Journal of Electrical Technology UMY (JET-UMY), Vol. 9, No. 1, June 2025
ISSN 2550-1186 e-ISSN 2580-6823

Smart Alarm Driver Assistance as an Early Warning of Drowsiness Drivers Based on Raspberry pi 4 Model B

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Abstract – *A decrease in the level of awareness due to drowsiness while driving a motorized vehicle can increase the risk of traffic accidents. Smart Alarm Driver Assistance is a computing system development based on one board Raspberry Pi 4 model B. Digital image processing is intended to automatically recognize signs of drowsiness and provide warnings as early as possible. It is hoped that this research will reduce the number of road accidents caused by drowsy drivers. Raspberry pi is integrated with Raspberry pi camera noir v2 8MP for real-time eye monitoring, audio speaker and I2C OLED 128x64 as a warning output. Shape Predictor_68_Facial landmark model is used to detect Eye Aspect Ratio (EAR) as a parameter of driver drowsiness. The results of the test obtained an average response time of 0.82 seconds for the audio speaker to turn on and the average time the 128x64 OLED I2C lights up 0.90 seconds. This research can prove that the Raspberry Pi 4 model B can be implemented for drowsiness detection and warning. In the future, the protoype can be developed in terms of software and proper tool design.*

Keywords: *Drowsiness Drivers; Raspberry Pi 4 Model B; Eye Aspect Ratio (EAR)*

I. Introduction

Physiological conditions accompanied by the desire to sleep and a decrease in the level of consciousness that affects alertness and concentration are some of the signs of someone being sleepy. Drowsiness itself can be caused by many things ranging from lack of adequate rest, the influence of drugs or fatigue [1]. Drowsiness has a significant impact in activities that require high concentration such as driving a vehicle[2]. A decrease in the level of awareness due to drowsiness while driving a vehicle can lead to an increased risk of violating traffic rules in driving on the highway, even the desired thing in the form of a traffic accident [3]. Drowsiness detection can be considered quite important because it can prevent accidents caused by decreased alertness, especially when doing activities that require concentration such as driving a vehicle[4]. Drowsy drivers tend to be less focused, slower to act, and more prone to making mistakes[5]. Drowsiness detection systems allow for earlier identification especially using technologies such as cameras, sensors and etc, this allows for the provision of warnings or preventive measures [6], [7], [8], [9]. This not only increases one's safety, but also improves public safety[10].

Raspberry pi 4 model B is a hardware device used for single-board based computing platforms. The Broadcom BCM2711 quad-core Cortex-A72 processor, which works at speeds up to 1.5 GHz, can support the Raspberry Pi 4 capabilities for image processing. The GPU on the device supports acceleration for image processing tasks [11]. There is a CSI camera interface that allows the use of a camera to capture images or videos in real-time. With the help of Raspberry pi 4 model B can perform efficient image processing algorithms, with a small-sized and power-efficient platform. Connectivity on the Raspberry pi 4 model B is quite a lot starting from the GPIO pin (General Purpose Input Output), USB port, HDMI, and Wi-Fi and Bluetooth network connectivity [12]. This connectivity makes it easy to integrate with other devices communication between users and the system.

Digital image processing is a computer algorithm for processing visual information from images or videos[13]. Digital processing is needed in drowsiness detection to analyze visual data such as images of a driver's face or real-time video footage to find signs of drowsiness. The process consists of

Manuscript received December 2024, revised June 2025

several steps, from capturing images, extracting elements such as eye movements and blink frequency [14]. Identification through digital image processing helps early warning systems aimed at safety. In a drowsiness detection system, Eye Aspect Ratio (EAR) is used to observe eye movements in real time and identify signs of drowsiness, such as eye blink frequency or duration of closed eyes. The EAR parameter in drowsiness detection is effective because it can be implemented quickly and with high accuracy using digital image processing algorithms [15]. The application of EAR is one of the important components for the safety application of early warning systems in vehicles.

