DETECTION SYSTEM OF DROWSINESS FOR CAR DRIVER USING IMAGE PROCESSING COMPLETED WITH MULTI LEVEL SAFETY

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Abstract - The rate of road traffic accidents in the 38th and 39th week of 2020 has increased. Many factors influence the occurrence of accidents, one of the reasons is that the driver is sleepy. The parameters used to determine the condition of drowsiness are identifying the condition of the eyelids. With this identification, an image processing system can be utilized by applying the Haar Casecade Classifier and Circular Hough Transform methods with Find Countur using HSV parameters. The detection uses a camera with the driver's eye input, if the image detected is a drowsy eye, the system will wake up the driver by turning on a sound alarm, besides this system is equipped with an SMS gateway feature that will be sent to the driver's relatives, that the driver is sleepy. Message notification sent contains the condition and location of the rider. Based on system-wide testing, this system has a success rate of 100% against HSV1, 96% against HSV2 and HSV3, 89% against HSV4, and 88% against HSV5 on eye detection results and response time. The resulting error is because the lighting at a certain distance is not match with HSV set, the system experiences a freeze due to the buzzer sound delay that is too long and the performance of the PC is also less than optimal.

Keywords: Sleepy Eye Detection, Driver Safety System, Haar Cascade Classifier, Circular Hough Transform, Find Contour HSV

I. INTRODUCTION

The number of traffic accidents in Indonesia has increased in the 38th and 39th weeks of 2020, about 1.28%. In week 38 the number of accidents was recorded as many as 1,089 incidents. Whereas at week 39 the number of accidents was recorded as many as 1,103 incidents [1]. There are various factors that influence the occurrence of traffic accidents, one of them is the condition of the driver who is sleepy [2].

Based on the identification of the problem, the researcher conducted a literacy study from several previous studies. In a study conducted by Bagus Hartiansyah (2018), the parameter of drowsiness can be used as a reference for image processing by identifying the driver's eye using the circular hough transform and edge threshold methods to determine the value of the pupil circle at the pixel edge value, except that the output is still displayed in the form of an application form, so it still requires additional actuators to make the system more realized [3]. On the other hand research conducted by Bagus Tryanto, et al (2018) states that the haar casecade classifier and circular hough transform methods are used to identify eye ball movements and changes in pupil diameter, but in this study there is a limitation of detection time, so additional HVS parameters will be needed for intensity regulation, light received by the object [4].

In a study conducted by Nadya Ratna Fadila (2019), using the haar casecade classifier method for face detection, eye and blink detection for eye detection, these methods can be used as guidelines for processing face and eye images. However, it is still necessary to apply the circular hough transform method and HSV parameters in order to minimize errors when identifying the eye [5].

Whereas in the research conducted by Ressa Ardiansya Putra, et al (2017) to determine the dark and bright areas of the eyes using the Viola Jones detector, if that fails, the detector will be given other options, but for the open/closed eye process it still uses the corelation coefficient tamplate matching method. [6]. And in research conducted by Siti Khumaerah Mufti (2018), using the Find Contour method with the HSV (Hue Saturation Value) parameter to find the contours of the mouth area [7], so it can be used as a reference for determining contours in the eye area.

Based on a review of several studies, this system will be developed using an image processing process through analysis of the condition of the eyelids using several methods, namely the Haar Casecade Classifier and Circular Hough Transform with Find Countur using HSV parameters. This system is equipped with a sound alarm as a form of security so drivers are awakened from their drowsiness. In addition, this system is equipped with an SMS gateway feature that will be sent to the driver's relatives, notification messages containing the driver's condition and location when sleepy.

II. METHODS

Design of System

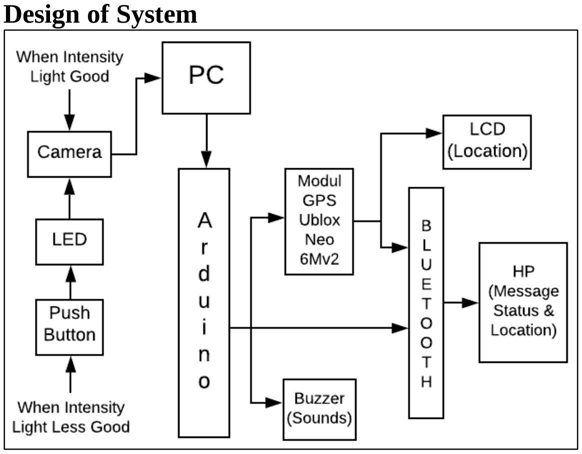

Figure 1. Block Diagram System

In the image processing system, the main components used are the camera as the image taking process of the driver's eye and the PC as the image processing process. In the initial design using the Logitech C310 camera, errors often occur when detection, so it is replaced with a Sony PS3 camera, with the image capture specifications used 25 FPS (Frames Per Second) with a resolution of 640x480 pixels, besides that there is an addition of a LED that is integrated with a pushbutton. will be used when the light intensity is not good during the image capture process.

