Prototype Traffic Light Control System Based on Ambulance Objects Using YOLO Method

Dimas Tubagus Hanggar Kesuma[1], Mila Kusumawardani[2*], Azam Muzakhim Imammuddin[3]

1,2,3 Digital Telecommunication Network Study Program, Department of Electrical Engineering, State Polytechnic of Malang, 65141, Indonesia.

[1]dimastubagus95@gmail.com , [2]mila.kusumawardani@polinema.ac.id , [3]azam@polinema.ac.id

***Abstract*— Ambulances are emergency service vehicles, but they are often caught in traffic jams that can potentially cause death to patients due to the need for quick action. Then, there was a case of an ambulance accident at a traffic intersection when requesting priority access to the road because it was carrying a corpse. With a traffic light control system using the YOLOv8 image processing method as an ambulance car detector and an audio warning signal output, it can provide warnings to prevent accidents at traffic intersections and prioritize ambulances to arrive faster to their destination. In the system, the ambulance is detected in front and rear view with a minimum confidence value of 70% to send a command to the ESP32 to activate or turn off the output. The ambulance detection system based on distance obtained a confidence value of 95% at a distance of 30cm, where the system is more accurate because the object is closer to the camera. Then, the detection system with light and speed obtained an average confidence value of 78.3% which is getting lower at night due to poor lighting conditions, in the object speed factor obtained a confidence value of 89% at a speed of 40km / hour. The confidence value is also influenced by the angle of the camera position when detecting objects, at an angle of 45° obtained a value of 89% and an angle of 135° with a value of 82%. The system is able to distinguish ambulances with similar objects, other objects detected obtained a confidence value of 43% - 56%. There is a delay in object recognition, the average delay value is 18.9 m/s which is influenced by computer performance. In the overall system delay there is an average delay value of 3 seconds. In order for the system to control traffic lights and output on time, it is determined that the minimum detection distance is 66.6m which is influenced by a delay of 3 seconds and an ambulance speed of 22.2 m/s.**

Keywords*—*Ambulance, Camera, Image Processing, Speaker, Traffic Light, YOLO.

I. INTRODUCTION

Every country has laws governing the operation of emergency service vehicles. Ambulances have the privilege of traveling at high speeds in emergency conditions. Because of the safety of a patient, ambulance drivers are generally exempted from speed regulations, the prohibition of breaking traffic lights and going against the direction of the road [1]. In accordance with medical vehicle operational standards, ambulances are allowed to drive at 40 km/h on normal roads and 80 km/h on freeways [2]. In this case, an ambulance gets special privileges on the road because it has visual signs in the form of signal lights and audio devices [3].

With the increasing population in big cities, ambulances are often caught in traffic jams and have to wait minutes to hours. This traffic jam situation can potentially cause death to patients carried by ambulances because they need fast action because ambulances are vehicles that have the task of moving quickly to bring patients to their destination. But in reality, ambulance cars are often late to the scene due to traffic conditions because people prioritize individual interests [4].

Reporting from a news written by Kurniawan [5], that there was a traffic accident between an ambulance and a Datsun Cross car in the center of Malang, precisely the Kahuripan Road - Semeru Road intersection, Klojen District, Malang City, Thursday (11/6/2020). The accident occurred at around 15.30 WIB, where this accident involved an ambulance car from the Public Funeral Management Technical Implementation Unit (UPT PPU) of DLH Malang City which would participate in helping the funeral procession of the corpse of PDP Covid-19. At the beginning of the accident, the Datsun Cross car hit the ambulance from the side while passing at the scene while the ambulance had given a warning in the form of a siren to be given priority. As a result of the accident, an officer in the ambulance fainted. Both cars were wrecked.

Based on cases related to ambulance delays and accidents, a system is needed that can provide alerts to prevent accidents at traffic intersections and prioritize ambulances crossing emergency trips to arrive faster to the destination. Visual traffic monitoring is an effort in the development of intelligent transportation systems. Unlike the previous traffic system, this tool system uses image processing with the YOLOv8 method as an ambulance car detector in the traffic density of the city center intersection and how it works like a train traffic system starting from train detection, warning signals, then the door portal.

The YOLO algorithm is a real-time object detection algorithm, designed to improve upon existing object detection algorithms. Real-time object detection is becoming a critical component in various applications, including autonomous vehicles, robotics, video surveillance, and augmented reality [6]. Among various object detection algorithms, the YOLO work system stands out for its outstanding balance between speed and accuracy, enabling fast and reliable identification of objects in images. Since its inception, the YOLO family has continuously evolved, with each new version fixing limitations and improving performance from previous versions [7].

The literature review provides a perspective on previous research and integrates research methodologies and techniques to enhance the validity and reliability of the research. The first research with the title Traffic Light Control System Based on

*Corresponding author

Vehicle Density Using Image Processing, where the purpose of this research is to design a prototype traffic light system by utilizing image processing technology to process vehicle density data detected by camera sensors installed at each intersection, this traffic light management system works based on input in the form of captured images processed using image processing methods [8]. Due to the limited number of cameras, in the experiment the number of road directions is limited to only two directions. In image processing after black and white is obtained, the proportion of the number of pixels will be used to determine the length of the green light in each direction [9].

The second research with the title Implementation of a Traffic Light Control System Based on Siren Sounds on Arduino, where the purpose of this research is to design a traffic light control system based on siren sounds using Arduino UNO. This research produces a sensor to detect siren sounds from emergency vehicles by analyzing the siren sound first. The process of analyzing siren sounds using the MFCC method in recognizing siren sounds. In general, MFCC is used as a phonological feature parameter in speaker recognition applications using the Euclidean distance method [10]. To identify an unknown speaker, it can be done by measuring how much difference between two sets of objects or data based on their minimal distance. This research traffic light control system uses Arduino where the sounds tested are sirens from ambulances, police cars, and fire engines [11].

