American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-11, Issue-01, pp-185-193
www.ajer.org
Research Paper Open Access

Vehicle Driver Warning Systems Using Road Marking and Traffic Light Detection

Akuwan Saleh[1], Haryadi Amran D[2], Amanda Septia A[2]
[1,2](Department of Electrical Engineering, Politeknik Elektronika Negeri Surabaya, Surabaya, Indonesia)

ABSTRACT :*Everyone has experienced fatigue and sleepiness while driving. This makes him not know the direction so that it violates traffic and can cause an accident. Violations that usually occur are breaking through traffic lights and violating road markings. Therefore, a simulation software was made to help negligent and sleepy drivers not to violate traffic and reduce accidents. The technology used is image processing with C# programming and the EmguCV library using the Haar Cascade Classifier and Color Detection methods. Haar-like features are rectangular features, which give a specific indication of an image. The captured image will be processed in two stages, namely preprocessing to detect markings and Gaussian filter to detect traffic lights. The results of the preprocessing will be processed in the Haar Cascade Classifier to get the ROI of the marker and then look for the coordinates to find the distance between the marker and the driver. The limit used in measuring distance is 25.57 cm (85 pixels). If the coordinate distance is less than 25.57 cm, the alarm will sound and alert the driver to stay away from the marker and if the coordinate distance is more than 25.57 cm, the alarm will be off. While the results of the gaussian filter will be converted into HSV frames to detect red and green colors using the color pixel values of each color. The color of the light can be detected when the contour size value is between 0 and 6.*

KEYWORDS *Road Marking, Image Processing, Haar Cascade Classifier, and Color Detection.*

Date of Submission: 16-01-2022 Date of acceptance: 31-01-2022

I. INTRODUCTION

Drowsiness is something that is always experienced by many people. If a person lacks sleep, is tired of working, and so on, it will definitely cause someone to be sleepy. Especially if someone is on the way. Especially in urban environments that require constant concentration of the driver resulting in visual fatigue [1]. Of course this is very detrimental because it can endanger yourself and others. Currently, there are frequent traffic violations that can lead to accidents. Most of the causes are due to negligent and sleepy drivers.

In the 2019 Land Transportation Statistics Data, During the 2015-2019 period, the number of traffic accidents has increased by an average of 4.87 percent per year. Improvement in the number of traffic accidents is followed by an increase in the number of dead and slightly injured by 1.41 percent and 6.26 percent, respectively. However, material losses increased by an average of 4.23 percent per year. Indonesian State Police (Korlantas POLRI) recorded the number of accidents in 2019 as many as 116,411 accidents. The number has incresed 6.59 percent compared to 2018 as many as 109,215 events [2].

Things like this must of course be minimized so that the number of violations can be reduced. To overcome these problems, in this research, the Detection of Road Marks and Traffic Lights Based on Image Processing is made. The detection is visualized in the form of software. If the driver approaches the road marking there will be a reminder alarm to notify the driver to stay away from the marking line, and if there is a traffic light, an alarm will sound to notify the driver if the light shows red or green.

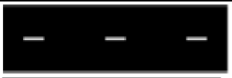
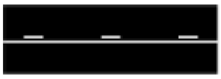
With this detection can help drivers who are negligent or sleepy on the way so as to reduce traffic violations and avoid accidents.

II. MATERIAL AND METHOD

2.1 ROAD MARKINGS

Road marking is a sign located on the road surface or above the road surface which includes equipment or signs that form longitudinal lines, transverse lines, oblique lines and other symbols that function to direct traffic flow and limit traffic interest areas. Road markings are regulated in the Minister of Transportation Regulation Number 34 of 2014 [3].Longitudinal markings are marks that are parallel to the axis of the road. longitudinal markings connected by transverse lines used to delimit parking spaces in vehicle traffic lanes are not considered as longitudinal road markings. Types of road marks as shown Table 1.

