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by International Journal Artificial Intelligence and Robotics

Submission date: 01-Dec-2020 01:18AM (UTC+0900)
Submission ID: 1460345960
File name: 3194-10388-1-CE_70-79.pdf (346.54K)
Word count: 3658
Character count: 18818

Traffic Light Automation with Camera Tracker and Microphone to Recognize Ambulance Using the HAAR Cascade Classifier Method

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ABSTRACT

Lack of knowledge by road users regarding these priorities, especially when there is a passing ambulance that is often stuck in traffic at a crossroads due to accumulated vehicles and the traffic light is still red. The purpose of this paper is to simulate traffic light automation by giving a green light every time an ambulance passes by using the HAAR and Computer Vision methods. The HAAR method is used for training data from less sharp images as part of the Ambulance object classification process. The Computer Vision method is used as a tool in image processing objects to processing the image captured by the Camera. Hardware through the microphone performs pattern recognition to pick up ambulance sirens. The test result at the average frequency caught by the microphone is 1.3 kHz. The test results of the System to capture ambulance objects received a precision value of 75%, a recall of 100%, and an accuracy of 75%.

Keywords : Traffic Light Automation, Ambulance, Computer Vision, HAAR Cascade Classifier

Article History		
Received : November, 9th 2020	Revised : November, 25th 2020	Accepted : Noverber, 28th 2020

I. INTRODUCTION

According to Law No. 22 of 1999 concerning Road Traffic and Transportation, Clause 209 Concerning Road Traffic and Transportation, Road users who get the main right to precedence are fire fighting vehicles that are carrying out their duties, and Ambulances carrying sick people, then state institution vehicles [1]. There are many cases where patients die at the place and when they are going to the hospital because of the delay in getting to the hospital. The net death rate (NDR) in the hospital is the mortality rate ≥ 48 hours after being treated for each patient 1,000 patients discharged from the hospital [2]. The pure death rate or NDR in 2015 was 30.5 per 1,000 discharged patients, meaning that for every 1,000 patients who were alive or out of the hospital, 31 dead patients had previously been treated ≥ 48 hours (2 days) [2]. It is estimated that more than 11,000 critically ill patients require the transfer of patients between hospitals each year [2]. The quality and outcome of these patient transfers are highly dependent on the transfer team's experience, careful clinical preparation, and adequate monitoring facilities [2]. The mortality rate during patient transfer is very low (<1%) [2]. Thus, it can be concluded that the Ambulance has an essential role for many people.

Previous research used the ATMEGA16 microcontroller to simulate traffic light settings to reduce traffic congestion using image processing data. The webcam cameras were used to detect vehicle density and calculate the traffic light turnover timer [3]. This study discusses a system that can determine the length of time the green light is on based on the density of roads using Matlab 2009a software and a digital camera as a manager and digital image input [4]. An alternative to finding the best traffic control solution is based on the characteristics of vehicle density in previous studies by developing the Miloza algorithm [5].

To solve the congestion problem due to the very congestion of vehicles, a controller solution for the Model Traffic Light Timer is made based on the Background image processing method using the Raspberry Pi [6]. Practical benefit in solving traffic congestion problems and reducing people's waiting time at traffic intersections with a traffic light-independent, intelligent decision model based on a Dynamic Bayesian network [7]. However, in the literature study that the author has conducted, there has been no research that has conducted traffic light automation using the HARR method and computer vision to recognize passing ambulances using a camera and microphone.

This study's results provide an interruption to the Traffic Light so that the road that is traversed by the Ambulance car takes precedence, can recognize the Ambulance car in the Traffic Light area, with the characteristic parameters and the sound of the siren from the Ambulance. The System uses the HAAR and Computer Vision methods to determine a time decision when automating traffic light when the camera tracker and microphone identify the Ambulance car. The benefit of this research can be used as a policy in determining the priority of Traffic Light Automation on a passing Ambulance.

DOI: 10.25139/ijair.v2i2.3194

 E - ISSN : 2686-6269

II. METHOD

The research method in the discussion of this paper is based on the flow in Figure 1. Figure 1 describes the entire System's workflow, starting from the siren reading stage, image processing, and data classification. The microphone is always on standby to pick up sound. When the microphone picks up the sound, the LM567 Chip will detect that frequency. If the frequency caught by the mic on the LM567 CAN turn on the indicator light on the LM567, then "Camera ON". If the frequency caught by the mic on the LM567 CANNOT turn on the indicator light on the LM567, then "Camera OFF". The image processing program algorithm will clarify the data only if the captured frequency matches the pattern that has been set on the LM567 Chip, and there is a captured image from the Camera.