Smart Alarm Assistance is a system development using digital image processing technology, which is intended to automatically recognize signs of drowsiness and provide warnings as early as possible[16]. The hardware needed for development consists of 4 main components Raspberry pi 4 model B, Raspberry pi camera, Audio speaker, I2C 128X64 Oled display module. Raspberry pi 4 model B hardware supports computer algorithms to process visual information from videos and images. This system applies EAR for measurement parameters to the level of drowsiness that can be adjusted for various scenarios, if the system identifies drowsiness from the parameters that have been set outputs to provide warnings in the form of audio speakers as a sound warning and I2C 128X64 Oled display module to provide visual warnings. It is hoped that this research will reduce the number of road accidents caused by drowsy drivers, which will have an impact on the safety of road users and reduce the potential for human and material losses.

II. Materials

Hardware and software that support each other in the process of processing digital images are the materials used in Smart Alarm Assistance. There are 4 main hardware materials in this research which consist of Raspberry pi 4 model B as a computing platform, raspberry pi camera which functions as a visual data device that can capture real-time images or videos, jumper cables, batettery 5V, audio speakers and I2C 128X64 Oled display module as an alert output.

Raspberry pi 4 model B in Smart Alarm Driver Assistance is used to accommodate the entire system, with 1 board-based computing. In this study, the Raspberry Pi 4 model B used has a specification of 2 GB RAM, memory or ROM with a capacity of 32 GB. The operating system uses 32-bit Raspberry Pi OS, based on Debian Bullseye. Software for performing image processing algorithms and sending Raspberry Pi 4 model B data in this research is based on the Python programming language.

The Raspberry Pi camera module v2 itself is used for visual data devices that can capture video in real-time. Raspberry Pi camera module v2 is made specifically for Raspberry pi devices equipped with a Sony IMX219 camera with a resolution of 8 MP, its small size allows this camera to be installed in various places [17]. This arguably facilitates the design of the tool, besides that it allows real-time image processing to detect signs of drowsiness.

The Speaker Audio is an important part of the drowsiness detection system that serves as a warning sound[18]. The speaker will emit a warning sound to wake up the driver or remind them to stay alert if the system finds signs of drowsiness, such as a decrease in the Aspect Eye Ratio (EAR) value which indicates that the eyes are closed for too long. This Speaker Audio is directly connected to the Raspberry Pi 4 model B and is managed by a programming algorithm that issues an audible alert when it recognizes that someone is sleepy [19].

The 4th main component is the I2C 128x64 OLED display module, which is used to provide visual warnings to driver. I2C 128x64 OLED display module is a small OLED module with a resolution of 128x64 pixels, this module is connected to the Raspberry Pi 4 model B via I2C communication [20]. Enables fast and efficient data communication using multiple GPIO pins, which are connected via jumper cables with female to female type. Its small size makes it ideal for simple yet informative and easy-to-read displays in various lighting conditions.

III. Method

Eye monitoring is needed for identification in Smart Alarm Driver Assistance which aims to detect drowsy drivers. Raspberry pi camera module V2 is integrated with Raspberry pi 4 model B to capture images in real time, the image results are sent to Raspberry pi 4 model B which acts as image processing. The Raspberry pi 4 model B is equipped with the Open CV (Open Source Computer Vision Library) image processing computer vision library, the dlib library is equipped with a shape predictor 68 facial landmarks feature used to detect facial parts, especially the eyes.

