet Riyadi (
2ker	kerten	3	2	Slamet Riyadi (
3ker	kerten	3	3	A. Yani
1man	manahan	4	1	A. Yani (utara)
2man	manahan	4	2	A. Yani (selata)
3man	manahan	4	3	Adi Sucpto (ba
4man	manahan	4	4	Adi Sucpto (tm

Figure 3. Form Of Intersection Data Processing

Kode	Waktu	Arah Belok	Masuk Jalan	S.Motor	K. Kecl	K. Besar
1Nona	Pagi	kanan	Yos Sudarso	115	56	2
1Nonu	Pagi	lurus	Slamet Riyadi (Timur)	181	88	9
2keri	Pagi	kiri	A. Yani	175	136	22
2keru	Pagi	lurus	Slamet Riyadi (timur)	183	152	13
2Mana	Pagi	kanan	Adi Sucipto (timur)	134	84	29
2Mani	Pagi	kiri	Adi Sucipto (barat)	104	88	33
2Manu	Pagi	lurus	A. Yani (utara)	141	92	31
2Ngeu	Siano	lurus	Paniatan	200	130	55

Figure 4. Form Of Density Processing at Intersections



Figure 5. Manahan Intersection Simulation

4. CONCLUSION

A traffic light control system has been designed and built to reduce traffic congestion using visual basic. The system can produce traffic light simulations and traffic engineering at intersections which includes time setting of red and green lights, green lights flashing together and the rules of turning left to go or straight go on. The system has been tested in four intersection locations, they are intersection of Ngemplak, Sumber, Manahan and Kerten using data from observations made by the Surakarta transportation office. The resulting simulation has been able to set the duration of the red and green lights, the green lights simultaneously, and the signs turn left and go straight on. From the simulation results, it has been able to manage the traffic at the intersection so as to reduce congestion during peak hours.

REFERENCES

- Chu, H.C., Liao, Y.X., Chang, L.H., Lee, Y.H. (2019). Traffic Light Cycle Configuration of Single Intersection Based on Modified Q-Learning. *Applied Sciences*. 9(21), pp.1-19.
- Jana, F., Peter, M., Jaroslava, J., Michal, F. (2020). Design And Evaluation Of A New Intersection Model To Minimize Congestions Using VISSIM Software. *Open Engineering*, 10(1), pp. 48-56.
- Jang, S.J. (2018). Design of Traffic Flow Simulation System to Minimize Intersection Waiting Time. *International Journal of Advanced Computer Science and Applications(IJACSA)*. 9(5), pp. 46-50
- Muhammad, A., (2018). Fuzzy Logic System for Coordinated Traffic Signal Control with Dynamic Phase Selection. *Telekontran*, 5(1), pp. 1-10.
- Muhammad, R.M., Faridah, A.H., and Sherey, S.A.R. (2019). Optimising Traffic Flow At A Signalised Intersection Using Simulation. *Malaysian Journal Of Computing* , 4(2), pp. 261-269.
- Ria, Y.K., Graha, P., Deden, P. (2020). Optimization Of Traffic Light Control Using Fuzzy Logic Sugeno Method. *International Journal of Global Operations Research*, 1(2), pp. 51-61.
- Siti, K., & Evelyn, D.. (2021). Traffic Lights Analysis and Simulation Using Fuzzy Inference System of Mamdani on Three-Signaled Intersections, 5th International Conference on Computer Science and Computational Intelligence 2020. *Procedia Computer Science*, 179, pp. 268-280.
- Suni, P., Thuleswar, N. (2018). A Review On Modelling and Simulation Of Vehicular Traffic At Signalized Intersection. *International Journal of Engineering Trends and Technology (IJETT)*. 48(5), pp. 237-241.
- Tin, M.W., Than, T.Y., and May, Z.O. (2019). Implementation of an Optimized Virtual Traffic Light Algorithm in SUMO. *International Journal of Advances in Scientific Research and Engineering (IJASRE)*, 5(10), 171–179.
- Wu, Z., Zhang, Y., Tan, G. and Hu, J. , (2019). The Research Of Traffic Density Extraction Method Under Vehicular Ad Hoc Network Environment. *Journal of Intelligent and Connected Vehicles*, 2(1), pp. 25-32.
- Xiaoxia, P. (2020). Simulation Analysis On The Influence Of Traffic Light Changes Over Drivers' Emotions Based On Virtual Reality Platform, *Revista Argentina de Clínica Psicológica*, 9(1), pp. 304-309.