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Research Article

Detection of Drivers Drowsiness on Four-Wheeled Vehicles using the Haar Cascade Algorithm and Eye Aspect Ratio

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Abstract

One of the most common types of threats to four-wheeled vehicle drivers is *microsleep*. *Microsleep* is a condition in which a person's loss of attention or consciousness due to a state of fatigue or drowsiness. In general, *microsleep* lasts for a short duration, about a fraction of a second to a full 10 seconds. One way to modify the driver's sleepy condition is to form a drowsiness detection system through the extraction of facial feature points. The extraction of facial feature points refers to 68 *predictor landmarks* with detection in the eyes and facial movements of the driver in the form of poses with the determination of the angle threshold of changes in the position of the face while driving which indicates a state of drowsiness. This study implements the use of *the Haar Cascade Classifier algorithm* in detecting the drowsiness of four-wheeled vehicle drivers and the Eye Aspect Ratio of the points that form the eyes using Euclidean Distance. In detecting the eye index on the face predictor landmarks uses the dlib python library to detect objects, face detection, and face landmark detection. This study also uses the Face Detector library to create a face detector object and a Landmark Predictor. The test results showed that the detection system was 98.33% accurate with the condition of facial features that could still be identified by the system even though the difference in face distance with the webcam acquisition tool was far away. This detection system is also able to detect driver drowsiness with an average time duration of less than 5 seconds with a distance of up to 50 meters. The system detects drowsiness quickly with a notification in the form of a warning in the form of an alarm sound, which is very important in order to reduce the number of accidents due to drowsiness.

Keywords: Eye Aspect Ratio; Face; Haar Cascade Classifier; Landmark predictor; Microsleep.

Introduction

The increase in traffic accident cases is increasing year by year [1] and is one of the highest causes of death in the world. As the number of vehicle volumes in the world increases, the accident rate will also increase. One of the causes of accidents in driving is *human error* where the causes can occur due to drowsiness and fatigue, as well as unhealthy body conditions [2]. Drowsiness is a condition where this condition can occur at inappropriate times so that it can be fatal [3] due to factors such as: fatigue at work, lack of sleep breaks, and so on. Drowsy conditions based on research [4] identified by the condition of heavy eyelids, blurred vision and imbalance in the position of the head due to bearing weight. Conditions like this require the body's signals to lie down and rest. Motorists who tend to have accidents, usually still force themselves to drive their vehicles both at night and early in the morning. At these times, it is a time that is usually used to rest. Some of the most accidents occur at night and early in the morning. The cause of accidents due to falling asleep for a few seconds is known as *microsleep* [5]. Event *microsleep* This is very vulnerable to being experienced by motorists due to the condition of the body that experiences fatigue while driving. Condition *microsleep* It usually occurs with a very short duration of about 3 seconds, 5 seconds and can reach a duration of up to 10 seconds [6]. An increase in the number of accidents that may occur in the future due to the condition of *microsleep* This can be minimized and prevented by forming a system capable of detecting drowsiness [7] to motorists who are still driving vehicles when their condition is already sleepy.

Several studies related to the drowsiness detection system in knowing the information of a detection system have been carried out by previous researchers. Research [8] Implement the use of *Haar Classifiers* and *Convolutional Neural Network* (CNN) to predict the state of the driver's eyes (open or closed) [9]. CNN classification is ongoing. The haar algorithm is used by detecting the edge of the driver's eye based on the aspect ratio value by observing the condition of the driver's eye closed or partially closed [10]. This study determined a prediction variable of 1 for open eyes and a prediction variable of 0 for closed eyes.