For PC control and system hardware using Arduino Mega, because this system uses a relatively large flash memory and needs to use more than 2 serial modules. In this system, there are several security features, namely the sound alarm feature to wake the driver when sleepy with the components used, namely the 5v active buzzer, the navigation feature using the Ublox Neo-6Mv2 GPS module component and LCD + I2C which is used to be able to find out the longitude coordinates and route of the driver, and the SMS Gateway feature which uses the Bluetooth HC-05 as the sender of messages from Arduino which will be forwarded to the HP (integrated with the Merlyn Eye Detection application which is used to receive messages from Bluetooth). The flow in Figure 1 if the light intensity received by the image is not good, then press the push button to turn on the LED, then the camera will carry out the image capture process and the image results obtained will be processed by the PC to determine the status of the image, after that the detection results by the PC will be sent to Arduino to activate the existing features, namely activation of the navigation features displayed on the LCD and HP, activation of the buzzer as a sound alarm, and activating bluetooth to activate the SMS gateway feature that will be sent to the handphone.

Design of Hardware System

Design of Electronic

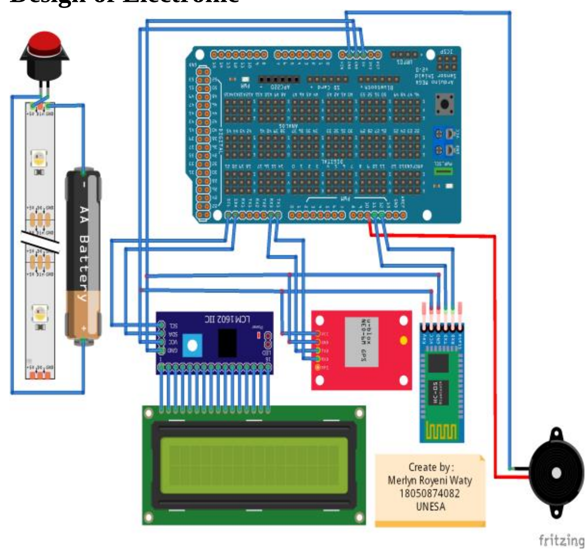

Figure 2. Design of Electronic

The Design in Figure 2 uses fritzing software. To save on the use of I / O on Arduino, the LCD is controlled serially in sync with the I2C protocol. To get GPS raw data, it must be communicated serially with Arduino by connecting the TX and RX GPS pins with pins 14 and 15 on Arduino, while the baud rate setting used is 9600 bps. Bluetooth functions as slave mode connectivity with HP, to be able to access it then connect the TXD serial with Arduino pin 10 and RXD with Arduino pin 11. For (+) buzzer is connected to pin 9 Arduino, (-) buzzer to GND. All components are supplied with (+) 5V voltage and (-) GND voltage from Arduino. If the status given from the PC is SLEEPING (Flag == 1) then the led and buzzer will log HIGH and Arduino will provide logic "1" to Bluetooth to send status and location messages to HP, meanwhile when the status of PC is NORMAL (Flags == 1) then otherwise. The (Flag == 1) and (Flags == 1) codes are serial communication codes between PC and Arduino.

Design of Mechanic

The visual form of hardware in Figure 3 consists of a tripod, PS3 and logitech cameras, led + pushbutton, Arduino Mega, Ublox Neo 6Mv2 GPS Module + antenna, LCD 1602 + I2C, buzzer, and Bluetooth HC-05 are integrated into a complete system and represented in 3D design using SketchUp 2017 software.