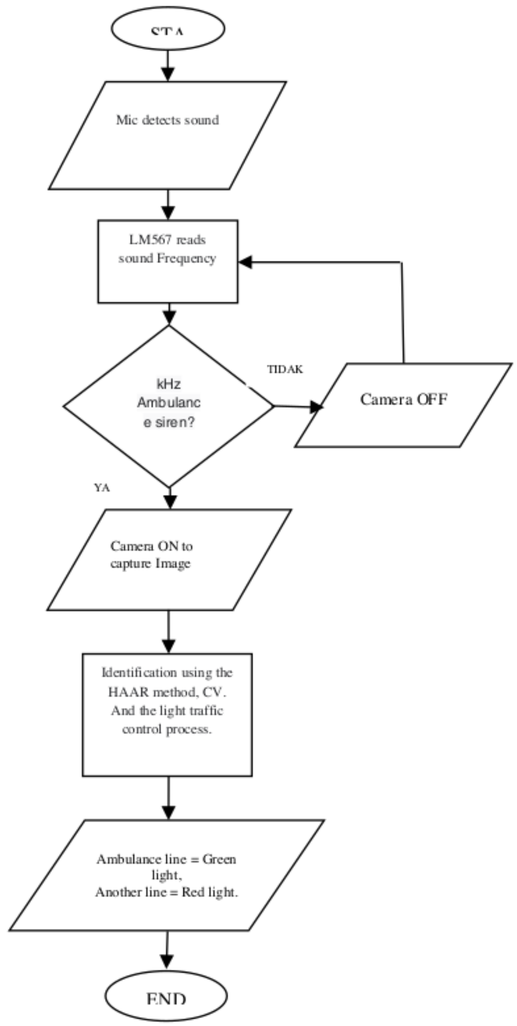

Fig.1. Flow Traffic Light Automation System

A. *System Block Diagram*

Block diagram of the entire traffic light automation system using a camera and microphone to identify ambulances. The block diagram in Figure 2 describes the workflow of the whole System, starting from the microphone capturing the sound frequency of the siren than the orange pi mini pc activating the Camera to capture images in the front area of the Camera. The results of image capture are processed in image processing computer vision, and the image is clarified. Mini PCorange pi gives an output command in the form of time duration management of the traffic light for Traffic Light to perform actions following program commands.

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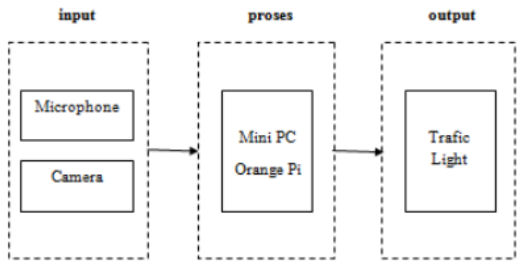

Fig. 2. Traffic Light Automation System Block Diagram

B. System Architecture

Traffic light automation using a camera tracker and microphone to recognize an ambulance has several stages in carrying out the entire process, from input to process to output. The system architecture in Figure 3 illustrates the primary hardware devices used to support traffic light automation simulation research using a microphone and a camera to recognize ambulances. This device is the first to come from an input that uses a microphone built with the LM567 Chip as a tone decoder and a camera, which is useful for the image identification capture process. An orange pi mini PC processes the whole System to control automation.