TABLE I. MARK TYPE

Mark	Mark Name	Meaning
	Dotted line marker	• Line separator • Lane separator
	Approach mark	That there will be full line longitudinal markings / full line marking approaches
	Full line marking	It is forbidden to pass through the marker
	Dotted and intact line markings	• Road lanes on the side of the solid line are prohibited from crossing these markings • The lane on the side of the dotted line may cross that line
	Marking two solid lines	It is forbidden to pass through these markings and be installed if the road has three or more lanes

2.2 TRAFFIC LIGHT

Traffic lights (according to Law no. 22/2009 on Traffic andRoad Transportation: traffic signaling device or APILL) is a light that controls traffic flow installed at road junctions, zebra crossings, and other traffic flow areas. These lights indicate when the vehicle must run and stop alternately from various directions. Traffic regulation at crossroads is intended to regulate the movement of vehicles in each group of vehicle movements so that they can move alternately so that they do not interfere with each other between existing flows [4].

Fig.1. Example of traffic lights

2.3 SYSTEM PLANNING

Software created using objects in the form of highways that have road markings and traffic lights. This object was recorded using a camera mounted on a motorcycle. Fig.2 shows block diagrams and system flowcharts.

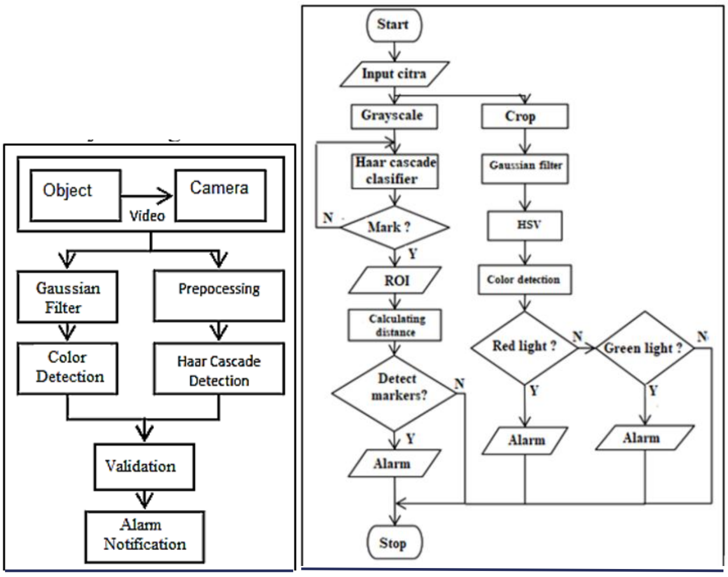


Fig. 2. Block diagrams and system flowcharts

The videos obtained are processed by preprocessing and followed by the haar cascade classifier for get the road marking object. Meanwhile, to detect traffic lights, video frames will be cropped and processed with a gaussian filter and followed by color detection to detect the color of traffic lights. If the traffic light is red, the alarm will activate and warn the driver to stop, if the light is green, the alarm will tell you to keep going, if the driver approaches the marker, the alarm will warn you to stay away from the marker.For more details,

2.4 GAUSSIAN FILTER

Gaussian filter or gaussian blur filter is one of the basic and widely used image processing techniques. Gaussian filter [5] is a basic preprocessor used to remove noise in each image, then the image is transferred to a gray map. Gaussian filters are very good at removing normally distributed noise. In Figure 3, after converting the image to grayscale, cropping is done and the next step is to determine the mask. Masks that are often used for image improvement are Gaussian smoothing masks [6],[7]. The weights on the Gaussian smoothing mask follow a normal distribution as stated in the equation below:

$$h(m,n) = \frac{1}{2\pi\sigma^2} e^{\frac{-(m^2+n^2)}{2\sigma^2}} \quad (1)$$

Where:

- σ is the standard deviation value of the normal distribution used. The greater the value of σ, the more neighboring points are included in the calculation.
- x=m and y=n are the coordinates of the mask where the coordinates (0,0) are the positions of the midpoint of the mask that have the greatest / highest value.
- π is a constant with the value 3.14.
- e is a natural number constant with the value 2.718281828

2.5 HAAR CASCADE CLASSIFIER

The haar cascade method uses the haar feature function which requires prior training to obtain a decision tree called the cascade classifier, to determine the presence or absence of objects in the processed image [8]. In general, Haar-Like Feature is used to detect objects in digital images [9]. The haar cascade classifier method is used to detect road markings. Where this method will classify marker data existing ones to find suitable features. The vehicle camera captures RGB three-channel color images, and most of the road markings are white [10].The first thing to do is change the RGB frame to a grayscale frame. This frame each pixel has a gradient color ranging from white to black (0-255). Then the results of this frame are processed using the haar cascade classifier method. Fig.3shows the flowchart and process of the haar cascade classifier for road marking detection.