The third research with the title Design of IoT-Based Emergency Response Traffic Light System, the purpose of this research is to produce a traffic light system design that utilizes IOT, where sound sensor technology for vehicle density at road intersections is used to regulate the smooth traffic of emergency vehicles (ambulances, fire trucks or officials) so that they can work in a timely and maximum manner. This automatic traffic sign control can make it easier for officers at each intersection so that they do not need to manage priority vehicles through each intersection. It is hoped that there will be further testing on the use of other microcontroller-based traffic lights, so that the differences can be seen and can provide more effective results [12].

The fourth research with the title Implementation of Real Time Detection of Vehicle Type Classification in Indonesia Using the YOLOV5 Method, where the purpose of this research is to produce an object detection system using the YOLOV5 method to detect vehicle types on the highway. Using a dataset of 1332 images with bajaj, becak, bus, car, molen car, pick up car, bicycle, motorcycle, and truck classes. In the research results using the YOLOV5 method which can recognize objects consistently with a fairly high level of accuracy and has an accuracy value of 90% [13]. In this study, researchers used private datasets that were collected privately. To prepare the dataset in the training process, researchers use data downloaded from the internet and from videos taken by themselves and in which there are images of various types of vehicles [14].

Then, the fifth research with the title Integrated Smart Traffic Control System Towards Pekanbaru as a Smart City, where the purpose of this research is to provide a design solution for intelligent traffic light management (Smart Traffic Control System), based on object detection technology that uses deep learning to detect the number and type of vehicles. The number of vehicles becomes the basis for automatically determining the green light timer [15]. The Smart Traffic Control System (STCS) is integrated with a web-based geographic information system that continuously receives congestion information (current image, number of vehicles, congestion level).

Based on the review of previous research, this study uses image processing with the YOLOv8 method to classify ambulance objects in order to control traffic lights and provide audio warnings so that ambulances are given priority to go at high speed in the midst of traffic density. This traffic control system is like a portal on a train [16].

II. METHOD

The method section provides detail of research conducted.

A. System Design

The type of research to be carried out is Research and Development (R&D), which is a method of research and building a tool that is a problem solver with existing methods. This research method is used to produce certain products and test the effectiveness of these products. Where later it will build a system that can control traffic lights and provide warnings for ambulance priority using the YOLOv8 method and then test the system during implementation. The research design begins with a literature study, namely conducting a literature review of journals, articles, and dissertations related to the importance of monitoring fuel supplies for generators and maintaining generator performance in telecommunication device power supply systems and their impact on generator engine conditions.

The detection system carried out is by using a repurpose classifier. The YOLO stage is Pre-processing, which is a process used to obtain information about the original image that is ready to be processed. The first thing to do is to take an image of the object used as a dataset, then do the labeling and determine the class on the object, the results of the process will get the coordinate points and the class of the object that will be used as a dataset. The system will be depicted on a block diagram that explains the work process:

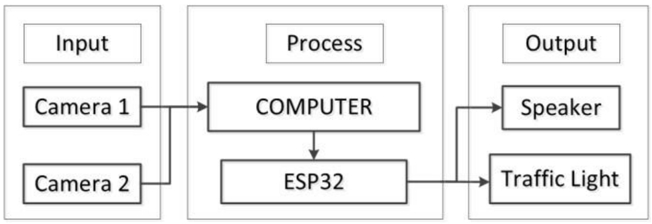


Figure 1. System Block Diagram

In Figure 1, the system input comes from the camera. The camera will capture video as input, then object detection is carried out according to the dataset, namely the ambulance in the computer using PyCharm with the YOLO method. Where, in the detection process there are 2 classes, namely the ambulance looking front and back to clarify the ambulance entering or leaving the intersection. Then, the data is sent in the form of commands to the ESP32 microcontroller to perform processing which results in the output of audio warnings using speakers and controlling traffic lights.

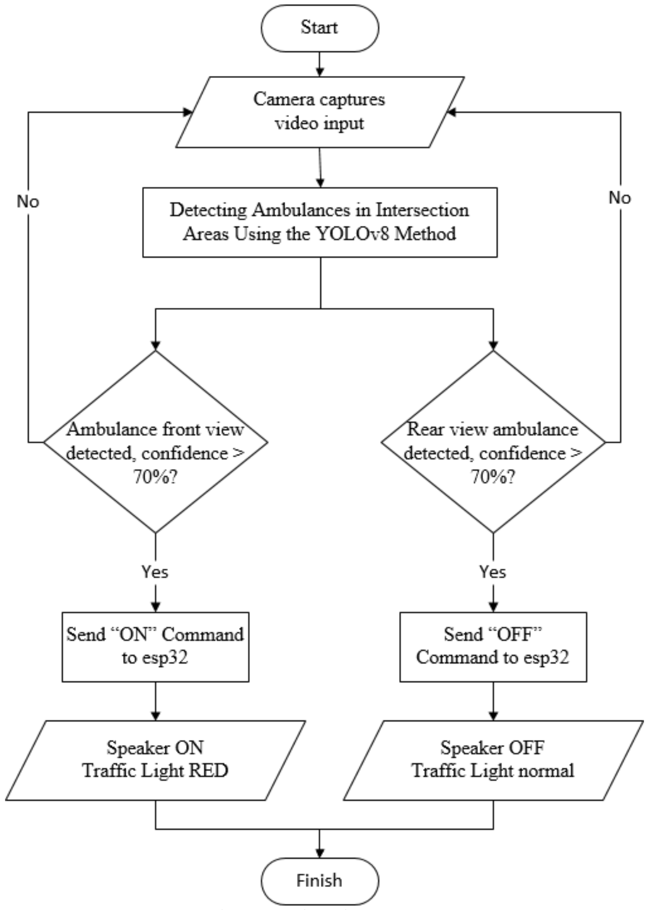


Figure 2. Flowchart System

In Figure 2, it is explained how the system works starting with running the system then the camera will record and then take video at the prototype traffic intersection as input. Then, the detection of the ambulance object will be carried out in front or behind to decide the output that will be executed after going through the process of clarifying the ambulance object coming or going. If the ambulance appears in front with a confidence value above 70%, the system will automatically command the speaker output ON and traffic light RED, but if the ambulance appears behind with a confidence value also above 70%, the speaker output is OFF and the traffic light is normal.