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Research [11] detect early symptoms of drowsiness while driving. The proposed method uses a deep learning approach by utilizing *Ensemble* CNN and *Dlib* with 68 famous face detectors to analyse facial cues. Symptoms analysed include the frequency of eyes opening or closing and yawning or not yawning. Approach *Ensemble* CNN itself is a combination of three architectures, namely: DenseNet169, VGG16 and Xception. Type *Ensemble* The CNN proposed in this study achieved an accuracy of 97.4% from the eyes and 96.5% from the mouth. It outperforms other trained models. Proposed system [11] (can immediately remind the driver and send text messages and sleepy emails to third parties, ensuring timely intervention to prevent accidents. Identification of sleepy conditions was also carried out in the study [12] by implementing *Eye Aspect Ratio* and the use of methods *Haar Cascade* to show the difference in sleepy eye movements to the rider. This study uses *Raspberry* pi 4B connected to *Webcam* to detect riders with sleepy eye conditions. This study uses closed eye parameters with a predetermined duration of time. The results of the drowsiness detection system test in this study showed an accuracy of 90% under normal conditions. At a success rate for abnormal conditions of 40%.

Several difficulties occur in detecting drowsy drivers. Research [8] It cannot detect test images with facial pose, lighting and additional attributes outside of the face image so that the score will exceed a certain limit indicating an error in predicting the state of the eye. Research [13] also requires the position of the face to be caught on camera [12] Due to the minimum size setting of the detected face position of 30 cm. In several previous studies, it was seen that the detection of drowsy drivers was carried out on the condition of the eyes without paying attention to the position of the face, considering the limitations of several studies regarding the necessity of the acquired face position. There are floors *error* which is quite large in the previous study of 60% of the 10 trials with a gap between acquisitions *Webcam* with riders is 30 – 50 cm [12].

Based on the background given, the problem studied in this study is traffic accidents caused by drowsiness in drivers. These accidents become very dangerous because drowsiness or fatigue can cause the driver to lose consciousness or make fatal mistakes while driving, which often occurs at critical times such as at night or towards morning (bedtime). In these cases, one of the high-risk phenomena is microsleep, which is a short sleep for a few seconds that can be very dangerous when it occurs while driving. Previous studies have focused on detecting symptoms of drowsiness using a variety of technologies [8], [13], such as open or closed eye detection, as well as the use of deep learning methods and facial recognition algorithms. However, some obstacles in the existing detection system are still found, such as the problem of the position of the face that must be precisely detected by the camera, inconsistent accuracy, and a fairly high error rate in testing [12].

In this study, the detection of drowsy drivers was carried out based on the analysis of head movements through the observation of the driver's facial expressions or signs that could indicate drowsiness or fatigue. The movement of the head position in the drowsiness detection system is a sign of drowsiness that is reflected in the expression of the human face not only from the condition of eye movements, but also changes in the position of facial movements. The position of the face pointing down or tilting also indicates the state of the driver who experiences drowsiness which has not been done in previous studies. This study calculates the value of *Eye Aspect Ratio* (EAR) of the points that make up the eye using the equation *Euclidean Distance* So that the detection system can detect faces even though the distance between the face and the acquisition tool *Webcam* far. Calculation using *Eye aspect ratio* (EAR) which is the ratio of eye height and width is one way to detect changes in the condition of the eyelids [14]. The distance between the upper eyelid and the lower eyelid is assumed to be the height of the eye and the distance from the left corner to the right corner of the eye is assumed to be the width of the eye [15]. The value of the EAR parameter will increase in two conditions, namely: the condition if the eyes are open and decreasing if the eyes are closed [16]. This study also uses a marker system *Landmark* on the face, so that the position of the point used using the EAR equation can be found. EAR value of each *Frame* on the acquired facial image using *Webcam* will be conditioned a decrease in the EAR value when the driver closes his eyes will return to normal levels when the eyes are opened again. This approach is also used to detect blinking and eyes in an open state, where when the eyes move, the eyelids will change [17]. The calculation of the EAR value in this study uses the distance formula *Euclidean distance* [18]. This study also uses *Haar Cascade Classifier* in detecting faces based on the number of pixels in a square from a facial image acquired using *Webcam* with *Cascade classifiers*. This parameter is used to detect *sub -window* provided by the system contains the existence of facial feature data.