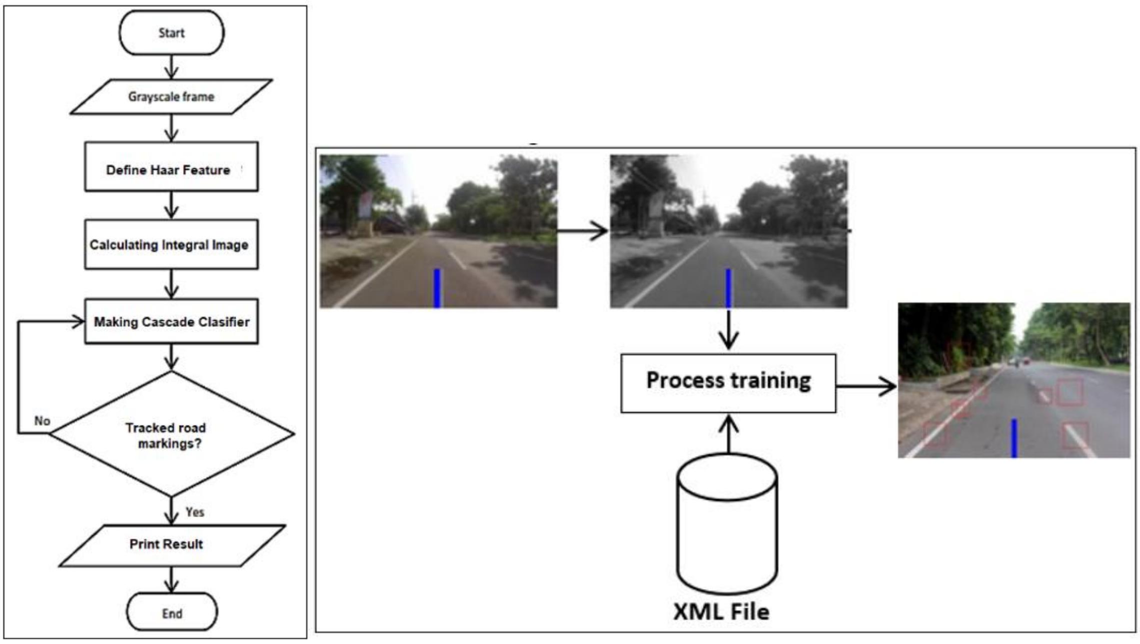


Fig.3. Flowchart and process of haar cascade classifier

This method will classify existing road marking data to find features that match the road markings and this feature is used to detect road markings.In haar cascade classifier must first create an XML file first. First of all, make a positive and negative picture. Positive images are images of road markings, while negative images are images other than road markings. Then make a positive data sample by cropping the images one by one. Positive data samples are stored in vector files. The next process is doing training. This process is carried out to obtain features that match the road markings. The more features that are used, the longer it takes to classify. The pre-built cascade classifiers are combined or converted into an XML file. This file will be read or loaded on the program so that it can detect traffic signs and lights. Region of interest (ROI) detector helps prune the image to portions which are good candidates for being road markings [11].To determine the distance, the distance between the coordinates of the ROI marker with red box line and the driver's coordinates (blue line) is used. The formula used to determine the distance is as follows:

$$(x, \mathrm{y}) = x + \frac{width}{2}, y + \frac{height}{2} \qquad (2)$$

$$distance(pixels) = \sqrt{(\mathrm{x2} - \mathrm{x1})^2 + (\mathrm{y2} - \mathrm{y1})^2} \qquad (3)$$

$$distance(cm) = \text{pixel value x } 0.300808422 \qquad (4)$$

The distance of the resulting marker is from the coordinates of the marker and the driver who then calibrated with 0.300808422 this value is the pixel/cm value.