Since the system uses image processing with the YOLO method, the flowchart of the stages is shown in Figure 3. The stages of object detection using the YOLO method begin with the process starting, then Preprocessing prepares the image data for further processing. Then, divide the image into SxS-sized grids to detect objects in each grid. After that, it enters the Bounding Box prediction stage, which is marking the object to be detected. Convolutional Layer is processing the bounding box prediction through the convolution layer for feature extraction. Then, proceed with the calculation of IOU (Intersection over Union), which measures the suitability of the detected bounding box. The Non-Max Suppression stage is to eliminate overlapping bounding boxes to ensure only one detection per object. Next, Loss Calculation then Loss==Convergent stage ensures the loss value is as desired (convergent). This detection process detects objects based on the dataset that has been obtained through training and then evaluates the performance of the object detection model.

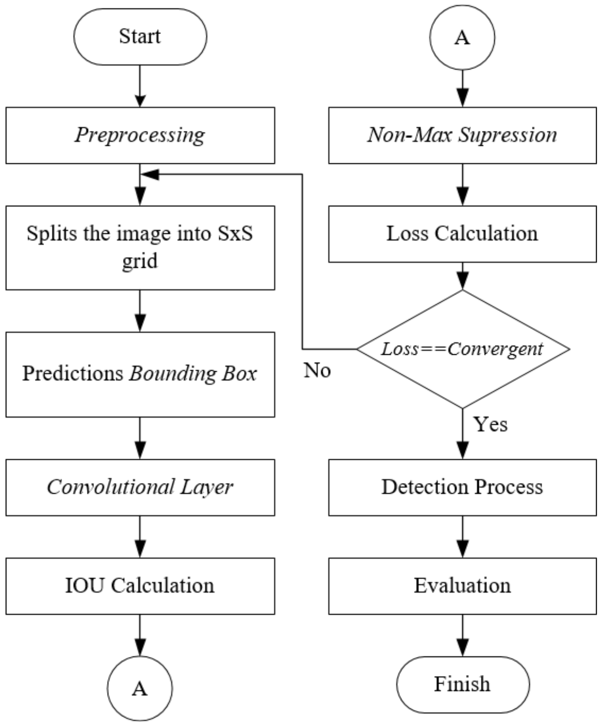


Figure 3. YOLO Method Flowchart

B. Hardware System Design

This prototype uses a plywood base material which is then created to resemble a miniature intersection with traffic lights. In the prototype there are 2 cameras as input for direct image capture and mini traffic lights and speakers as output. Using system design to explain the cable ports connected to each module and other electronic components. This test starts from detecting objects using image processing, then the data is received by the microcontroller to process the output. The outputs implemented are traffic light controllers and speakers to provide warnings. Design of output system and connection of system circuit shown in Figure 4 the system and Table 1.

TABLE I
CONNECTION OF SYSTEM CIRCUIT

Laptop	ESP32
USB 1	Micro USB
Laptop	**Webcam**

USB 2	USB Cable
Pin ESP32	**Pin LED**
12	Red1
	Red2
15	Red3
	Red4
13	Yellow1
	Yellow2
	Yellow3
	Yellow4
14	Green1
	Green2
4	Green3
	Green4
GND	GND
Pin ESP32	**DFPlayer Mini**
RX2	TX
TX2	RX
3V3	VCC
GND	GND
Speaker	**DFPlayer Mini**
+	SPK_1
-	SPK_2

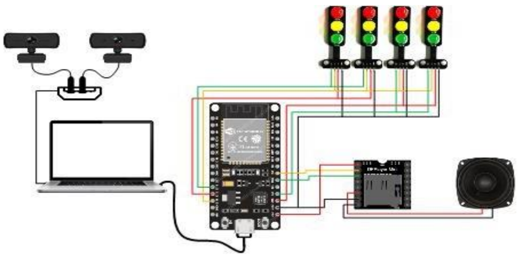


Figure 4. Design of Output System

The mechanical design provides an overview of the prototype to be built it can be seen the position of the camera that will be used as an ambulance detector.

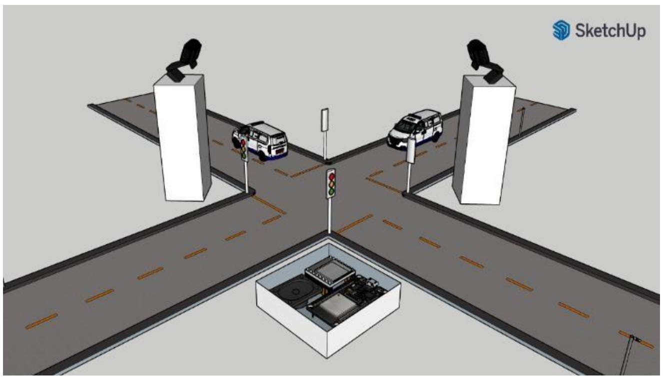


Figure 5. Mechanical Design

Shown in Figure 5 the mechanical design of the prototype. The position of the camera that will be used as an ambulance detector and components such as ESP32, speakers, DFPlayer, and traffic lights as output.

III. RESULTS AND DISCUSSION

A. System Prototype Design Results

As a result of the implementation, the mechanical design designed previously is in accordance with the implementation of the prototype system made. Where, this prototype uses plywood base material which is then created to resemble a miniature intersection with traffic lights.

The results of the research should be written clearly and concisely. Discussions consider outlines the importance of research, not repeat it. Avoid excessive uses quotations and discussions about literature published.

Figure 6. Prototype Implementation Result

In Figure 6, it is shown that the previously designed mechanical design is in accordance with the implementation of the prototype system. Where, this prototype uses plywood base material which is then created to resemble a miniature intersection with traffic lights. In the prototype, there are 2 cameras as input for direct image capture and mini traffic lights and speakers as output.