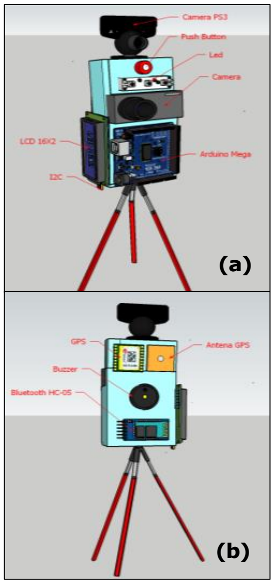

Figure 3. (a) 3D From Front View, (b) 3D From Behind View

Design of Software System

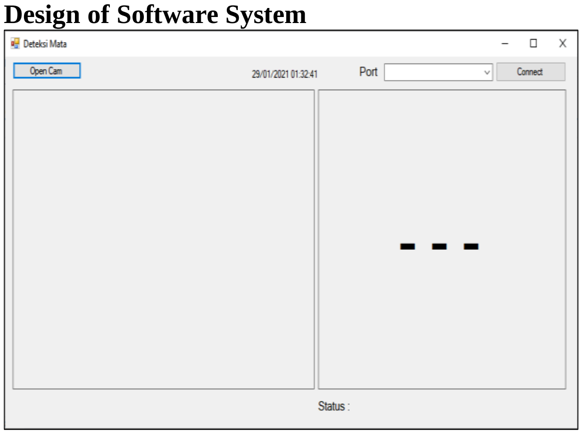

Figure 4. Platform of GUI

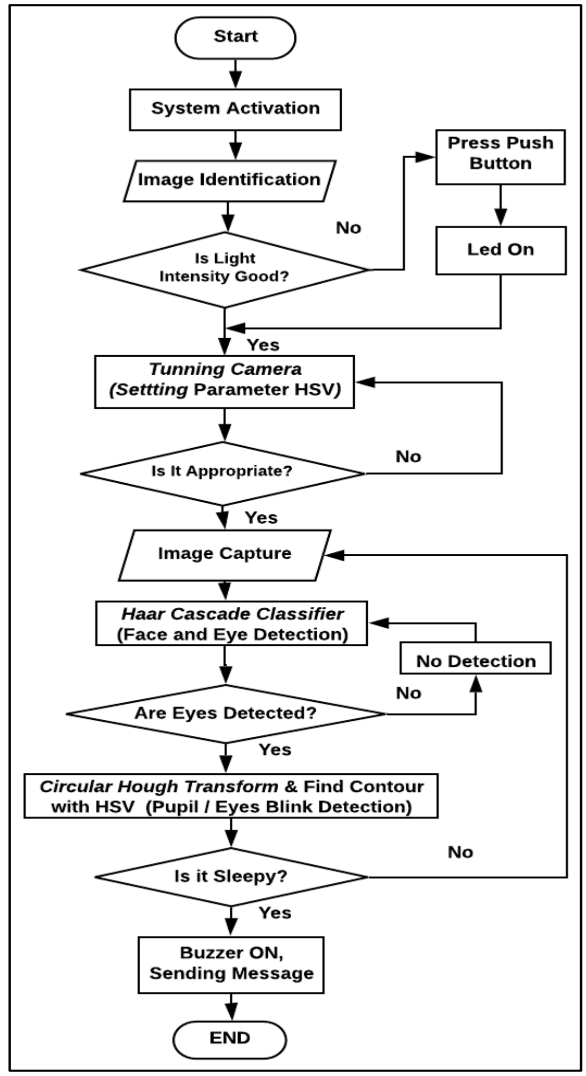

Figure 5. Flowchart of Software System

System Activation

In this design process, the software used is Visual Studio based on OpenCV 2.4.8 with programming C language as image processing, Arduino IDE as system control and Android Studio as SMS gateway. For the detection flow (Figure 5), the initial start of detection is activation of the system by connecting the hardware and camera to the PC for serial communication, to connect the PC and hardware then do the settings in Figure 4 by selecting the Arduino port in the GUI platform, then selecting the “Connect” button and button "Open Cam" for image capture process. Meanwhile, for hardware and handphone activation, in the Merlyn Eye Detection application that has been integrated on the handphone as shown in Figure 6, select "CONNECT DEVICE". After system activation is carried out, the system will carry out the image capture process.