2.6 Color Detection

In detecting traffic lights, color detection is used. Where the colors to be detected are red and green. The method takescropped RGB color images as the input. Images are then converted from the RGB color space to the HSV color space [12]. Frames that have been cropped and filtered using a Gaussian filter are converted to HSV and then red and green are searched for using the minimum and maximum values for each color.

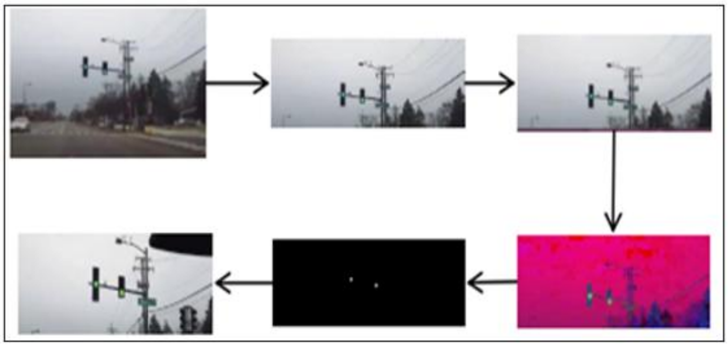


Fig.5. Color detection process

Where the value of red has a minimum value (166, 84, 141) and maximum (186, 255, 255) while the green color has a minimum value (66,122, 129) and a maximum (86, 255, 255). To get the ROI of the lamp, contour is used. If the contour size has a value between 0 to 6, then the ROI of the lamp will appear, if the contour size value is other than 0 to 6 then the ROI does not appear.

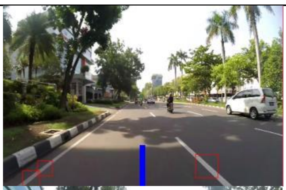
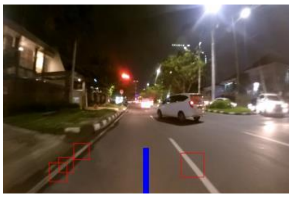
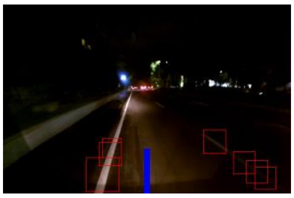
III. RESULT AND DISCUSSION

System testing is carried out based on light intensity, namely in light, overcast, and dark conditions. In testing road markings, three road locations were used.The first video takes the Dr.Ir.H.Soekarno road near campus C UNAIR, the second video takes the southern Dr.Ir.H.Soekarno road, and the third video takes the Kertajaya Indah road in the city of Surabaya, Indonesia.Traffic light testing was carried out from Jalan Ijen to Jalan Kawi in the Malang City area, Indonesia. The time needed in bright conditions to get results in the form of information about road markings and traffic lights that are detected is 1.6 seconds. Meanwhile, when it is overcast and dark, the time it takes is 0.9 seconds.

3.1 Road Mark Detection

Table 2. is the result of testing which shows that video 1, video 2, and video 3 can detect road markings in light, overcast, and dark conditions. This is indicated by the appearance of a red ROI rectangle on the frame.

TABLE 2. ROAD MARK DETECTION RESULTS

Condition	Video 1	Video 2	Video 3
Light			
Overcast			
Dark			

Tables 3 to 11 are test results data on road markings consisting of contour values, coordinate values, distances in pixels, distances in centimeters, voice, and descriptions.

3.1.1 DETECTION OF ROAD MARKINGS IN LIGHT CONDITIONS

The test results on video 1, video 2, and video 3 in light conditions are shown in Tables 3 to 5.