This research aims to develop a system that can detect drowsy conditions in drivers more effectively and accurately, by minimizing obstacles that have arisen in previous studies. The system is expected to detect signs of drowsiness, such as closed eyes or other signs associated with fatigue, even with less than ideal facial positions or lighting. With a more reliable detection system, it is hoped that the number of traffic accidents caused by *microsleep* and drowsiness can be significantly reduced, improving the safety of motorists on the road.

Method

The stages of research on the creation of a drowsiness detection system using facial data acquisition, determination of facial patterns, creation of facial detection systems, threshold determination, system notifications, and calculation of detection system accuracy can be seen in **Figure 1**. The stage of facial data acquisition aims to collect image information related to a person's face using a camera. The stage of determining facial patterns in the identification process is to analyze certain patterns on the face that can indicate a degree of drowsiness or fatigue. The stage of creating a face detection for the process of developing a system or algorithm that can identify and monitor faces to detect signs of drowsiness or fatigue. The detection of face detection systems begins with the extraction of facial landmarks for the process of identifying and marking specific points on the face in the image or video, Detection of facial points to identify locations and mark specific points on the face in the image, these facial points are referred to as facial landmarks and include important locations that can be used to describe the structure of the face in detail. Facial culture analysis is the understanding of facial expressions and signs of drowsiness.

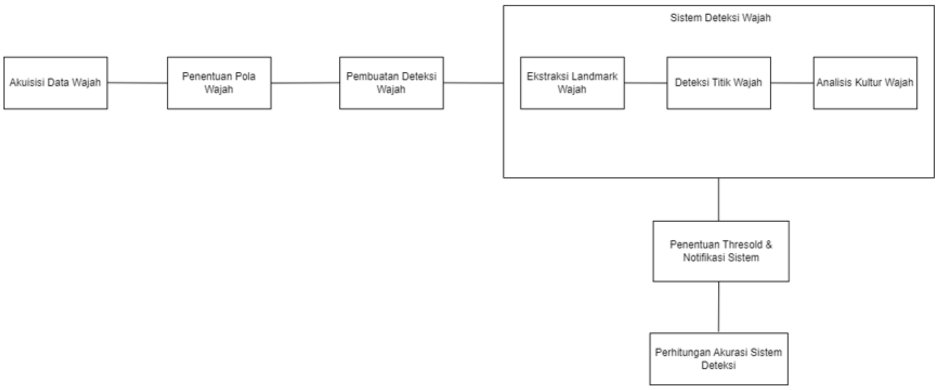


Figure 1. Research Methods for Detecting Sleepy Faces

As can be seen in **Figure 1**, the stages of determination *threshold* and the system notification is to decide on a condition that is considered a sign of drowsiness or fatigue, so that a warning or action is given. On the drowsiness detection system *threshold* [19] is defined as the limit at which the score is considered to reach a level that requires a response or warning. System notifications are carried out when the value generated by the analysis reaches or exceeds a predetermined threshold value. The last stage is to calculate the accuracy of the detection system using a test table. The creation of a drowsiness detection system aims to identify and warn when a person shows signs of drowsiness or fatigue that can threaten a person's safety. Programming language *Python* used to develop this system, by using *Visual Studio Code software*.

A. Facial Data Acquisition

Acquisition is the process of capturing facial data. In this study, the system requires input data in the form of facial data that is acquired directly using a camera as can be seen in the illustration in **Figure 2**. Data acquisition in this study was carried out using a camera placed on a holder that must be visible to both eyes to detect the eyes accurately.