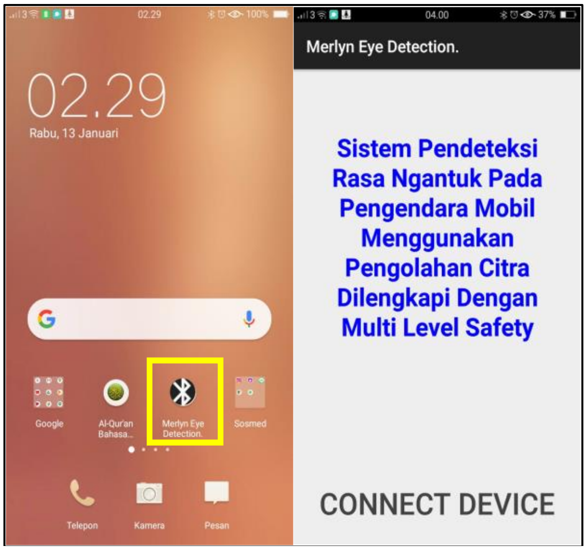

Figure 6. Android Application Form Display

Image Capture Process

For the detection flow, you must first ascertain the camera tunning and lighting at the time of image identification. The image capture process is carried out in real time so the system will always process each resulting image. After the tuning is successful, the camera will take a role in the image capture process, after which the PC will process the image according to the rules that have been made.

Image Processing Process

Haar Casecade Classifier

Face Detection

There is preprocessing detection where the image will experience an integral image. In moving video, the system will process the figure in a box consisting of several pixels which undergo calculation and addition of pixels continuously, therefore it needs an integral image to produce a fast process for correcting features in the image [8]. The feature value in Figure 7 is said to be eligible if the threshold value is below the ABFE square feature value, the system will make a decision whether the feature fulfill the requirements. If the ABFE square meets the feature, the system will run the next rule, until all the rules are fulfilled, then the system will decide that on the ABFE square there is the correct object. Meanwhile, when the feature does not comply with the rules that have been made, the system will give a decision that no object is detected correctly and the rectangle will move until the rule is fulfilled. The rectangle will get dark and light values, these values determine image processing during image filtering [9], if there is a failure, the image region will give the status "not detected" (Figure 8), while when the feature can detect faces, the feature goes to the stage of Eye Detection.

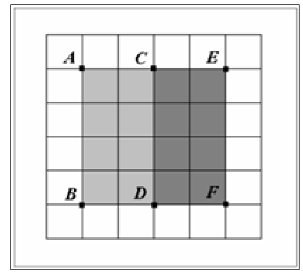

Figure 7. Haar-like Square Features
(Source : jati.stta.ac.id)

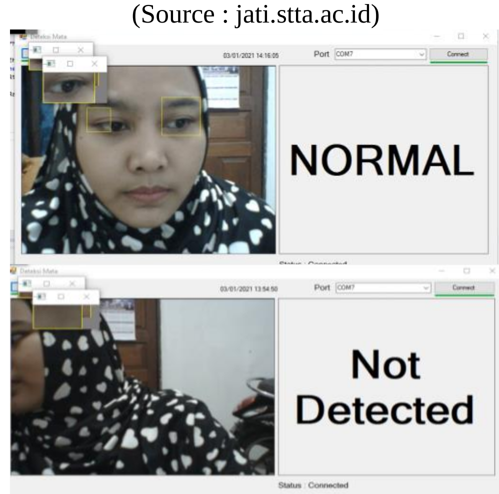

Figure 8. Face Detection

Eye Detection

The top rows in Figure 9 shows 2 features. The first feature chosen focuses on the eyes, that the eye area is often darker than the nose and cheek areas. The second feature selected by the eye is darker than the bridge of the nose. If a sample is obtained, the eye area is cropped for eye detection [10]. If one eye is detected, the image region will mark the area as the eye (Figure 10), a yellow box for normal eye status and a red box for sleeping eye status.

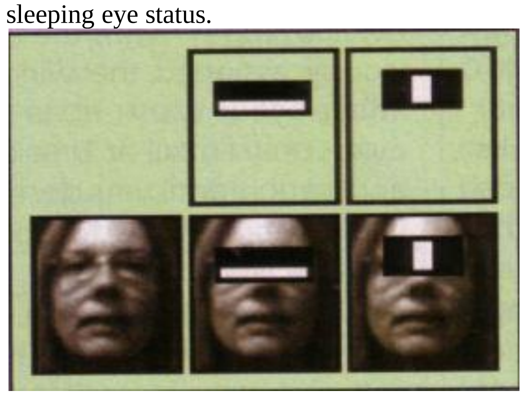

Figure 9. Eye Recognition Process
(Source : gofat.wordpress.com)