TABLE 3. TEST RESULT ON VIDEO 1

Seconds to	Contour Value	Value (x,y) X	Y	Distance (pixels)	Distance (cm)	Voice	Description
10	X=268, Y=241, W=43, H=43	289	262	46.329	13.9349	On	Stay away from Marks
20	X=284, Y=260, W=48, H=48	308	284	47.1699	14.1891	On	Stay away from Marks
30	X=134, Y=238, W=43, H=43	155	259	116.811	35.1377	Off	Safe Distance
40	X=296, Y=154, W=27, H=27	309	167	141.354	42.5204	Off	Safe Distance
50	X=346, Y=207, W=51, H=51	371	232	127.318	38.2983	Off	Safe Distance
60	X=174, Y=230, W=67, H=67	207	263	68.5054	20.6070	On	Stay away from Marks

TABLE 4. TEST RESULT ON VIDEO 2

Seconds to	Contour Value	Value (x,y) X	Y	Distance (pixels)	Distance (cm)	Voice	Description
10	X=286, Y=258, W=43, H=43	307	279	48.3011	14.5293	On	Stay away from Marks
20	X=242, Y=279, W=30, H=30	257	294	9.8994	2.97782	On	Stay away from Marks
30	X=437, Y=122, W=40, H=40	457	142	250.059	75.2198	Off	Safe Distance
40	X=36, Y=288, W=26, H=26	49	301	215	64.6738	Off	Safe Distance
50	X=171, Y=246, W=58, H=58	200	275	69.0796	20.7797	On	Stay away from Marks
60	X=338, Y=243, W=46, H=46	361	266	103.121	21.0196	Off	Safe Distance

TABLE 5. TEST RESULTS ON VIDEO 3

Seconds to	Contour Value	Value (x,y) X	Y	Distance (pixels)	Distance (cm)	Voice	Description
10	X=107, Y=263, W=31, H=31	122	278	143.850	43.2712	Off	Safe Distance
20	X=299, Y=129, W=44, H=44	321	151	160.464	48.2689	Off	Safe Distance
30	X=254, Y=223, W=76, H=76	292	261	48.8262	14.6873	On	Stay away from Marks
40	X=394, Y=267, W=34, H=34	411	284	147.979	44.5135	Off	Safe Distance
50	X=288, Y=253, W=42, H=42	309	274	52.4785	15.7859	On	Stay away from Marks
60	X=336, Y=213, W=45, H=45	358	235	114.856	34.5496	Off	Safe Distance

W=Width, H=Height

From the data generated, in Table 3 it can be seen that the driver approaches the road markings at the 10th, 20th, and 60th seconds so that the alarm is on.For Table 4 the driver approaches the road markings at the 10th, 20th, 50th seconds. While in Table 5, the driver approaches the road markings at the 30th and 50th seconds.Based on the 10th second data in table 5, the ROI coordinate value can be calculated using equation 2:

$$(x, y) = \left(107 + \frac{31}{2}\right), \left(263 + \frac{31}{2}\right) = (122.5, 278.5)$$

Furthermore, the calculation of distance (pixels) and distance (cm) can be calculated by equations 3 and 4.

$$\text{distance(pixels)} = \sqrt{(264 - 122)^2 + (301 - 278)^2} = \sqrt{20693} = 143.850$$
$$\text{distance(cm)} = 143.850 \text{ x } 0.300808422 = 43.2712$$

3.1.2 Detection of Road Markings in Overcast Conditions

The test results on Tables 6 to 8 are the results of tests on video 1, video 2, and video 3 which were carried out in cloudy/overcast conditions.

TABLE 6. Test Results on Video 1

Seconds to	Contour Value	Value (x,y) X	Value (x,y) Y	Distance (pixels)	Distance (cm)	Voice	Description
10	X=93, Y=276, W=35, H=35	110	293	154.207	46.3867	Off	Safe Distance
20	X=164, Y=205, W=25, H=25	176	217	121.655	36.5948	Off	Safe Distance
30	X=253, Y=205, W=32, H=32	269	221	80.1560	24.1115	On	Stay away from Marks
40	X=182, Y=243, W=38, H=38	201	262	74.0945	22.2882	On	Stay away from Marks
50	X=170, Y=236, W=31, H=31	185	251	93.4933	28.1235	Off	Safe Distance
60	X=341, Y=238, W=40, H=40	361	258	106.103	31.9166	Off	Safe Distance

