RESEARCH ARTICLE OPEN ACCESS

Web Camera and Fuzzy Logic System Controlled Traffic Light System

Marjun S. Sequera[1]
[1]Department of Electro-Mechanical Technology, University of Science and Technology of Southern Philippines, C.M. Recto Avenue, Lapasan, Cagayan de Oro, Philippines
Email: marjunsequerademt@gmail.com

Abstract:

The heart of the economy in any country is the central business district and trading center areas of cities. One of the many unresolved problems in most country nowadays is the heavy traffic. Philippine is one of the country who is experiencing this and dubbed as the country with the worst traffic congestion. This problem clearly affecting the economy of the country and drastically changes the culture of the Filipinos living in the cities to counter this crisis. However, most of this countermeasure is unhealthy and unsafe such as shortening sleep time and riding motorcycles. There are many improvements in the traffic system technologies, however it seems like these innovations are not solving the problemeven the slightest. This is because the timing strategies is traditional. There sensorized traffic light but still prone to malfunctions due to environment conditions and human disturbances. This study aims to improve traffic light by replacing sensors with computer vision in the allotment of time for lanes to discharge their accumulated vehicles.

***Keywords* — Traffic light system, computer vision, intelligent system.**

I. INTRODUCTION

The productivity of the Philippines is diminishing and it greatly affects its residents and industry sectors and this is due to unresolved traffic. Road expansions, highway developments, application of several traffic schemes and other numerous efforts have been implemented in the country to regulate traffic. Researchers are finding out solutions on the limitations of traditional traffic light systems [1].

In terms of traffic congestions, Metropolitan Manila has been dubbed as one of the world's 'worst' and thispredicament left an impact to the commuters [2][3].

As center of activities is where the economic and social rationale of the communities has been derived, however,the streets conditions has worsen as they grow the movement and affecting everyone. The people's capacity to buy vehicles increases as the country improves its socio-economic situation.An average of 5% year on year of growth rate of car registration has been observed in Metro Manila [4].

The capacity limits of existing roads has been overcame by rise in car ownership, most of which were longstanding roads not intended to carry heavy traffic. One of the functions of an economy is undeniably the increased of number of vehicle ownership or volume of traffic, but if not strategically managed, can also cause significant losses in economy. If traffic congestion is not addressed, losses at least PhP 2.4 billion daily and will increase to PhP 6 billion will be experienced by Metro Manila for example [5].

Heavy traffic is also posing health risks to peoplebecause it worsens vehicle exhaust containing high levels of nitrogen oxide, sulfur dioxide and carbon dioxide [6].Industrial emissions and vehicular emissions are almost equal in the year 2000 [7].

Nowadays, Pre-timed traffic light system is no longer effective at dealingtraffic congestion becausethis system only concentrated on the factors of the vehicles, however, most intersections contain pedestrian lanes which must also be considered in the decision making of the intelligent traffic signals [8].With the advent of Internet of Things, the concepts of smart cities and technology have become prevalent these days [9].For the past two decades, literatures has been captured by computer vision-based human motion [10]. Implementing

computer vision on the control of traffic congestion where timing controls are based on the images captured by the camera might improve the traffic systems. This is through basing the allotted time for the lanes on the heaviness and the rate of increase in the number of vehicles in every lane. This way, the lane that requires more time will be prioritized.

II. COMPUTER VISION

One of the parameters that should be considered in the determination of the level of congestion of a specific lane is the length of the lining of vehicles. Based on this length, the allotted time for every lane must be adjusted. However, traditional traffic light systems are not capable of performing. Using cameras, this length can be determined based on the captured images. In determining the length of congestion, images will be captured in intervals. But the captures images may differ from one another due to weather and the period of the time it is captured such as if it is captured in daytime or night time or early morning or late in the afternoon. This must also be considered in designing algorithm in measuring the length of congestion basing on the images captured.

A. Length of Congestion

The actual dimension of the captured image object can be determine through ratio and proportion between pixels and the measured dimension of an subject object. Depending on the distance between the camera's aperture and the object location, an equation can be formulated. Shown in Fig. 1 is a sample image lay over with its actual dimension.