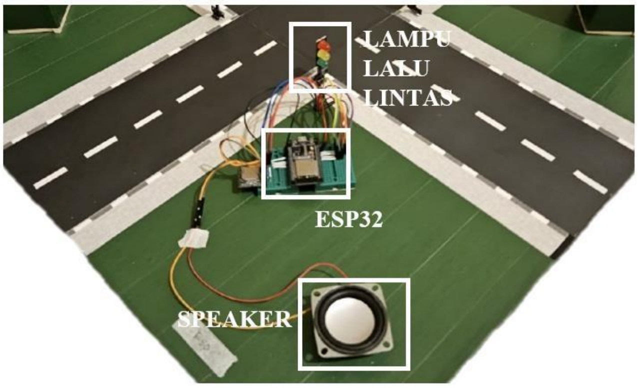
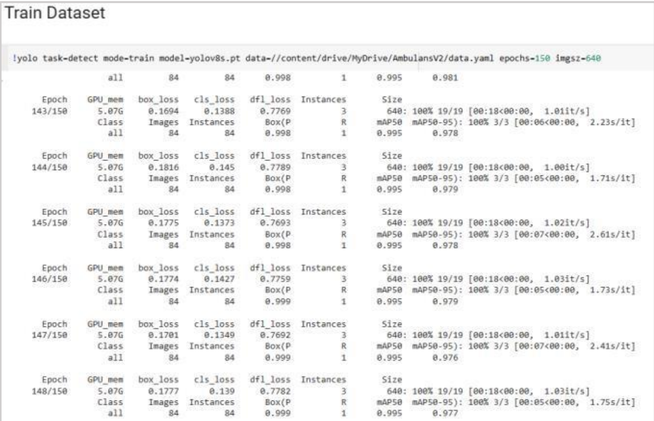


Figure 7. Hardware Implementation Result

In Figure 7, the hardware implementation shows that the components used in the prototype consist of ESP32, traffic light modules and speakers that are connected to each other to act as the output of the system. The components connected to the ESP32 will then be processed on the laptop along with the image captured by the camera through the USB hub.

B. Test Results of Epoch Changes

This test aims to determine the effect of epoch changes (repetition of the training process) on the confidence value when detecting objects. Testing is done by training the dataset repeatedly according to a predetermined epoch value and detecting objects at a certain distance.



```
Train Dataset

!yolo task-detect mode-train model-yolov8s.pt data-//content/drive/MyDrive/AmbulansV2/data.yaml epochs-150 imgsz-640
                 all         84         84      0.998          1      0.995      0.981

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
    143/150      5.07G     0.1694     0.1388     0.7769          3        640: 100% 19/19 [00:18<00:00,  1.01it/s]
               Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100% 3/3 [00:06<00:00,  2.23s/it]
                 all         84         84      0.998          1      0.995      0.978

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
    144/150      5.07G     0.1816      0.145     0.7789          3        640: 100% 19/19 [00:18<00:00,  1.00it/s]
               Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100% 3/3 [00:05<00:00,  1.71s/it]
                 all         84         84      0.998          1      0.995      0.979

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
    145/150      5.07G     0.1775     0.1373     0.7693          3        640: 100% 19/19 [00:18<00:00,  1.02it/s]
               Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100% 3/3 [00:07<00:00,  2.61s/it]
                 all         84         84      0.998          1      0.995      0.978

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
    146/150      5.07G     0.1774     0.1427     0.7759          3        640: 100% 19/19 [00:18<00:00,  1.03it/s]
               Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100% 3/3 [00:05<00:00,  1.73s/it]
                 all         84         84      0.999          1      0.995      0.979

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
    147/150      5.07G     0.1701     0.1349     0.7692          3        640: 100% 19/19 [00:18<00:00,  1.01it/s]
               Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100% 3/3 [00:07<00:00,  2.41s/it]
                 all         84         84      0.999          1      0.995      0.976

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
    148/150      5.07G     0.1777      0.139     0.7782          3        640: 100% 19/19 [00:18<00:00,  1.03it/s]
               Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100% 3/3 [00:05<00:00,  1.75s/it]
                 all         84         84      0.999          1      0.995      0.977
```

Figure 8. Dataset Training Process

From the test results shown in Figure 8, epoch changes to the confidence value with epoch values of 10, 30, 50, 100, 150 and object detection distance with cameras as far as 20cm, 40cm and 60cm obtained values in Table 2.

TABLE II
RESULTS OF EPOCH CHANGE

Epoch	20cm	40cm	60cm
10	90%	92%	90%
30	94%	92%	88%
50	94%	94%	92%
100	96%	95%	92%
150	94%	94%	93%

Based on the tests carried out, it is shown in Table 2 that the confidence value obtained does not differ much from several epoch changes during object detection. At epoch 10-30 the value obtained is good enough but not yet stable and can be improved again, at epoch 50-150 the results of the confidence value are higher because the system has improved performance due to more repetition of training (epoch), shown in Figure 9.

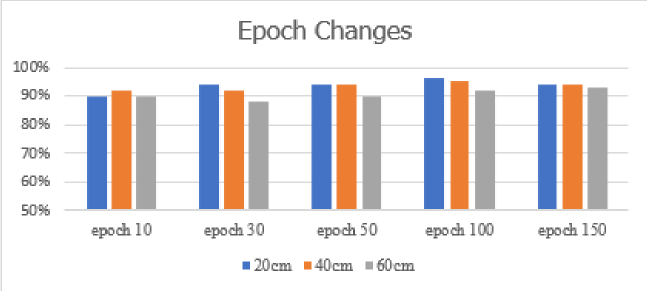


Figure 9. Graph of Epoch Changes

C. Test Results of Ambulance Detection Based on Distance

This test is carried out based on the distance when the ambulance is traveling to find out the system can detect the ambulance properly. This test is applied directly to the prototype that has been designed based on the mechanical design.