TABLE 7. Test Results on Video 2

Seconds to	Contour Value	Value (x,y) X	Value (x,y) Y	Distance (pixels)	Distance (cm)	Voice	Description
10	X=317, Y=220, W=37, H=37	335	238	94.9210	28.5530	Off	Safe Distance
20	X=221, Y=243, W=44, H=44	243	265	41.6773	12.5368	On	Stay away from Marks
30	X=266, Y=251, W=50, H=50	291	276	36.7967	11.0687	On	Stay away from Marks
40	X=280, Y=256, W=40, H=40	300	276	44.8292	13.4850	On	Stay away from Marks
50	X=261, Y=196, W=35, H=35	278	213	89.1066	26.8040	Off	Safe Distance
60	X=174, Y=260, W=50, H=50	199	285	66.9402	20.1361	On	Stay away from Marks

TABLE 8. Test Results on Video 3

Seconds to	Contour Value	Value (x,y) X	Value (x,y) Y	Distance (pixels)	Distance (cm)	Voice	Description
10	X=376, Y=262, W=41, H=41	396	282	133.360	40.1158	Off	Safe Distance
20	X=237, Y=258, W=34, H=34	254	275	27.8567	8.37952	On	Stay away from Marks
30	X=366, Y=258, W=32, H=32	382	274	121.049	36.4125	Off	Safe Distance
40	X=168, Y=248, W=53, H=53	194	274	75.0266	24.5686	On	Stay away from Marks
50	X=331, Y=249, W=39, H=39	350	268	92.1140	27.7086	Off	Safe Distance
60	X=362, Y=282, W=31,H=31	377	297	113.070	34.1240	Off	Safe Distance

W=Width, H=Height

Based on the 10th second data in table 8, the ROI coordinate value can be calculated using equation 2:

$$(x, y) = \left(376 + \frac{41}{2}\right), \left(262 + \frac{41}{2}\right)$$

$$(x, y) = (369.5, 282.5)$$

Furthermore, the calculation of distance (pixels) and distance (cm) can be calculated by equations 3 and 4.

$$\text{distance(pixels)} = \sqrt{(264 - 369)^2 + (301 - 282)^2} = \sqrt{17785} = 133.360$$
$$\text{distance(cm)} = 133.360 \text{ x } 0.300808422 = 40.1158$$

3.1.3 Detection of Road Markings in Dark Conditions

The test results on Tables 9 to 11 are the results of tests on video 1, video 2, and video 3 which were carried out in dark conditions.

TABLE 9. TEST RESULTS ON VIDEO 1

Seconds to	Contour Value	Value (x,y) X	Y	Distance (pixels)	Distance (cm)	Voice	Description
10	X=223, Y=251, W=54, H=54	250	278	26.9258	8.09950	On	Stay away from Marks
20	X=265, Y=280, W=33, H=33	381	296	117.106	35.2264	Off	Safe Distance
30	X=390, Y=290, W=27, H=27	403	303	139.012	41.8159	Off	Safe Distance
40	X=276, Y=261, W=44, H=44	298	283	38.4707	11.5723	On	Stay away from Marks
50	X=171, Y=217, W=25, H=25	183	229	108.374	32.7802	Off	Safe Distance
60	X=320, Y=224, W=30, H=30	335	239	94.2602	28.3542	Off	Safe Distance

TABLE 10. TEST RESULTS ON VIDEO 2

Seconds to	Contour Value	Value (x,y) X	Y	Distance (pixels)	Distance (cm)	Voice	Description
10	X=328, Y=251, W=37, H=37	346	269	88.0222	26.4778	Off	Safe Distance
20	X=335, Y=247, W=44, H=44	357	269	98.3514	29.5849	Off	Safe Distance
30	X=291, Y=224, W=46, H=46	314	247	73.5934	22.1375	On	Stay away from Marks
40	X=150, Y=216, W=32, H=32	166	232	119.854	36.0530	Off	Safe Distance
50	X=129, Y=264, W=33, H=33	145	280	120.838	36.3490	Off	Safe Distance
60	X=228, Y=230, W=65, H=65	260	262	39.2045	11.7930	On	Stay away from Marks