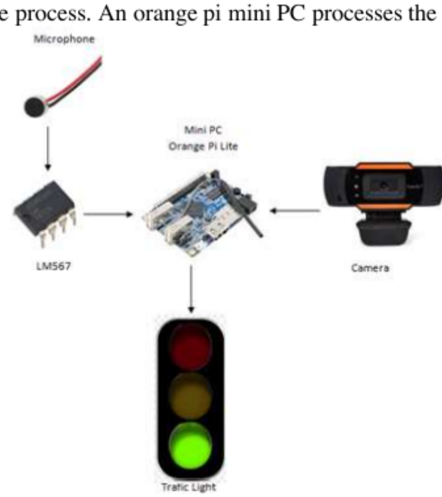

Fig. 3. Traffic Light Automation System Architecture

The process flow of the overall system architecture in Figure 3. The first stage has two inputs, namely from the microphone and Camera. The first input from the microphone is a siren sound from an ambulance passing by with the aid of the LM567 Chip, a general-purpose tone decoder designed to provide a saturated transistor switch to the ground when the input signal is present in the passband [8]. The second input is a Camera (Havit HV-N5086) with a resolution of 8 megapixels [9], which is tasked with capturing images of ambulances passing in the traffic light area. One special thing that must be understood is that the camera input will only activate if the microphone input captures an ambulance siren's sound. So, the siren sound is an automatic switch to activate the Camera to encapture whether what will pass in the traffic light is an ambulance or not. The Orange Pi Lite Mini PC [10] receives input data from a camera that captures an ambulance's image in the traffic light area. The results of capturing the image by the Camera are then processed with the python algorithm and computer vision image processing methods. The results of image processing are then identified using the HAAR method with reference to the training data, the feature values in the pixels of the captured object captured by the Camera. This image processing aims to identify ambulances that are in the traffic light. After the identification process is complete, the System will make decisions from the results of image processing. Suppose the identification results state that it is true that an ambulance will pass through the traffic light area. In that case, the system decision-making is interrupting the traffic light to immediately give the green light to the intersection lane that the Ambulance passes and give a red light to all lanes to the sale of the lanes that the Ambulance passes. An ambulance that will pass at a traffic light intersection does not have to have difficulty passing in an emergency to assist.

C. Module Schematic

In Figure 4, the Mechanical Device Design Scheme explains all mechanical devices connected on the GPIO pin, becoming one with the control center on the Orange PI Mini PC. The sound sensor is started to recognize the ambulance siren, then the Camera connected via the orange pi board USB port, and the LED light control of automating the traffic light simulation. If you want to add more lights, you just need to assemble the series while maintaining one control point.

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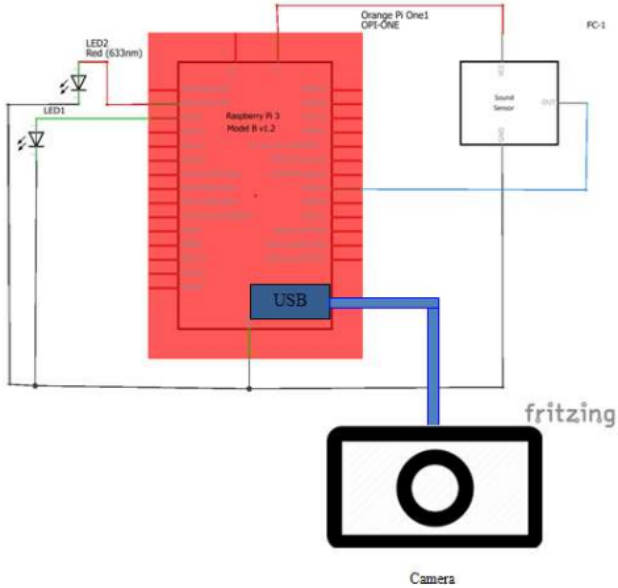


Fig. 4. Schematic of Mechanical Device Design Module

D. System Design

The system design will provide an overview of the hardware and the placement of the traffic light automation system components using a camera and microphone to recognize ambulances in Figure 5. The design of this traffic light automation simulation is indeed only one lane that the introduction of an ambulance is doing due to limited research. Still, for traffic light control, it is carried out to all road intersections.

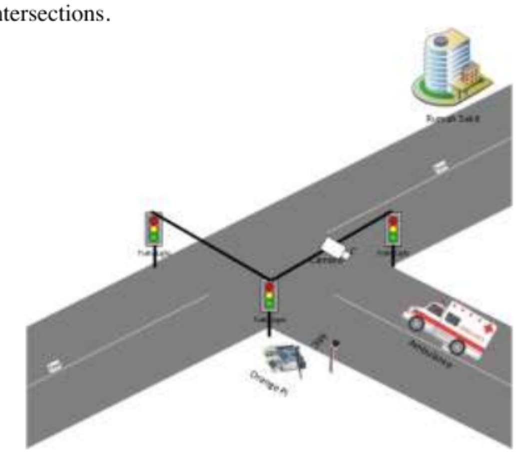


Fig. 5. The design of this traffic light automation

E. Computer Vision

The human eye is a sophisticated system that responds to visual stimuli [11]. Functionally, computer vision, and human vision intend to interpret spatial data, namely data indexed by more than one dimension. However, computer vision cannot be expected to replicate exactly like the human eye. This is because knowing how the eye and brain systems work is not fully understood, so it is not possible to design a system to replicate the functions of the human eye properly. Computer vision techniques can reproduce, in some cases, to improve the social visual system [11].