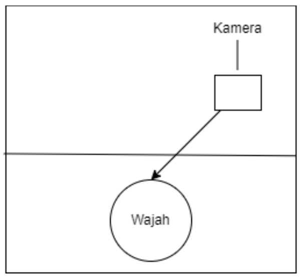


Figure 2. Facial Data Acquisition

When the face image is not in a normal position, that is, in a straight position on *Pivot* coordinates (0.0), then translation will be carried out using the Equation [20] :

$$x' = x + tx \quad (1)$$

$$y' = y + ty \quad (2)$$

Equation 1 at point *(x,y)* is the origin point before the translation and point *(x', y')* is the new point of translation. as can be seen in **Figure 2**.

B. *Facial Pattern Determination Stage*

The determination of the face pattern is carried out based on the use of distance to calculate the value *eye aspect ratio* (EAR). Determination of EAR values based on the points that make up the eyes [21] which is done with the following steps:

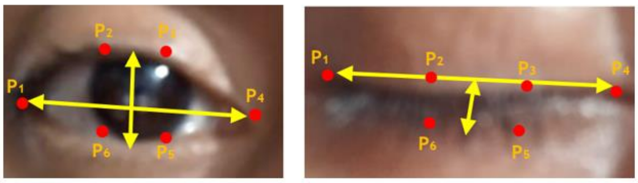
1. Calculate the length of *the horizontal eye* side (A) between points 1 and 5.
2. Calculate the length of the *vertical eye* side (B) between points 2 and 4.
3. Calculate the length of the eye diagonal (C) between points 0 and 3.
4. Calculate EAR using Equations 3 and 4 by calculating the average length of *the horizontal* and vertical sides (A + B) divided by the length of the diagonal (2 * C).

Calculation of EAR values using equations [22] :

$$\mathrm{EAR} = \frac{||\,P2 - P6\,|| \;-\; ||\,P3 - \;P5\,||}{2\,||\,P1\; - P4\,||} \tag{3}$$

$$\mathrm{EAR}\;\frac{1}{2}\;(\mathrm{EAR}_{left} + \;\mathrm{EAR}_{right}) \tag{4}$$

Points *p1, p2, p3, p4, p5,* and *p6* are the points on the eye that can be seen in **Figure 3**. The important points in the eye are used to calculate the EAR where the points p2, p3, p5, and p6 are used to measure the height of the eye, while p1 and p4 are used to calculate the width of the eye.



(a) (b)

Figure 3. Determination of *Eye Aspect Ratio* (EAR)

(a). Open Eye Condition (b). Closed Eye Condition

The results of the EAR can be used to see changes in eye condition and identify eye conditions (closed or not). On the drowsiness detection system, if the EAR value drops below a certain limit [23], then the value is an indication that the eyes are closed or sleepy.

C. *Face Detection Stage*

In this study, the manufacture of face detection and eye detection was carried out using *Haar Cascade Classifier* [24] to perform face and eye object detection on images and videos. On this sleepiness detection system *Haar Cascade* Identify signs of drowsiness on the face and eyes. The signs of drowsiness are when the eyes are closed. In the creation of face detection, the drowsiness detection system requires a file *Haar Cascade* in the form of .xml provided by *OpenCV*. This file contains the definition of *Haar Cascade Classifier* which has been trained previously to detect faces with a front position in the image with the following steps:

1. Performing Extraction *Landmark* Face. Extraction *Landmark* Face for the process of identifying and extracting important points or characteristic features on a person's face for the purpose of detecting signs of drowsiness or fatigue. Facial spot detection is the process of identifying the location of important points on a person's face in the detection of drowsiness or fatigue by labelling 68 points of the face [25] as can be seen in **Figure 4**.