TABLE 11. TEST RESULTS ON VIDEO 3

Seconds to	Contour Value	Value (x,y) X	Y	Distance (pixels)	Distance (cm)	Voice	Description
10	X=242, Y=246, W=48, H=48	266	270	31.0644	9.34443	On	Stay away from Marks
20	X=271, Y=208, W=45, H=45	293	230	76.6941	23.0702	On	Stay away from Marks
30	X=151, Y=249, W=43, H=43	172	270	97.8243	29.4263	Off	Safe Distance
40	X=94, Y=250, W=48, H=48	118	274	148.475	44.6625	Off	Safe Distance
50	X=211, Y=229, W=47, H=47	234	252	57.4543	17.2827	On	Stay away from Marks
60	X=372, Y=229, W=52, H=52	398	255	141.675	42.6170	Off	Safe Distance

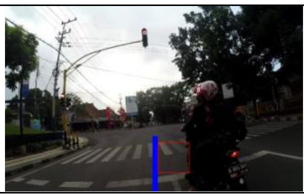
W=Width, H=Height

The x and y coordinate values or can be called the midpoint are obtained from the x, y, width, and height values of the detected ROI. Because the distance limit uses a value of 25.57 cm or 85 pixels, then a distance value that exceeds 25.57 cm is at a safe distance and the alarm is off while a distance value of less than 25.57 cm is at an unsafe distance so that the alarm is on to warn the driver.

3.2 TRAFFIC LIGHT DETECTION

Detected traffic lights are indicated by the appearance of a white ROI rectangle on the frame. Traffic light test data will be entered into the table. Where the data is in the form of the number of lights detected, the actual number of lights, the color of the lights, the sound, and the status.

TABLE 12. TESTING ON TRAFFIC LIGHTS

Condition	Light	Overcast	Dark
Detection Results			

Tables 13 to 15 will show traffic light test data in light, overcast, and dark conditions. The actual number of lights is the number of traffic lights installed on the left and right of the road.

TABLE 13. TRAFFIC LIGHT DETECTION RESULTS IN LIGHT CONDITIONS

Test to	Actual Number of Lights	Number of Lights Detected	Lamp Color	Voice	Status
1	2	1	Green	On	Way forward
2	2	1	Green	On	Way forward
3	2	Not Detected	-	-	-

4	2	2	Green	On	Way forward
5	2	2	Green	On	Way forward

From Table 13 it can be seen that the third test was not detected, because the distance between the traffic light and the camera was too far and was covered by signs. Accuracy results in light or bright conditions reach 60%.

TABLE 14. TRAFFIC LIGHT DETECTION RESULTS IN OVERCAST CONDITIONS

Test to	Actual Number of Lights	Number of Lights Detected	Lamp Color	Voice	Status
1	2	2	Red	On	Stop
2	2	2	Red	On	Stop
3	2	1	Green	On	Way forward
4	2	3	Red	On	Stop
5	2	1	Red	On	Stop

From Table 14 it can be seen that all traffic lights can be detected. However, there is still a 3rd test error. The resulting accuracy in overcast conditions is 90%.

TABLE 15. TRAFFIC LIGHT DETECTION RESULTS IN DARK CONDITIONS

Test to	Actual Number of Lights	Number of Lights Detected	Lamp Color	Voice	Status
1	2	2	Red	On	Stop
2	2	-	Yellow	Off	-
3	2	3	Red	On	Stop
4	2	2	Green	On	Way forward
5	2	3	Green	On	Way forward

From Table 15 it can be seen that at night conditions, traffic lights are a little difficult to detect because the light emitted by the lights is too diffuse and too bright. In the second test, it was not detected because the light emitted was yellow while the detected lights were red and green. From the results obtained, it can be seen that the level of accuracy in dark conditions is 75%.