F. HAAR Cascade Classifier Method

The HAAR Cascade Classifier Method uses training data from less sharp images as part of the image classification process. Image classification is done based on the value of a feature [12]. HAAR algorithm uses statistical methods to detect objects. This method uses a sample haar-like feature. This classifier uses a fixed size image (generally 24x24). The way haar works in detecting objects is to use a 24x24 point sliding window on the whole image and look for whether any part of the image is shaped like an

DOI: 10.25139/ijair.v2i2.3194

object or not. HAAR method also has the ability to scaling so that it can detect objects that are larger or smaller than the classifier image [13].

The HAAR method features a feature based on the haar wavelet, known as light and dark areas. Box combinations are used for better object detection. Each haar-like feature consists of a combination of black and white boxes. There are three types of rectangular features in Figure 6, namely [13]:

1. Two-rectangular feature
2. Three-rectangular feature
3. Four-rectangular feature

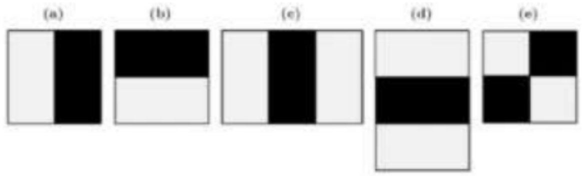


Fig. 6. The HAAR method features [13]

The HAAR method features in Figure 6 are determined by subtracting the mean pixel in the dark area from the average pixel in the bright area. If the difference is above the threshold value, it can be said that the HAAR feature exists. The HAAR-like feature's value is the difference between the gray level pixel value in the black box and the white box. Equation (1) is used for the gray level of the HAAR-like feature [13].

$$f(x) = SumBlack\ Rectangle - SumWhite\ Rectangle \quad (1)$$

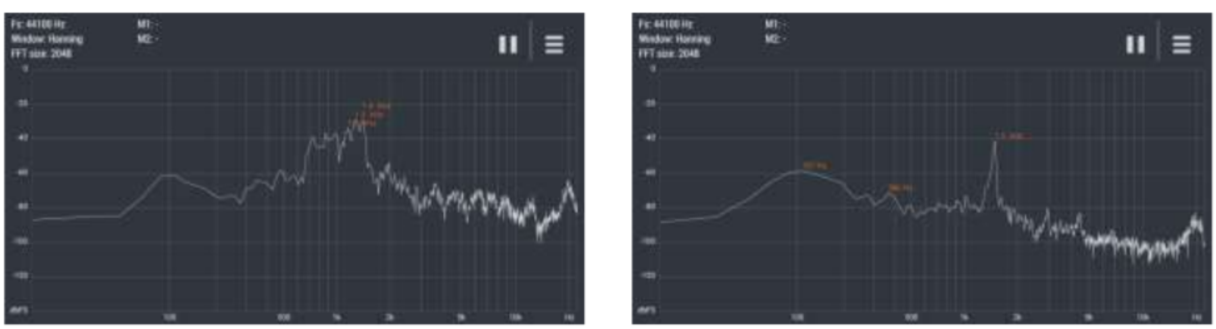
III. RESULT AND DISCUSSION

The Siren Frequency reading using the Advanced Spectrum Analyzer Pro application is a display that shows the amplitude of the siren by taking the highest siren value. Table I explains the siren frequency reading results of each siren mode tested in Figure 7. The average 1.3 kHz frequency is used to detect the ambulance siren sound at that frequency value. So, if the frequency of the sound picked up by the microphone is less than 1.3 kHz, the sound sensor will not recognize the sound. Here's how the researchers found the average value of the three siren frequency readings in equation (2).

$$\text{Average value} = (1.400\text{Hz} + 1.500\text{Hz} + 1.200\text{Hz}) / 3 = 1{,}333.333\ \text{Hz} \quad (2)$$

TABEL I
AMBULANCE FREQUENCY READING SIRINE AMBULANCE

Name	Frequency
Siren Mode 1	1.4 kHz
Siren Mode 2	1.5 kHz
Siren Mode 3	1.2 kHz
Siren Frequency Average Value	**1.3 kHz**