Figure 10. Incoming Ambulance Detection Testing, Distance 60cm

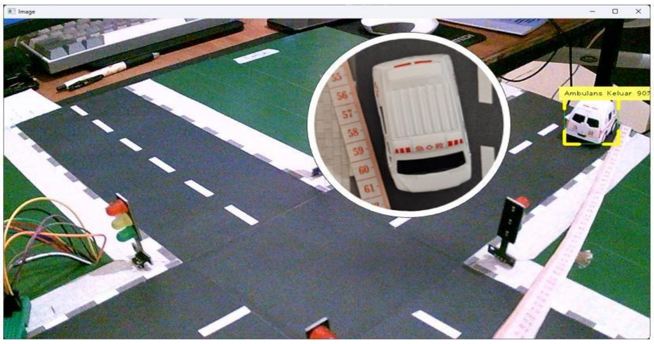


Figure 11. Ambulance Out Detection Testing, Distance 60cm

From the results of testing the detection of incoming and outgoing ambulances shown in Figure 10 and Figure 11 based on the distance between the ambulance and the camera, the results value is obtained in the following table. In Table 3, the confidence value obtained is getting bigger, which is categorized as more accurate because the distance between the ambulance object and the camera is getting closer, such as at a distance of 30cm obtaining a confidence value of 95% both when the ambulance enters and the ambulance exits.

TABLE III
RESULTS OF AMBULANCE DETECTION BASED ON DISTANCE

Time 10/11/23	Incoming Ambulance		Ambulance Out	
	Distance (cm)	Confidence (%)	Distance (cm)	Confidence (%)
15:48:13	60	91%	-	-
15:48:14	50	93%	-	-
15:48:15	40	94%	-	-
15:48:16	30	95%	-	-
15:48:17	-	-	60	90%
15:48:18	-	-	50	91%
15:48:19	-	-	40	93%
15:48:20	-	-	30	95%

D. *Test Results of Detection System Based on Light and Speed*

This test is carried out based on light conditions and speed when the object is traveling at a speed that resembles the speed of an ambulance to determine the system's confidence value in detecting the ambulance properly.


Figure 12. Detection result in morning conditions of 40km/h speed


Figure 13. Detection result in daytime conditions of 60 km/h speed

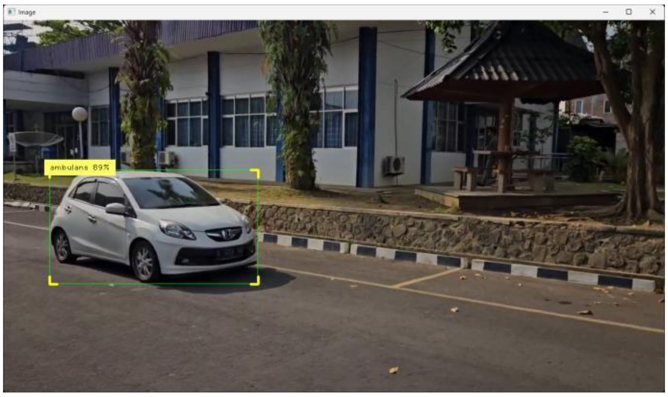


Figure 14. Detection result in afternoon conditions of 80 km/h speed

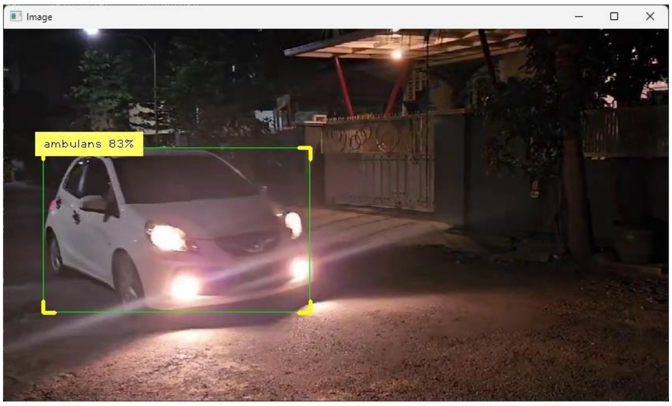


Figure 15. Detection result in night conditions at 40 km/h speed

In Figure 12, Figure 13, Figure 14, and Figure 15 are the results of testing the object detection system, which is the confidence accuracy value based on light conditions and object speed, the results are obtained in Table 4:

TABLE IV
RESULTS OF AMBULANCE DETECTION BASED ON LIGHT AND SPEED

Condition	Speed 40km/h	Speed 60km/h	Speed 80km/h
	Confidence (%)	Confidence (%)	Confidence (%)
Morning 9:00 AM	86%	84%	82%
Noon 12:00 AM	89%	87%	84%
Afternoon 3:00 PM	87%	86%	83%
Night 6:00 PM	82%	78%	75%

Based on the data in Table 4, the confidence value obtained is influenced by light conditions. Where, the confidence value obtained is lower at night than other time conditions because the light intensity is dark so that the system confidence value in detecting objects averages 78.3%. Then, another factor is also the speed of the object as in the test, the highest value is obtained at a speed of 40km/h which is 89% because it is slower than the speed of 60km/h and 80km/h.

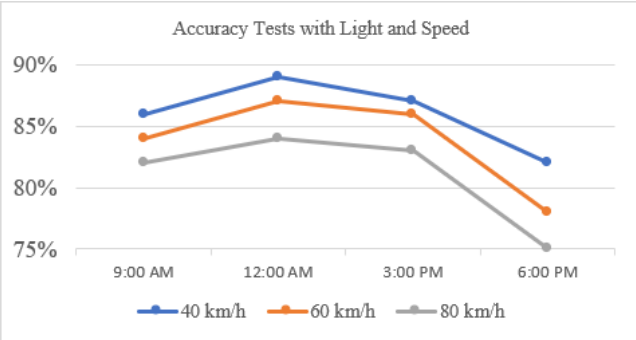


Figure 16. Graph of Accuracy Tests with Light and Speed

In Figure 16, a graph based on the test data shows a higher confidence value during daytime detection due to the very bright light intensity.