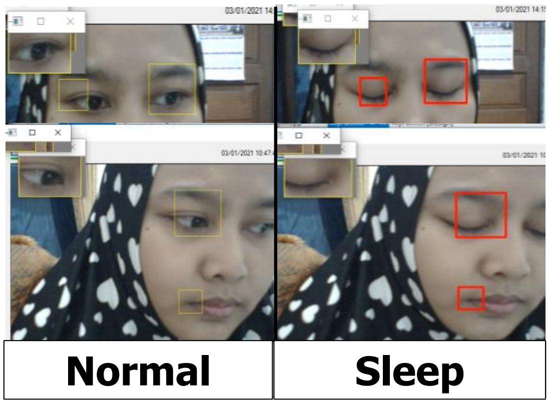

Figure 10. Eye Detection

Circular Hough Transform (CHT)

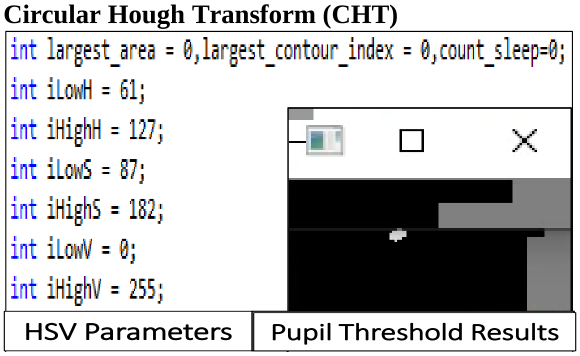

Figure 11. HSV settings for Eye Contour

In order to comply with flicker detection, the CHT process is carried out with the help of the threshold value from the previous image cropping [11]. For eye status decision making, you can see the pupil contour / white circle formed in Figure 11 by setting the HSV parameter (a parameter that processes images by distinguishing colors, levels of purity, and the amount of light received by the image). The condition of the eye is open / normal when the contour of the pupil is found. Meanwhile, the eye is closed / sleeps if the pupil contour is not found with a counter duration ≥10. The use of counters in order to reduce the load on the PC and the system does not need to get the time / process.

Drowsiness Parameters

Table 1. Eye Condition Parameters

Eye Conditions	Blink Description	Status
Open	-	Normal
Close	Counter ≤ 10	Normal
Close	Counter ≥ 10	Sleep
Eyes Not Detected	Eyes Not Detected	*No Detected*

The eye status conditioning parameters are shown in Table 1 which explains that if the eye condition is not detected, the image status is not detected, if the eye condition is open then the image status is normal, if the eye condition is not detected.closed with counter blink duration ≤ 10, the image status is still Normal, and if the counter value is more than that, the image status is Sleep. When the status is Sleep, Arduino will activate the buzzer as an sound alarm and activate bluetooth to send a message to the handphone.

III. RESULT AND DISCUSSION

The Result Of Tool Design

The design tool at Figure 12 is the result of a visual representation of the 3D design at Figure 3.

Figure 12. The Result Of Tool Design

Experiment of System

Experiment of Drowsiness Detection

The purpose of this experiment is to be able to know the results of response time and detection distance between the camera and object when the variable will be made different is the HSV value. With the parameter value HSV1 = 61; 127; 87; 182; 0; 255 (representative of integer number (i), HSV parameter of iLowH: iHighH; iLowS; iHighS; iLowV; iHighV) at the living room location, HSV2 = 63; 128; 87; 182; 0; 255 in the location of the living room with backlit settings, HSV3 = 66; 125; 87; 181; 0; 255 at room location, HSV4 = 65; 122; 87; 182; 0; 255 in the living room location, HSV5 = 62; 127; 88; 183; 0; 255 in the living room white background. The control variable is the angle between the eye and the camera, for the tilt angle range is 0º to 90º step with steps 22.5º. The experiment was carried out indoors because of the light intensity and the HSV setting which is more suitable for that location.

Table 2. Detection Time Response With HSV1

Distance (cm)	0^o		$22,5^o$		45^o		$67,5^o$		90^o	
	T	N	T	N	T	N	T	N	T	N
44	1	1	1	1	1	1	1	1	1	1
44	1	1	1	1	1	1	1	1	2	1
38	1	1	1	2	1	1	1	1	1	2
38	1	1	1	2	1	1	1	1	1	1
50	1	2	1	2	1	1	1	1	2	3
50	1	2	1	1	2	1	1	1	2	1
57	4	1	2	1	1	1	3	1	1	3
57	2	1	2	1	1	2	2	3	2	1
41	1	3	1	1	1	2	1	2	1	1
41	1	2	1	1	1	1	1	1	1	1