(a) Siren Mode 1 (b) Siren Mode 2

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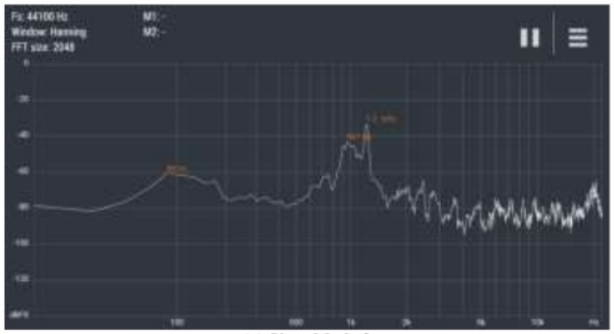
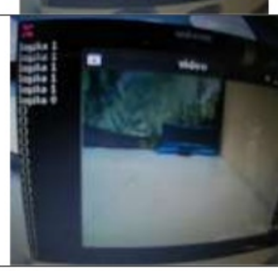


(c) Siren Mode 3

Fig. 7. Mode Siren Frequency Readout

Table II Conducted several siren sound detection simulation tests with three differences in the distance between the sound source and the microphone. The results of this trial can be concluded that in a distance of less than 210 cm, the microphone can still pick up and read the ambulance siren's sound by giving logic 0 to the microcontroller. The maximum reading value is at a frequency of 1.2 kHz. The Camera also begins to detect ambulances actively.

TABEL II
READING SIMULATION OF SIRINE AMBULANCE

Distance	System Reading	Frequency
90 cm 		1.5 kHz - 40 dbFs
150 cm 		1.4 kHz - 30 dbFs
210 cm 		1.2 kHz - 30 dbFs

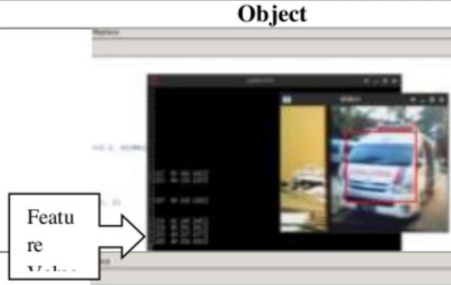
In Figure 10 Capture Object on the System, object recognition is found by the System which is indicated by the appearance of a red box on the captured image from the webcam, where the image is shown by a red arrow and the object feature value that is read by the System from the capture result is shown by a colored arrow blue.

DOI: 10.25139/ijair.v2i2.3194

Fig. 10. Capture Object on System

Test on an ambulance that has physical similarities to a car or public vehicle. And also, the reading results by the System are summarized in Table III. It can be concluded in Table 3 that the Object Detection Test on the System, that the object that can recognize the object is an ambulance that passes by displaying the feature value of the object. Meanwhile, objects that do not recognize the object are marked with empty feature values.

TABEL III
AMBULANCE CAR DETECTION

NO	Object	Feature Value
1.		[[125 49 134 134]]
2.		[[137 41 108 108]]
3.		( )
4.		( )

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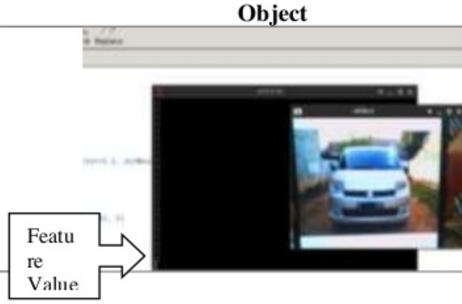
NO	Object	Feature Value
5.		( )

The simulation trial of a traffic light automation system is close to that in the field using video based on Table IV results.

TABEL IV
UJI COBA SIMULASI DETEKSI MOBIL AMBULANCE

No.	Distance	Havit HV-N5086 Camera 8MP	
		Ambulance Video on Screen 6 in	Feature Value
1.	Object to Camera (10 cm)		[[183 167 180 180]]
2.	Object to Camera (30 cm)		[[115 63 296 296]]
3.	Object to Camera (50 cm)		[[267 101 108 108]]
4.	Object to Camera (70 cm)		[[254 173 82 82]]

DOI: 10.25139/ijair.v2i2.3194

5.	Object to Camera (100 cm)		()

For the second system simulation test carried out on the detection of the Ambulance where to what extent the Camera used in this study. The capture moving images of an ambulance crossing the highway that is rotated on a 6 in screen, and then the Ambulance is detected by the System in Table IV. Simulation an object in the form of an ambulance video crossing the highway which is rotated through a 6 in screen then detected by the Havit HV-N5086 8MP Camera through several different distances shown in Figure 11.