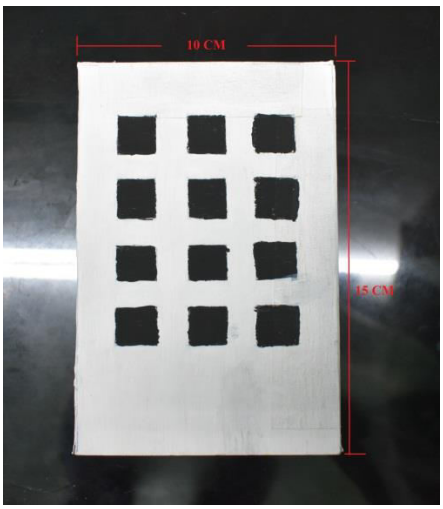

Fig. 1Captured object with its actual dimensions

$$P = rL$$

Using the formula above where P is the number of pixels, L is the dimension to be converted into pixels and r is the ratio between the captured image and the actual measurement in terms of centimeters, the equivalent number of pixels for every dimension shown in Fig. 1 tabulated in Table 1.

TABLE I
PIXELS EQUIVALENT OF THE DIMENSIONS SHOWN IN FIGURE 1

In Centimeters	In Pixels	Ratio
10	1830	183
15	2787	185

However, the presented formula is only applicable if the aperture of the camera is perpendicular to the centroid of the object. For instance, the image shown in Fig. 2 which is captured with the aperture of the camera is roughly tilted more than 45° against the centroid of the sheet the camera captured.

Fig. 2Image of the lane captured by the camera used

The subject shown in Fig. 2 has drawn Red lines with distance between line equal to ten centimeters. The number of pixels between lines were counted and was observed that the distance in pixels in every gap is decreasing. Table 2 tabulates the equivalent length in terms of centimeters given pixels.

TABLE II
PIXELS EQUIVALENT OF THE DIMENSIONS SHOWN IN FIGURE 1

In Centimeters	In Pixels	Decrement
10	1047	0
20	2046	999
30	2668	622
40	3132	464
50	3481	349
60	3764	283

B. Weather and Period

In determining the distance of the line of vehicles from the intersection using camera, precaptured images is compared with the recently captured image to determine the changes of the lane imagery due to the presence of the vehicles. However, relying on single precaptured image is not enough specially if the weather and period when the precapture image was captured is different with recetly captured image. The system might treat this as changes in the lane image and results into miscalculation of the length of the congestion. To avoid this, the recently captured image must be compared with several precaptured images taken in different weather and period.Some of this images are shown in Fig. 3 – 5.

Fig. 3Image of the lane with full light

Fig. 4Image of the lane with slightly dim

Fig. 5Image of the lane with dimmer light

But doing this, another problem arises. Evaluating changes between two images already takes time and much more if the number of precaptured images to be compared with the recently captured image also increases. To solve this, a certain portion of the recently captured image, portion that is not affected as the number of vehicle increases, is cropped and this portion is used to determine the appropriate precaptured image to use. Fig. 6 shows an example of the crop image.

Fig. 6 Sample crop image

III. FUZZY LOGIC SYSTEM

Fuzzy logic system is an intelligent system that mimics the ability of human brain to reason based on input variables and prior knowledge. In this study, the decision making is done by this system. Among other intelligent system, fuzzy logic is utilized because for machine learning, observations are required while for probabilistic inference requires several conditions and these requirements required more time to gather. Whereas, fuzzy logic system requires only rules which can be determined anytime.

The determination of the time to be allotted in every lane must be based not only in length of congestion but also the rate of the increase of vehicle on the lanes. The design of fuzzy logic therefore which is the system that computes the time to be alloted for every lane must also consider the rate of the increase of vehicles on the lane. The rate is determine by the length of the displacement of the length of congestion against the time required for asingle cycle of evaluation for all four lanes.

A. Membership Functions

There are only three membership functions to be designed for fuzzy logic system controlling traffic light system. As mentioned, the alloted time for every lane are determined based on the length of congestion and the rate of increase in number of vehicles. The membership functions therefore are the input variables length and rate and output variable time. Fig. 7 – 8 show the three said membership functions.