Table 3. Detection Time Response With HSV2

Distance (cm)	0^o		$22,5^o$		45^o		$67,5^o$		90^o	
	T	N	T	N	T	N	T	N	T	N
56	1	3	2	2	1	2	1	2	2	1
56	1	2	1	2	1	2	2	1	1	1
47	1	1	1	1	1	1	1	1	1	1
47	1	2	1	1	1	1	1	1	1	1
27	1	3	1	2	1	1	2	1	-	-
27	2	2	1	1	1	2	2	1	-	-
32	1	1	1	1	1	1	1	3	2	1
32	1	3	1	2	2	1	1	1	1	1
39	1	2	1	3	1	1	1	1	1	1
39	1	2	1	2	1	1	1	1	1	1

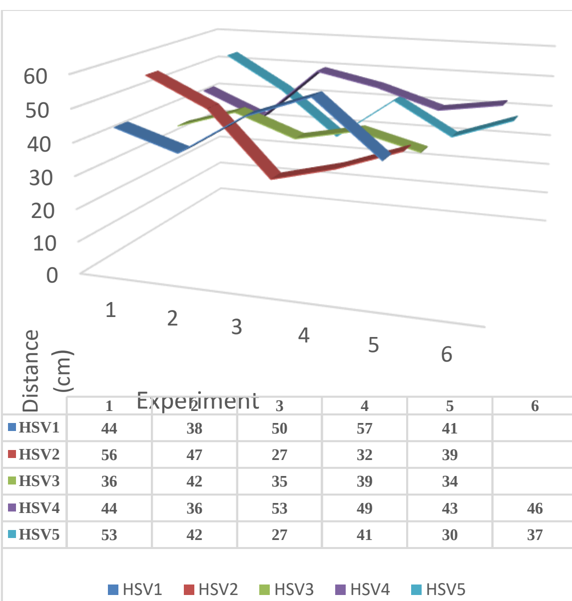

Figure 13. Graph of Detection Distance to HSV

Table 4. Detection Time Response With HSV3

Distance (cm)	0^o		$22,5^o$		45^o		$67,5^o$		90^o	
	T	N	T	N	T	N	T	N	T	N
36	1	1	1	1	1	2	1	1	1	1
36	2	1	3	1	1	2	1	1	1	1
42	1	1	1	1	1	1	1	1	1	2
42	1	2	1	1	1	1	1	2	1	1
35	1	1	1	1	1	1	1	1	1	1
35	1	2	1	1	1	1	1	1	1	1
39	1	1	1	1	1	1	1	1	2	1
39	1	1	1	1	1	1	1	1	2	1
34	1	1	1	1	1	1	1	3	-	-
34	1	1	1	1	1	1	1	3	-	-

Table 5. Detection Time Response With HSV4

Distance (cm)	0^o		$22,5^o$		45^o		$67,5^o$		90^o	
	T	N	T	N	T	N	T	N	T	N
44	1	2	1	2	1	3	2	1	-	-
44	1	2	1	1	2	2	1	2	1	2
36	3	1	1	1	1	1	1	1	1	1
36	1	1	1	1	1	1	1	1	1	1
53	1	2	1	1	1	1	1	1	1	2
53	1	3	1	1	1	2	1	3	1	1
49	1	1	1	3	1	2	1	2	2	2
49	1	1	1	4	1	1	1	3	1	1
43	1	1	1	1	1	1	-	-	-	-
43	1	1	1	1	1	-	-	-	-	-
46	1	1	1	1	1	1	1	1	1	1
46	1	1	1	1	1	1	1	1	1	1

Table 6. Detection Time Response With HSV5

Distance	0^{0}		$22{,}5^{0}$		45^{0}		$67{,}5^{0}$		90^{0}	
(cm)	**T**	**N**	**T**	**N**	**T**	**N**	**T**	**N**	**T**	**N**
53	1	2	2	1	1	3	2	2	1	1
53	1	4	1	3	2	2	2	2	1	1
42	1	1	1	2	1	2	1	3	1	1
42	1	2	1	3	1	4	1	1	1	2
27	2	1	1	2	-	-	-	-	-	-
27	1	2	2	1	-	-	-	-	-	-
41	1	7	2	3	1	2	1	5	2	7
41	1	6	2	3	1	4	2	5	1	3
30	1	2	1	1	1	3	1	1	2	2
30	2	1	1	2	2	3	1	1	2	1
37	2	1	1	1	1	2	1	3	1	1
37	1	2	1	1	2	1	1	1	2	1

Note: The time response table in seconds, T is the change in status to Sleep, and N is the change in status to Normal.