E. Test Results of Detection System Based on Camera Angle

This test is carried out based on the camera angle to test the ability of the YOLOv8 method to detect objects from various viewpoints and positions, in order to know that the system is able to recognize objects consistently even though the object is seen from different angles or perspectives.

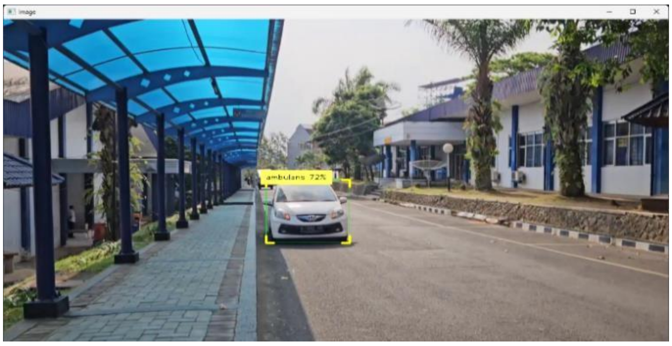


Figure 17. Detection Result at 0° Camera Angle

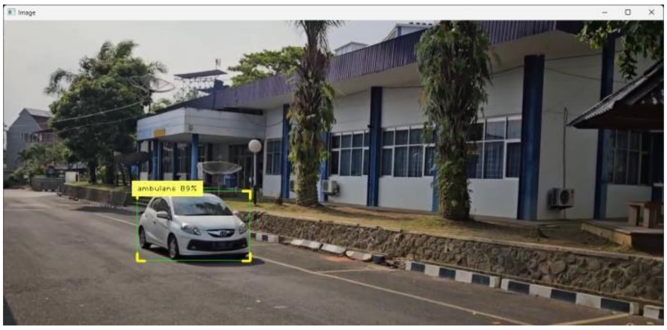


Figure 18. Detection Result at 45° Camera Angle

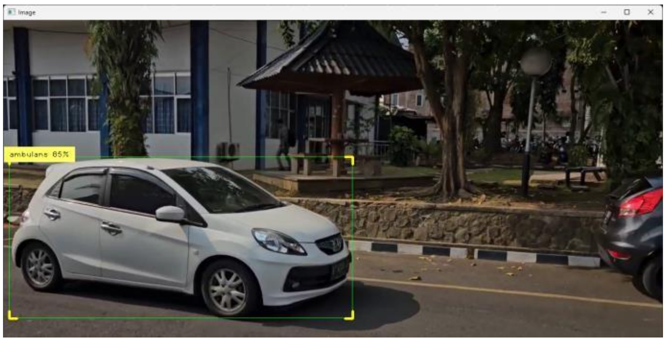


Figure 19. Detection Result at 90° Camera Angle

Figure 20. Detection Result at 135° Camera Angle

Figure 21. Detection Result at 180° Camera Angle

In Figures 17 to 21 are the results of the detection system test that measures the confidence accuracy value based on the camera angle obtained in its following table:

TABLE V
RESULTS OF AMBULANCE DETECTION BASED ON CAMERA ANGLE

Angle	Confidence (%)
0°	77%
45°	89%
90°	83%
135°	90%
180°	73%

Based on the test results data in Table 5, the confidence value is obtained which is influenced by the angle and position of the camera when detecting objects. At an angle of 45° obtained a value of 89% and an angle of 135° obtained a value of 82%. So that detecting at oblique camera angles and positions obtains a better system confidence level in identifying objects because it is more detailed.

F. Test Results of Object Similarity Detection System

Object similarity detection testing is carried out to measure the accuracy of the system in recognizing and distinguishing objects similar to ambulances, referring to how precise the system is in classifying the detected objects.

The objects used in the test are miniature ambulances, power banks, mice, miniature cars in white, gray and black. So that with these similar objects can show differences in the accuracy of the confidence value.

Figure 22. Object Detection Results of Miniature Ambulance, White Car and Black Car

Figure 23. Object Detection Result of a White Mouse

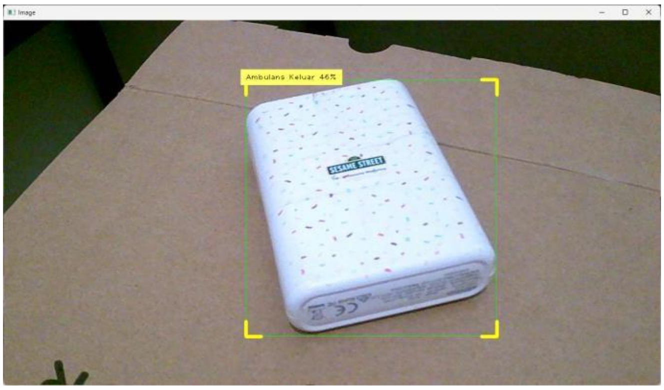


Figure 24. Object Detection Result of a White Power bank

Figure 25. Object Detection Result of Miniature Gray Car

Figures 22 to 25 are the results of testing the detection system, the confidence accuracy value based on objects like ambulances so that the results to be minor to undetectable. The detection result value data is shown in the following table:

TABLE VI
RESULTS OF OBJECT SIMILARITY DETECTION SYSTEM

Object	Confidence (%)
Ambulance	93%
White car	43%
Mouse	56%
Power bank	46%
Gray car	Not detected
Black Car	Not detected

In Table 6, the confidence value is obtained in testing the similarity of objects like an ambulance visually. It can be seen in comparison with the ambulance object which has a confidence value of 93%, where other objects detected are objects with white color characteristics. So that the confidence value obtained when detecting white objects is 43% - 56%, while other color objects, especially those with dark colors such as gray and black are not detected.