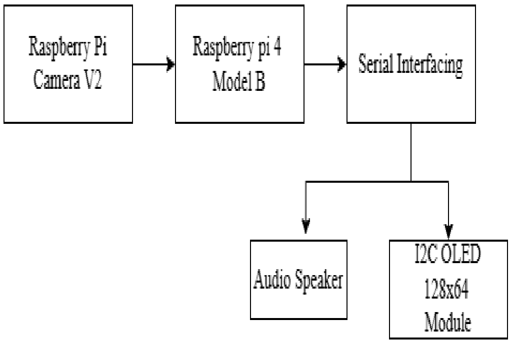

Fig 1. Block Diagram

There are different ways to measure drowsiness such as blinking patterns and facial expressions. In this research, the author implements the Eye Aspect Ratio (EAR) to measure the drowsiness level of the car driver, the pupil and iris area of the eye is calculated and then compared with the threshold value. If it exceeds the threshold value, the driver is defined as drowsy, the audio speaker will provide a sound warning and the 128x64 OLED module provides a visual warning. Speaker audio and 128x64 OLED module are connected directly to Serial Interfacing on Raspberry pi 4 model B. 5V battery with 3A current is used to provide a power source according to the operational needs of a Raspberry pi 4 model B [21]. How Smart Alarm Driver Assistance system works is shown in the block diagram image Fig 1, and for the circuit design can be seen in Fig 2.

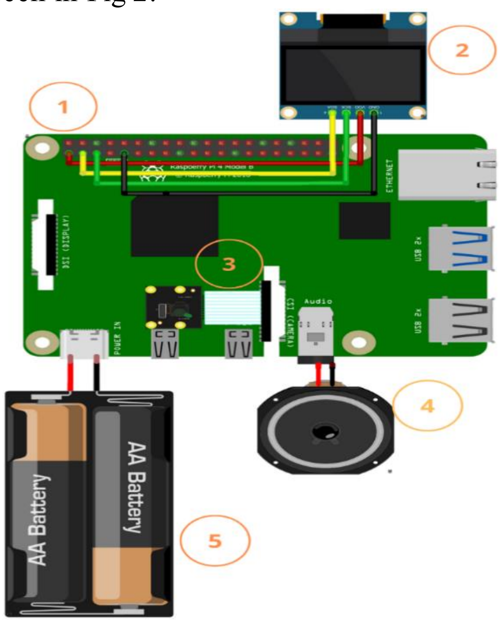

Fig 2. Device Schematic Design

The Fig 2 is a schematic of designs used in Smart Alarm Driver Assistance. For component details are in the Table 1.

Table 1. DETAIL PART

No	Detail Part
1.	Raspberry pi 4 model B
2.	I2C OLED 128x64
3.	Raspberry Pi Camera Noir V2
4.	Audio Sound
5.	Battery 5V 3A

III.1. OpenCV

OpenCV library is used for computer vision-based drowsiness detection image processing. OpenCV can convert camera-captured images into grayscale, grayscale is used to simplify visual data by reducing the complexity of the three-color process (BGR) to one intensity channel and returning to color format after successfully detecting facial objects [22]. OpenCV in research is also used to display information related to drowsiness detection through streaming video displays and display messages through different frames, this process is very important for real-time drowsiness detection applications.

III.2. Shape Predictor_68_Facial Landmark Detection

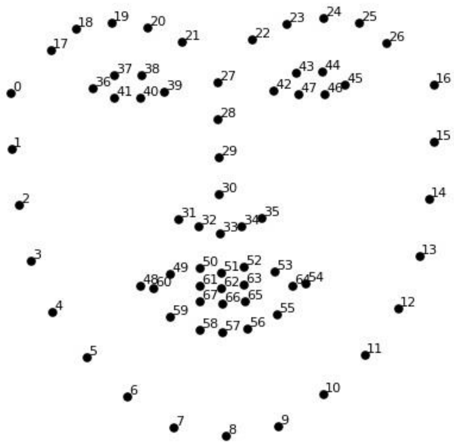

Fig 3. Shape Predictor_68_Facial landmark

The model recognizes landmarks on the face based on 68 feature points or also called Shape Predictor_68_Facial landmark detection as show in Fig. 3. This model is implemented through the dlib library as a landmark detector that maps parts of the face such as cheeks, nose, eyes and mouth. Shape Predictor_68_Facial landmark detection analyzes the position of the face and assigns 68 landmark coordinates to the facial features [11]. Tracking the coordinates of eye landmarks is quite important for the implementation of EAR measurements, which will be discussed in more detail in the EAR chapter below.