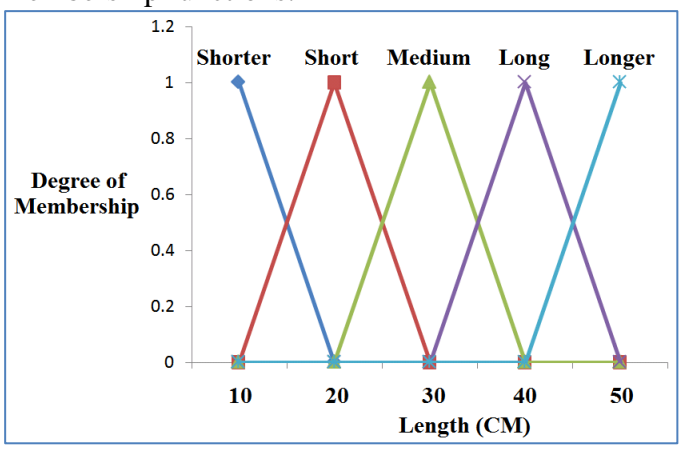

Fig.7 Membership function for length of congestion

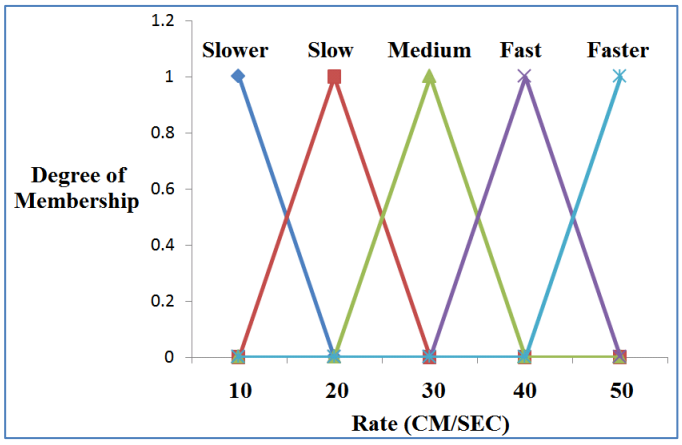

Fig.8 Membership function for rate of increase in number of vehicles

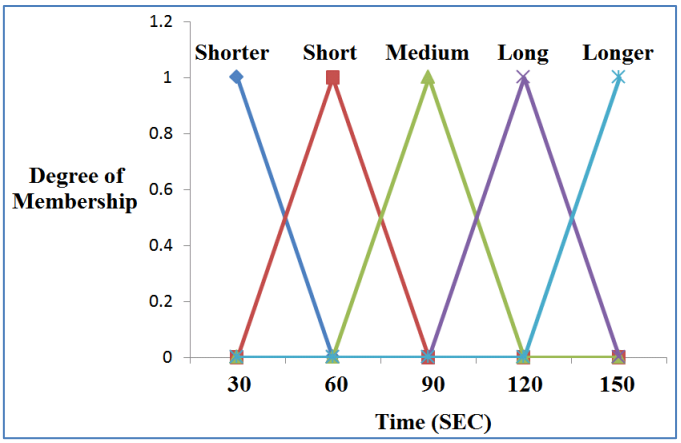

Fig. 9 Membership function for number of time to be allotted

B. Rule Base

Table 3 shows the rule base used for the fuzzy logic to control the timing system of the traffice light system.

TABLE III
TRAFFIC LIGHT SYSTEM RULE BASE

	Length	Rate	Time
1	Shorter	Slower	Shorter
2	Shorter	Slow	Shorter
3	Shorter	Medium	Short
4	Shorter	Fast	Short
5	Shorter	Faster	Short
6	Short	Slower	Short
7	Short	Slow	Short
8	Short	Medium	Medium
9	Short	Fast	Medium
10	Short	Faster	Medium
11	Medium	Slower	Medium
12	Medium	Slow	Medium
13	Medium	Medium	Long
14	Medium	Fast	Long
15	Medium	Faster	Long
16	Long	Slower	Long
17	Long	Slow	Long
18	Long	Medium	Longer
19	Long	Fast	Longer
20	Long	Faster	Longer
21	Longer	Slower	Longer
22	Longer	Slow	Longer
23	Longer	Medium	Longer
24	Longer	Fast	Longer
25	Longer	Faster	Longer

IV. RESULTS AND DISCUSSIONS

The traffic light system was tested by inputting series of values of length and rate and record the generated time as shown in Table 4. After that the rest of the four lanes output are evaluated is which of the lanes requires more time and less. For

instance, if all lanes are equal in time requirement, it would be impractical to allot longer time which is equivalent to One Fifty Seconds for every lane. It is more practical to give them Sixty Seconds or Slow equivalent in the Time membership function to give motorists time to cope up with the time lost upon being stuck in the congestion.