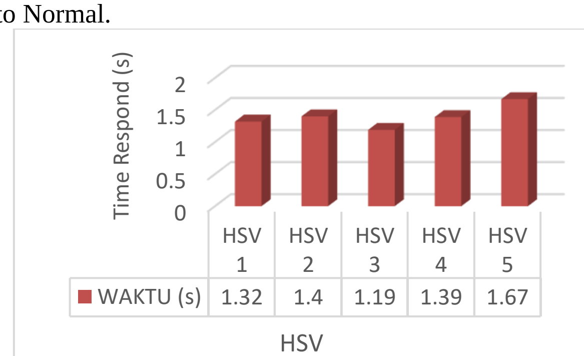

Figure 14. Graph of Time Response to HSV

In the results of this experiment, the detection distance obtained on HSV1 is (44, 38, 50, 57, 41) cm and can detect at any distance, on HSV2 the detection distance obtained is (56, 47, 27, 32, 39) cm but at a distance of 27 cm with a slope of 90^{0} cannot detect, HSV3 with the obtained detection distance (36, 42, 35, 39, 34) cm with a slope of 90^{0} the system cannot detect at a distance of 34 cm, on the HSV4 set with a detection distance that is obtained (44, 36, 53, 49, 43, 46) cm at a slope of 90^{0} a distance of 44 cm and at a slope of 45^{0} a distance of 43 cm cannot detect, and HSV5 with the obtained detection distance (58, 42, 27, 41, 30 , 37) cm at a slope of 45^{0} the system cannot detect at a distance of 27 cm. To find out the average value of the response time can use the formulation below:

$$\text{Average of Time Response} = \frac{\text{Sum of Time Respons}}{\text{Sum of EXperiment}} \ldots (1)$$

The average response time obtained is 1.32s with HSV1; 1.4s with HSV2; 1.19s with HSV3; 1.39s with HSV4; 1.67s with HSV5. The change in response time is relatively long at the HSV5 setting compared to other response times and there are some systems that cannot detect at certain tilt angles and distances, which can be an indication that the light detection range at that distance is

less. In accordance with the HSV set, in addition to that, the long duration of the buzzer and the PC condition is less than optimal, making the camera freeze when making decisions on the image.

Experiment of GPS

The purpose of this experiment is to be able to find out the results of the GPS output in the form of latitude (lat) and longitude (long) coordinates when the driver is sleeping. In each experiment, 9 experiments will be carried out with different location points in the writer's house.

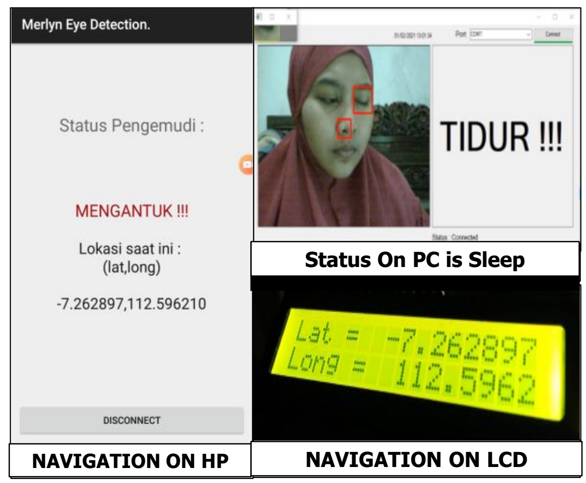

Figure 15. Navigation on HP & LCD

Based on experiment, the navigation results between LCD and handphone when the status on PC is sleep, which is the same, the experiment results can be seen in Figures 15 and 16, but there is a slight difference, namely the value of 2 digits behind the comma on the longitude of the LCD because the character space given by the LCD is not long enough, so the reading of the coordinates of the 6 digits behind the comma in the program is truncated by the LCD so the longitude coordinates are read only 4 digits behind the comma.

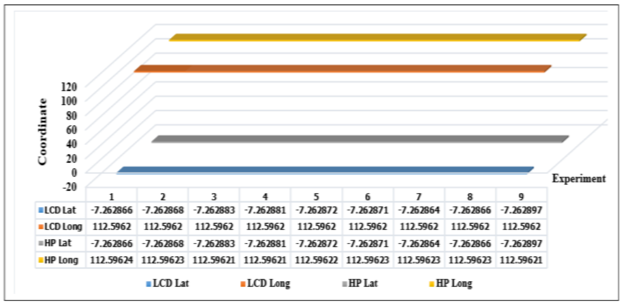

Figure 16. Graph of Navigation Experiment for LCD and HP

Experiment of Bluetooth and HP

The purpose of this experiment is to be able to find out the results of Bluetooth connectivity to what distance Bluetooth can be connected to the handphone and whether the detection results sent by bluetooth are the same as the status on the PC.