III.3. Eye Aspect Ratio (EAR)

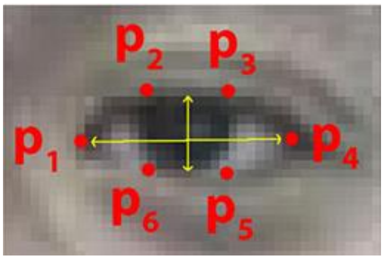

Fig 4. Open Eyes With Landmark

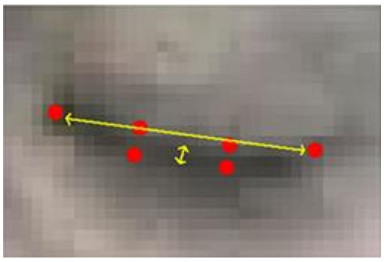

Fig 5. Close Eyes With Landmark

Eye Aspect Ratio (EAR) is used as the main parameter to measure real-time eye conditions and sleepiness levels. To calculate the EAR, the landmark coordinates of eye areas found on a face are used. This is done using 68 face points generated by the shape_predictor_68_face_landmarks model. The model can find important points around the left eye and right eye with the data [23]. The EAR calculation is done by looking at a ratio between the vertical and horizontal distance of an eye, the ratio changes automatically when eyes are open or closed. An illustration can be seen in Fig 3 where the eye is open and where Fig 4 the eye is closed accompanied by landmarks.

$$EAR = \frac{||P2-P6|| + ||P3-P5||}{2||P1-P4||} \quad (1)$$

$$AVG\ EAR = \frac{1}{2} EAR_{Left} + EAR_{Right} \quad (2)$$

Shown in equation 1. written as EAR, it is calculated based on P1-P6 which represent points between eye landmarks [24]. Here, p2-p6 and p3-p5 are the vertical distances between pairs of points on each upper and lower eyelid, intended to measure the vertical opening or closing of each eye. Meanwhile, p1-p4 is a horizontal distance between two corners of the eye that remains relatively constant. By dividing the sum of the horizontal distances by two, EAR generates a ratio value that will decrease when eyes start to close due to the vertical distance addressed in equation 2. [24]. This method can identify eye closure which is an important system in Smart Alarm Driver Assistance. The author uses the EAR threshold with eyelid condition (0.20), the value can indicate that driver is tired or sleepy [25]. Thus, precautions can be taken to prevent unwanted things due to drowsiness.