G. Test Results of Delay for Object Recognition

Object recognition delay testing is done with the aim of knowing the time it takes for the system to recognize objects. Testing is done by observing the delay value displayed on Pycharm, shown in Figure 26 and Figure 27:

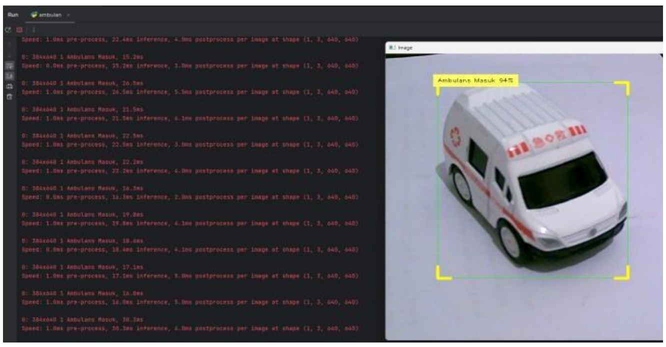


Figure 26. Delay Testing Results of Front View Ambulance

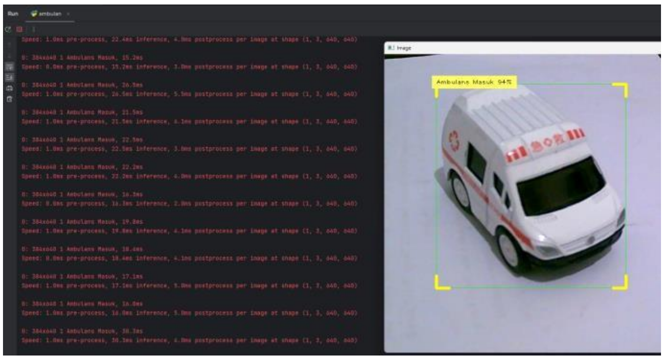


Figure 27. Delay Testing Results of Rear-View Ambulance

From the results of testing the delay of ambulance object recognition in front and rear views on Pycharm, the average delay value is obtained as long as the system detects and then recognizes objects in an image captured by the camera. Object recognition test result data is shown in the following table:

TABLE VII
RESULTS OF DELAY OBJECT RECOGNITION

Ambulance Incoming		**Ambulance Out**	
Detection	**Delay**	**Detection**	**Delay**
1	15,2 m/s	1	15,8 m/s
2	26,5 m/s	2	27,3 m/s
3	21,5 m/s	3	18,0 m/s
4	22,5 m/s	4	21,3 m/s
5	22,2 m/s	5	15,2 m/s
6	16,3 m/s	6	17,5 m/s
7	19,8 m/s	7	19,2 m/s
8	18,4 m/s	8	14,2 m/s
9	17,1 m/s	9	15,0 m/s
10	16 m/s	10	19,2 m/s
Average: 19,5 m/s		**Average: 18,2 m/s**	

Based on the data from the object recognition delay test results in Table 7, the average delay value when recognizing the incoming ambulance object shows 19.5 m/s while when recognizing the outgoing ambulance object, the average delay value is 18.2 m/s. So, it is known how long it takes the system to recognize the front and rear ambulance objects tested on Pycharm.

H. Test Results of Overall System Delay

The overall system delay test is carried out with the aim of knowing the time it takes for the system to read input to produce output and ensure system performance by measuring delay using a stopwatch.

Figure 28. Result of Delay and Output when Ambulance Incoming

Figure 29. Result of Delay and Output when Ambulance Out

In Figure 28 and Figure 29 are the results of delay testing measured using a stopwatch and system output when the ambulance enters and exits the prototype, so that the results data are obtained in the following table:

TABLE VIII
RESULTS OF OVERALL SYSTEM DELAY

Ambulance Incoming		
Delay (s)	**Status LED**	**Status Speaker**
1,66	ON	ON
2,30	ON	ON
5,18	ON	ON
3,47	ON	ON
4,37	ON	ON
Average Delay: 3,39 s		
Ambulance Out		
Delay (s)	**Status LED**	**Status Speaker**
2,12	OFF	OFF
3,12	OFF	OFF
1,54	OFF	OFF
2,13	OFF	OFF
3,14	OFF	OFF
Average Delay: 2,41 s		

In Table 8, based on system and output delay testing, the average delay value when the ambulance enters shows 3.39

seconds during the process of automatically activating the output in the form of lights and speakers, while when turning off the output the delay is smaller at 2.41 seconds after the ambulance passes. The output status of the lights and speakers is tested to determine whether they are functioning properly and working according to the prototype planning requirements.

I. Test Results of Minimum Distance Detection

The minimum detection distance test is used to determine the minimum distance a detection system can accurately detect objects. The purpose of this test is so that the system can control traffic lights and issue outputs in a timely manner through the detection of incoming ambulance objects, shown with an illustration in Figure 30:

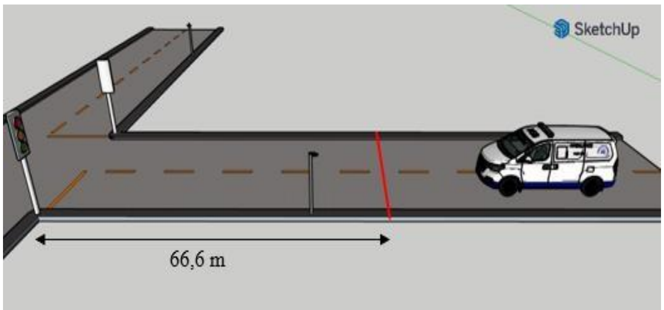


Figure 30. Illustration of Minimum Detection Distance

In Figure 30 is an illustration of the minimum distance limit for the camera to detect the input image and command the output on time. From the results of the average delay in Table 8, a time of 3 seconds is obtained, where if the speed of the ambulance used is 80 km/h then in seconds a speed of 22.2 m/s is obtained. To obtain the minimum detection distance, it can be measured using Equation (1):

$$S = V \times t \quad (1)$$

Description:

S : Distance
V : Speed
t : Time (s)

The results of the minimum detection distance calculation are obtained as follows:

$$S = 22{,}2 \times 3$$
$$= 66{,}6\ m$$

Based on the minimum detection distance test that has been carried out, the distance value is obtained which is influenced by the delay and speed of the ambulance. Where, the distance value of 66.6 m is generated from an ambulance speed of 22.2 m/s and an average system delay of 3 seconds. By calculating and knowing the minimum detection distance, the closest distance limit of object detection to the intersection is obtained so that the system can issue a warning output on time before the ambulance crosses the traffic intersection.