TABLE IV
GENERATED OUTPUT OF THE FUZZY LOGIC

	Length	Rate	Time
1	10	10	30
2	10	20	30
3	20	20	60
4	20	30	90
5	20	40	90
6	20	50	90
7	30	10	90
8	30	20	90
9	30	30	120
10	30	40	120
11	40	20	120
12	40	30	150
13	40	40	150
14	50	10	150
15	50	20	150
16	50	30	150
17	50	40	150
18	50	50	150

V. CONCLUSIONS AND RECOMMENDATIONS

The algorithm in determining the length of congestion using camera vision is satisfactory. It is capable of approximately estimate the equivalent centimeters given counted pixels. The result of testing the fuzzy logic system is satisfactory. It is able to generate allotted time as intended and stipulated from the rule base.

However, evaluation of the images as the number of precaptured images increases requires more time. It is suggested to lower the resolution of the image captured and process the images in a computer with high processing time capability.

The study was only simulated using single lane. It would be satisfying if tested using four lanes with four cameras and running miniature vehicles.

ACKNOWLEDGMENT

The realization of this study would like to express the profound gratitude to my beloved family for their moral, emotional and financial support and to our Almighty God for the strength, wisdom and guidance.

REFERENCES

1. *Nodado, J. T. G., Morales, H. C. P., Abugan, M. A. P., Olisea, J. L., Aralar, A. C., & Loresco, P. J. M. (2018, October). Intelligent Traffic Light System Using Computer Vision with Android Monitoring and Control. In TENCON 2018-2018 IEEE Region 10 Conference (pp. 2461-2466). IEEE.*
2. *Fallaria, A. J., de Jesus, R., Carpio, M., Jacinto, F. L., De Leon, L., Agapito, J., & Ramos, J. G. (2019). Emerging from the 'worst': An ethnography of the modern Filipino commuting culture behind the Metro Manila traffic crisis. In MATEC Web of Conferences (Vol. 272, p. 01032). EDP Sciences.*
3. *Quito, BG. And Aquino EC. (2016). Smart Transport System: The Role of Technology in the Efficient Management of Traffic Situations in EDSA. RTU Academic Journal, 5(1).*
4. *Rubite, CP., and Tiglao, CC. (2004). Development of a Car Ownership Model in Metro Manila. Philippine Engineering Journal, 25(1).*
5. *(2002) The IEEE website. [Online]. Available: http://www.ieee.org/*
6. *Zhang, K., and Batterman, S. (2013). Air Pollution and Health Risks due to Vehicle Traffic. The Science of the total environment 0(2013).*
7. *Krupnick, A., Morgenstern, R., Fischer, C., Rolfe, K., Logarta, J., and Rufo, B. (2003). Air Pollution Control Policy Options for Metro Manila. Resources for the Future.*
8. *Basconcillo, K. A. C., Benitez, D. J. B., Cantuba, E. A. S., Enriquez, R. E. L., Falcon, C. R. I., Serrano, K. K. D., ... & Vicerra, R. R. P. (2017, May). Development of a vehicle and pedestrian simulation environment with MISO fuzzy logic controlled intelligent traffic light system. In 2017 5th International Conference on Information and Communication Technology (ICoIC7) (pp. 1-6). IEEE.*
9. *Masoud, A. R., Al Mamari, H., Kazmi, S. I. A., Pandey, J., & Al Hinai, S. (2019, January). IoT based Smart Parking and Traffic Management System for Middle East College. In 2019 4th MEC International Conference on Big Data and Smart City (ICBDSC) (pp. 1-6). IEEE.*
10. *Moeslund, T. B., & Granum, E. (2001). A survey of computer vision-based human motion capture. Computer vision and image understanding, 81(3), 231-268.*