III.4. Workflow Chart

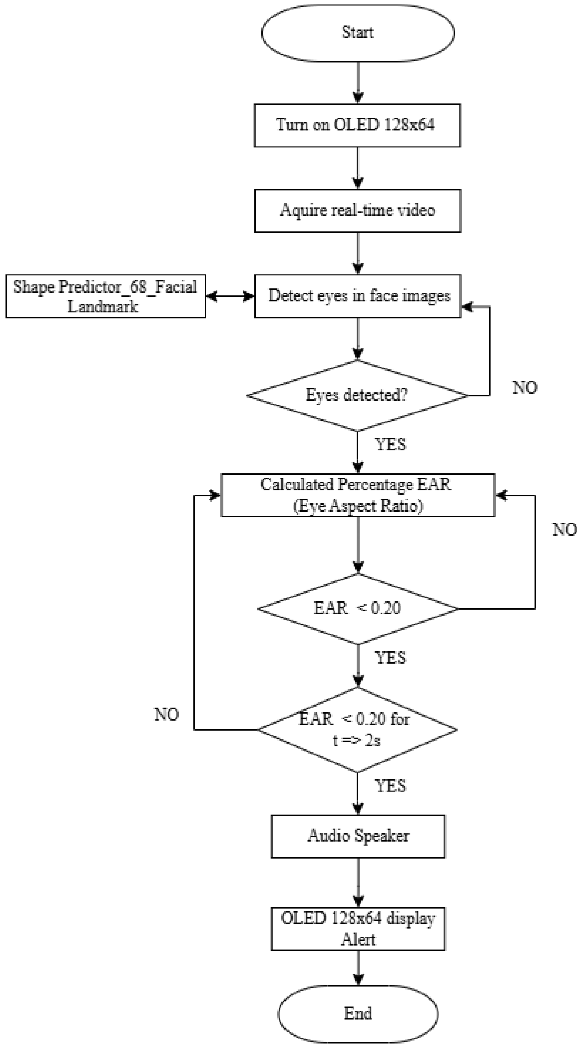

Fig 6. Workflow Chart

In Fig 6 is the flow diagram of Smart Alarm Driver Assistance device. The process starts with a start followed by turning on 12C OLED 128x64 module and turning on camera to aquire real-time video. To identify faces including eyes, Shape Predictor_68_Facial landmark is used, then system acts whether eyes are detected on the face to monitor eyes. EAR calculation is performed in real-time video; the author uses a modified threshold of 0.20 for 2 seconds. If the EAR is below 0.20 for 2 seconds, system will take action to activate audio speakers and display a warning sentence on I2C OLED 128x64 module.

IV. Result and Discussion

Fig 7. Device Result

This session presents the results and discussion, the main results of Smart Alarm Driver Assistance are discussed based on experimental analysis. The Fig. 7 shows the results of the implementation of the design that has been made. Based on the picture. The Raspberry pi 4 model B and audio speaker are located in a black box, while the real-time video capture Raspberry pi camera and I2C OLED 128x64 are located in a white box. The power source for the device uses a black battery on a black box that has a power source with a voltage of 5V and an electric current of 3A. For affirmation, this experiment is set not to be implemented in an actual car driver situation, because the designed device is still a prototype.

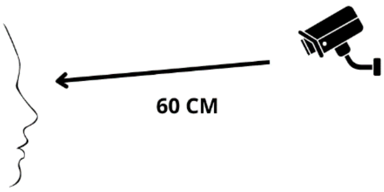

Fig 8. Distance between the device and the subject

The experiment was set up in an indoor environment with the distance between the device and the subject of 60 cm as shown in Fig. 8. Data was collected from real-time videos of 10 people, 9 males and 1 female in Sidoarjo, consisting of university students. The goal is to analyze the characteristics of the eye aspect ratio, each eye size varies due to the physical diversity of Indonesian people, which in this experiment is dominated by the Javanese tribe. In this study, the eye-closure threshold was determined as 0.20 for all subjects. Subjects were asked to perform 10 times of eyes closed for 1 minute per subject and eyes open for 1 minute per subject.

Fig 9. During Eyes Open (EAR = 0.28)

Fig 10. During Eyes Close (EAR = 0.19)

Fig 11. OLED Display ALert

Fig. 9 is a display of real-time video results; the system can detect distance between the vertical of an eye and the horizontal distance of an eye. The EAR values for both eyes are calculated based on equations, then the EAR values of both eyes are displayed in the frame. Based on the figure. as long as the eyes are closed, the EAR value is close to the value of 0, when the eyes are open the EAR value can be said to be greater than the value of 0. Figure 11 shows that the EAR value that appears in the frame in the figure is 0.28 in open eye conditions (not sleepy) so that the system on device will not provide a warning.

Fig. 10 shows the EAR value of 0.19 closed eye conditions (sleepy) in the frame will respond to display a warning sentence. While in Fig. 11 is the response of I2C OLED 128x64 if the EAR value is below the threshold of 0.2 will display the sentence "WARNING", and will also provide a voice warning through the audio speaker. Related to the output response section can be seen in Table 2 and Table 3.