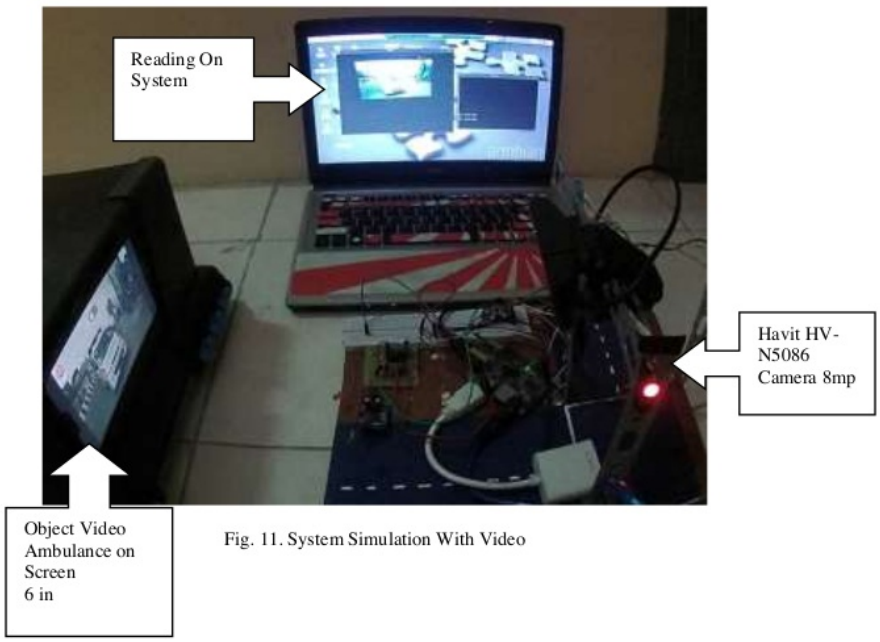


Fig. 11. System Simulation With Video

Determine the level of success of a system, calculations are carried out using Precision, Recall, and Accuracy with the results in Table VI based on equation (3)-(5). The traffic light automation system's simulation test using a camera and microphone to identify ambulances was carried out 12 times, with the results in Table V.

TABEL V
HASIL UJI COBA

1	The accuracy of introducing ambulances to the system using the HAAR Method	9 time
2	Inaccurate introduction of ambulances to the system using the HAAR Method	3 time
3	The system does not respond, or the system crashes	0 time

TABEL VI
NILAI *PRECISION*, *RECALL*, DAN *ACCURACY*

		ACTUAL VALUE	
		TRUE	FALSE
VALUE	TRUE	9	3
SYSTEM	FALSE	0	0

$$Precision = \frac{TP}{TP+FP} = \frac{9}{9+3} = \frac{9}{12} = 0{,}75 * 100 = 75\% \quad (3)$$
$$Recall = \frac{TP}{TP+FN} = \frac{9}{9+0} = \frac{9}{9} = 1 * 100 = 100\% \quad (4)$$
$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} = \frac{9+0}{9+0+3+0} = \frac{9}{12} = 0{,}75 * 100 = 75\% \quad (5)$$

Tests carried out by simulating the traffic light automation system using cameras and microphones to recognize ambulances can be identified that the success rate in the category is quite good. This is because the traffic light automation system gets a precision value of 75%, 100% recall, and 75% accuracy.

IV. CONCLUSION

Based on the results of testing and system analysis that has been done previously. Traffic light automation system simulation using camera tracker and microphone to recognize Ambulance. The system's success rate to acknowledge and identify ambulance objects in the category is quite good, with 75% precision, 100% recall, and 75% accuracy. The traffic light automation system using a camera tracker and microphone to recognize an ambulance is quite helpful, of course. For ambulances on duty and having to pass through traffic lights, no longer need to worry about not being given way by other vehicles that also stop because the traffic light is still red. Further research that can be done is to try other more complex methods, namely Deep Learning with YOLO or TensorFlow.

ACKNOWLEDGMENTS

This research has contributed to research in image processing technology to identify ambulances in the traffic light area. The results of this research can be used by developers and researchers in Artificial Intelligence and Robotics.

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