IV. CONCLUSION

From the discussion above, it can be concluded that, the driver alarm will sound if the resulting distance is less than 25.57 cm or 85 pixels. If the resulting distance exceeds 25.57 cm then the alarm does not sound, stating that the distance between the marker and the driver is long distance.

The highest traffic light detection accuracy during cloudy/overcast conditions is 90%. The cause of errors when detecting traffic lights is that many objects other than traffic lights have the same color.

The system has succeeded in issuing an output in the form of a warning alarm in accordance with the conditions of the markings and traffic lights. When the red light is detected, the alarm will warn the driver to stop temporarily, if the green light the alarm will tell the driver to continue.

REFERENCES

[1]. Aneesh, A. N., Shine, L., Pradeep, R., & Sajith, V. "Real-time Traffic Light Detection and Recognition based on Deep RetinaNet for Self Driving Cars," 2019 2nd International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT), pp.1554-1557, (2019), DOI: 10.1109/ICICICT46008.2019.8993293

[2]. Badan Pusat Statistik Indonesia, "Statistik transportasi darat 2019 (Land transportation statistics 2019)," BPS-Statistics, Indonesia, No. 06140.2002, ISSN.2598-5612, pp. 28-32, (2019),

[3]. Regulation of the Minister of Transportation of the Republic of Indonesia Number PM 34 of 2014 concerning Road Markers, Chapter I, Article 1.

[4]. Law of the Republic of Indonesia Number 22 of 2009 concerning Traffic and Transportation of Road, Chapter 1, Article 1.

[5]. Niu, J., Liu, Y., Guizani, M., & Ouyang, Z. "Deep CNN-based Real-time Traffic Light Detector for Self-driving Vehicles", IEEE Transactions on Mobile Computing, 1–1, pp.1-14, (2019), DOI:10.1109/tmc.2019.2892451.

[6]. I Dewa Gede R S, I Made W, "Gaussian filtering method to remove noise in images," Jurnal Elektronik Ilmu Komputer Udayana, vol.10, no.1, pp. 53-56, (August 2021).

[7]. Hery Sunandar, "Perbaikan kualitas citra menggunakan metode gaussian filter," MEANS (Media Informasi Analisa dan Sistem), vol.2, no.1, pp.19-22, (Juni 2017).

[8]. Abdurrahman, Muhammad Hanif, Haryadi Amran Darwito, and Akuwan Saleh. "Face recognition system for prevention of car theft with haar cascade and local binary pattern histogram using raspberry pi," EMITTER International Journal of Engineering Technology, vol. 8, no. 2, pp. 407~425, (December 2020), DOI : 10.24003/emitter.v8i2.534.

[9]. Darwito, Haryadi Amran. Akuwan Saleh, Indria Dwi M, "Implementasi deteksi gerak berbasis image processing untuk monitoring rumah," Seminar Nasional Teknologi Elektro Terapan (SNTET), Malang, Indonesia, vol.03, ISSN: 2581-0049, pp. 55-60,(2019).
[10]. Ding, L., Zhang, H., Xiao, J., et al,"A comprehensive approach for road marking detection and recognition",. Multimedia Tools and Applications, (2020), DOI:10.1007/s11042-019-08384-5
[11]. Tai Huu-Phuong Tran, Cuong Cao Pham, et al, "Real-time traffic light detection using color density," in Proc. 2016 IEEE International Conference on Consumer Electronics-Asia (ICCE-Asia), Suwon, Korea, (2016), DOI:10.1109/ICCE-Asia.2016.7804791.
[12]. Tao Wu and Ananth R, "A practical system for road marking detection and recognition," in Proc. 2012 Intelligent Vehicles Symposium, Alcalá de Henares, Spain, pp. 25-30, (June 3-7, 2012), DOI:10.1109/ivs.2012.6232144.

Akuwan Saleh, et. al. "Vehicle Driver Warning Systems Using Road Marking And Traffic Light Detection."*American Journal of Engineering Research (AJER)*, vol. 11(01), 2022, pp. 185-193.