Table 2. VALUE OF EAR DURING EYES OPEN AND EYES CLOSED

Subject	Gender	EAR during eyes open	EAR during eyes closed
1	Male	0.27	0.17
2	Male	0.27	0.13
3	Male	0.31	0.18
4	Male	0.28	0.19
5	Male	0.30	0.16
6	Female	0.33	0.17
7	Male	0.27	0.19
8	Male	0.27	0.18
9	Male	0.26	0.13
10	Male	0.28	0.15
Average		**0.28**	**0.17**

In Table. 2 Shows the average EAR results obtained from 10 subjects that have been tested. In the first column is the number of subjects tested. The third column informs about the gender of each subject. In the second column is the average EAR value when the subject is in a condition of both eyes normally open in 1 minute. Obtained an average EAR value of 0.28 from 10 subjects. This value indicates that when the eyes are open normally the EAR value is not close to 0. It can be said that this value indicates that the driver's condition is not sleepy or in a normal state.

Table 3. Time Taken by Audio Speaker to Respond

Subject	Average Time Taken by Audio Speaker to Respond
1	0.95
2	0.81
3	0.83
4	0.68
5	0.94
6	0.76
7	0.87
8	0.77
9	0.85
10	0.73
Average	**0.82**

The fourth column in Table. 2 shows results of the average EAR value when the subject was observed to perform 10 times closed eyes in 1 minute. The average EAR value of 0.17 was obtained from 10 subjects. The value shows that when eyes are closed the EAR value is close to 0. Furthermore, this value can be said to indicate that the driver's condition is drowsy and requires further intervention.

The intervention against drowsy drivers is the audio speaker. Table. 3 shows the time it takes for the audio speaker to respond. the unit of time used in the test is seconds. The time value is obtained when the subject is asked to close his eyes, then the stopwatch feature on the smartphone is used to measure the time value of audio speakers on. The results of the test obtained an average response time of 0.82 for audio speakers on. with the fastest response time of 0.82. With a response time of less than 1 second, it can be said that the audio speaker can function to intervene a drowsy driver.

Table 4. TIME TAKEN BY OLED TO RESPON

Subject	Average Time Taken by OLED
1	0.97
2	0.91
3	0.95
4	0.79
5	0.98
6	0.88
7	0.96
8	0.87
9	0.91
10	0.79
Average	**0.90**

Table. 4 shows the time it takes I2C OLED 128x64 to display (Alert). The unit of time used in the test is seconds. The time value is obtained when the subject is asked to close their eyes as well. Furthermore, the stopwatch feature on the smartphone is used to measure the time value of the I2C OLED 128x64 display (Alert). The average time value was 0.90, with the fastest time being 0.79. with a response time of less than 1 second OLED 128x64 can help to intervene a drowsy driver.

V. Conclusion

Smart Alarm Driver Assistance is designed to warn drowsy drivers, hopefully the driver will stay awake while driving a car to avoid unwanted things. Warnings issued by devices in the form of audio speakers to provide audible warnings and 128x64 OLED help for visual warnings. The microprocessor for processing the entire system is Raspberry Pi 4 model B, integrated with a Raspberry Pi camera capturing real-time images. Drowsy driver parameters are measured through eye detection using Shape Predictor_68_Facial landmark model, Eye Aspect Ratio (EAR) is calculated to identify drowsy drivers or in normal conditions. Eye Aspect Ratio at the maximum threshold condition within 2 seconds, Smart Alarm Driver Assistance interrupts in the form of audible and visual warnings that will help the driver remain conscious. Data testing gets an average audio speaker warning output response of 0.82 seconds and an average OLED 128x64 of 0.90 seconds. This research can prove that the Raspberry Pi 4 model B can be used for drowsiness detection and warning. In the future, the prototype can be developed in terms of software and proper tool design so that it can be implemented in real driving conditions.

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