Table 7. Experiment of Bluetooth and HP

Jarak (n	Connectivit	Status of GU	Status of HP
0	Connect	NORMAL	NORMAL
6	Connect	TIDUR	MENGANTUK + GETAR
1,8	Connect	NORMAL	NORMAL
2,4	Connect	TIDUR	MENGANTUK + GETAR
3	Connect	NORMAL	NORMAL
3,6	Connect	TIDUR	MENGANTUK + GETAR
4,2	Connect	NORMAL	NORMAL
4,8	Connect	TIDUR	MENGANTUK + GETAR
5,4	Connect	NORMAL	NORMAL
6	Connect	TIDUR	MENGANTUK + GETAR
7	Connect	NORMAL	NORMAL
.8	Connect	TIDUR	MENGANTUK + GETAR
9	Connect	NORMAL	NORMAL
10	Connect	TIDUR	MENGANTUK + GETAR
11	Disconnect	NORMAL	MENGANTUK + GETAR

Based on Table 7, bluetooth can send messages to handphone with a range (0 - 10) meters and the status of the driver's condition sent to the handphone according to the status of detection carried out on the PC (GUI).

Experiment of Buzzer

The purpose of this experiment is to determine the results of the buzzer sound conditions ON (sound) and OFF (no sound) and the response time generated when the detection system provides detection results in the form of a change from normal to sleep status and otherwise.

Table 8. Experiment of Buzzer

Status Deteksi	Kondisi Buzzer	Waktu (ms)
Tidur ke Normal	OFF	50
Normal ke Tidur	ON	50
Tidur ke Normal	OFF	50
Normal ke Tidur	ON	50
Tidur ke Normal	OFF	50
Normal ke Tidur	ON	50
Tidur ke Normal	OFF	50
Normal ke Tidur	ON	50
Tidur ke Normal	OFF	50
Normal ke Tidur	ON	50

Based on the experiment results in Table 8, the buzzer requires an average response time of 50ms when the system has given the decision results to the image. When the status is normal, the buzzer is OFF (buzzer does not sound) and during sleep status, the buzzer will be ON (buzzer sounds).

IV. CONCLUSION

The results of a series of experiments that have been carried out can be concluded that the results of the detection system design are able to detect normal eyes and sleeping eyes with a tilt angle of 0^o - 90^o with a step of 22.5^o towards objects and cameras at a certain distance according to the HSV parameter setting (Figure 14). The image capture process does not have to be 2 detected eyeballs, if only one of them has been detected, the system can make a decision-making process on the image. In designing this system can perform detection with a success rate of 100% for HSV1, 96% for HSV2 and HSV3, 89% for HSV4, and 88% for HSV5. As for the average response time at the HSV5 setting is relatively long compared to other response times and there are some HSVs that cannot be detected at certain distances and tilt angles, this is because the detection range of the image is not in accordance with the HSV set, besides that this is also due to the delay given to the buzzer when the sleep status is too long and at that time the performance of the PC is less than optimal, causing the system to freeze during experimenting.

For serial communication that is carried out between the PC and the hardware on the detector, it can be connected properly, seen from the buzzer sound response, the results of the GPS navigation output on the handphone and the LCD, and the bluetooth ability to send messages to the handphone according to the detection results on a PC with a bluetooth connectivity distance can be connected with HP that is in the range of 0 - 10 meters.

Suggestions for optimizing system performance in order to get good image capture results, before doing the experiment, you have to do the camera tuning according to the desired distance, adjust the light intensity of the surrounding environment and adjust the contours of the figure by changing its HSV parameters, if you think the image is taken, the light is still less bright so the eye position is not detected by the system, it is necessary to use additional light around the camera, besides that it should be noted that the space for this detection system is very limited if the driver is actively moving, it will affect the detection results because the detection position will change from the camera tuning state that has been previously set, so it can result in the face and eyes not being detected by the camera, the system will gives a decision to the image in the form of “No Detected” status as shown in Figure 8. If that happens, it is necessary to do another camera tuning so the detection results are more accurate.

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