IV. CONCLUSION

The number of epochs used in the training model affects the accuracy of object recognition. The higher the number of epochs 50, 100 and 150, the model tends to be better at recognizing objects so that the confidence value of 94% - 96% obtained will be better. The level of accuracy of the ambulance object detection system is influenced by various factors such as distance, light intensity, object speed, camera angle, and similarity to similar objects. At 60 cm, a confidence value of 91% is obtained, the further the object is detected, the smaller the confidence value. At the best light intensity and speed conditions are at a speed of 40 km / h during the day, the confidence value is 89% because the slower the speed of the object and the brighter the light conditions, the clearer the visual object. At the camera angle, a better confidence value is obtained at an angle of 45 ° and 135 ° with a value of 89% and 90% because at that angle the visual object is more clearly visible. Object recognition delay is affected by computing performance, the average value of the ambulance entry delay is 19.5 m/s and the ambulance exit is 18.2 m/s. Then, the overall system delay is obtained starting from the ambulance detection process until the output is turned on. The average ambulance entry delay is 3.39 seconds during automatic output activation, while when the output delay is

2.41 seconds. The minimum detection distance is affected by the ambulance speed of 80 km/h and the system delay of 3 seconds, so that 66.6 m is obtained so that the system can issue a warning output on time before the ambulance crosses the traffic intersection.

REFERENCES

[1] Republik Indonesia, *Undang-Undang Republik Indonesia Nomor 22 Tahun 2009 Pasal 134 tentang Lalu Lintas Angkutan Jalan*. Jakarta: Lembaran RI, 2009.

[2] Menteri Kesehatan dan Kesejahteraan Sosial, *Keputusan Menteri Kesehatan dan Kesejahteraan Sosial Nomor 143 Tahun 2001 tentang Standarisasi Kendaraan Pelayanan Medik*. Jakarta: Warta Perundang-undangan Nomor 2054, 2001.

[3] I. A. Qurni, "Analisis Daerah Rawan Kecelakaan Lalu Lintas (Studi Kasus Jalan Nasional Arteri Primer Dan Arteri Sekunder Kabupaten Kendal)," *Jurnal Geografi: Media Informasi Pengembangan Dan Profesi Kegeografian*, vol. 13, no. 1, pp. 53-60, 2019.

[4] F. Zulianti, R. Munadi, and I. H. Santoso, "Smart Traffic Light Berbasis Internet Of Things Pada Keselamatan Ambulans," *e-Proceeding of Engineering*, 2021.

[5] K. Kurniawan, "Kecelakaan Ambulans Vs Datsun di Kota Malang, Petugas Pemakaman PDP Covid-19 Dalam Ambulan Pingsan," *tribunnews.com*, Malang, 2020.

[6] M. Sarosa, N. Muna, and E. Rohadi, "Detection of natural disaster victims using You Only Look Once (YOLO)," dalam *IOP Conference Series: Materials Science and Engineering*, vol. 1098, 2021.

[7] C. Geraldy and C. Lubis, "Pendeteksian dan Pengenalan Jenis Mobil Menggunakan Algoritma You Only Look

Once dan Convolutional Neural Network," *Jurnal Ilmu Komputer dan Sistem Informasi*, pp. 197-199, 2020.

[8] P. G. Pamungkas, K. and H. Al Fatta, "Deteksi Mobil Ambulance Menggunakan Operator Sobel," *Jurnal Teknologi Informasi dan Komunikasi*, vol. 10, no. 1, p. 87, 2020.

[9] A. M. Ario Saputra, A. Mulyana, and S. Aulia, "Sistem Kontrol Lampu Lalu Lintas Berdasarkan Kepadatan Kendaraan Menggunakan Image Processing," *Journal e-Proceeding of Applied Science*, p. 3321, 2021.

[10] M. Ardiana, T. Dutono, and B. Santoso, "Gender Classification Based Speaker's Voice using YIN Algorithm and MFCC," *International Electronics Symposium (IES)*, pp. 438-444, 2021.

[11] M. H. Ibrahim, I. I. Tritoasmoro, and L. Novamizanti, "Implementasi Sistem Kontrol Lampu Lalu Lintas Berdasarkan Suara Sirene Pada Arduino," *JURTEKSI (Jurnal Teknologi dan Sistem Informasi)*, p. 3667, 2020.

[12] Usman, P. Albert, I. V. Sari, I. Idris, and R. Khair, "Rancang Bangun Traffic Light System Tanggap Darurat Berbasis IoT," *Jurnal Sistem Komputer dan Informatika (JSON)*, pp. 195-199, 2020.

[13] Q. Aini, N. Lutfiani, H. Kusumah, and S. Zahran, "Deteksi Dan Pengenalan Objek Dengan Model Machine Learning Model YOLOv5," *Journal of Computer Engineering System and Science*, vol. 6, no. 2, p. 192, 2021.

[14] D. I. Mulyana and M. A. Rofik, "Implementasi Deteksi Real Time Klasifikasi Jenis Kendaraan Di Indonesia Menggunakan Metode YOLOV5," *Jurnal Pendidikan Tambusai*, pp. 13971-13982, 2022.

[15] R. M. Taufiq, Sunanto, and Y. Rizki, "Integrated Smart Traffic Control System Menuju Pekanbaru Sebagai Smart City," *JURTEKSI (Jurnal Teknologi dan Sistem Informasi)*, pp. 67–74, 2020.

[16] A. Hilmani and L. Hassouni, "Automated Real-Time Intelligent Traffic Control System for Smart Cities Using Wireless Sensor Networks," *Wireless Communications and Mobile Computing*, vol. 2020, no. 1, 2020.