Figure 4. Face Landmark Shapes with 68 Dots

In this study, the detection of facial points uses *shape predictor 68 face landmarks* to detect and predict the position of 68 *Landmark* or important points on the face. *Landmarks* It includes various facial features such as eyes, nose, mouth, cheeks, and forehead [26]. Drowsiness detection refers to the Dot index for both eyes that can be seen in **Figure 5,** consisting of:

- Left Eye Point (36,37,38,40, 41)
- Right Eye Point (42, 43, 44, 45, 46, 47)

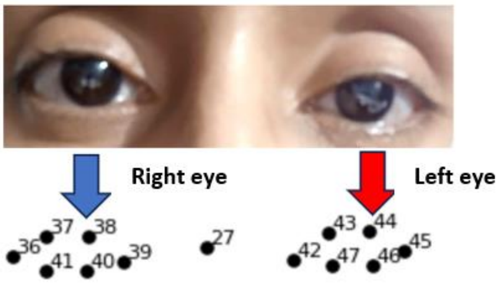


Figure 5. Right Eye Point Index and Left Eye

The position and changes in *the landmarks* in **Figure 5** are used to identify signs of drowsiness or fatigue in the drowsiness detection system. Position detection of 68 *landmarks* or points on the face using *the following* Pseudocode snippet:

```
face_detector = dlib.get_frontal_face_detector()

landmark_predictor = dlib.shape_predictor('shape_predictor_68_face_landmarks.dat')

image = cv2.imread('images/septian.png')
gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)

faces = face_detector(gray)

for face in faces:
    landmarks = landmark_predictor(gray, face)
    ap landmark pada wajah
    for point in landmarks.parts():
        x, y = point.x, point.y
        cv2.circle(image, (x, y), 2, (0, 255, 0), -1)
```

Eye index detection using *Library* Python *dlib* to detect objects [27], face detection, and detection *Landmark* face *Library* It serves as image processing and object analysis. *Library Face_detector* [28] used to create face detector objects and *Landmark_predictor* to create an object *Predictor Landmark* face. In the *Faces* to detect faces in color images changed to *grayscale*. *Pseudocode* is used to take every detected face, predict the *Landmark* on the face, and then draw a circle over each point *Landmark* on the picture.

2. Conducting facial culture analysis. Facial culture analysis in drowsiness detection is the observation of facial expressions or signs that can indicate drowsiness or fatigue in the driver. Facial culture in the drowsiness detection system are signs of drowsiness that are reflected in human facial expressions, such as changes in eye movements, and facial posture by paying attention to several aspects of facial culture that can be observed in drowsiness detection, including:

   1) Eye Movements. The human face can show signs of drowsiness through eye movements such as blinking for longer periods of time, eyes that look tired or lacking in energy, or even eyes that tend to be closed for a period of time

   2) Head Movement: A head pointing downwards or tilting can also indicate a state of drowsiness as can be seen in **Figure 6** with reference to the angle threshold [29] The representation of the head movement is as follows:

      - Head pose, if X from an angle of 7◦
      - Head poses downwards, if X from angle −7
      - Head poses right, if Y from an angle of 7◦

- Left head pose, if Y from an angle −7

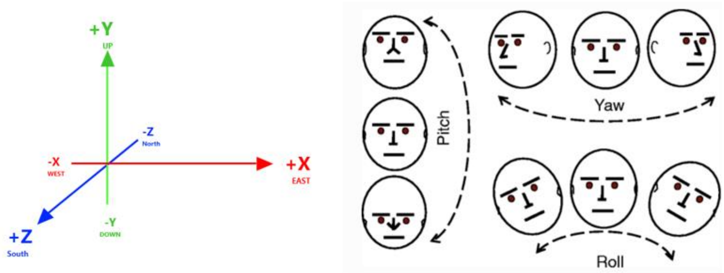


Figure 6. Head Movement Pose [30]

Head pose estimation can be defined as the ability to infer the orientation of the head relative to the view when acquiring a face using a camera [30]. Head pose as a representation of facial movements using three degrees of pose [30] namely, namely *Pitch*, *Yaw*and *Roll*. *Pitch* symbolizes the up-and-down movement on the axis *X*, *Yaw* symbolizes the left and right directions on the axis *Y* and *Roll* symbolizes the tilt of the head to the left and right on the axis *Z*.

3. Determining Thresholds and System Notifications. In determining the *threshold* of the drowsiness detection system, the system will make decisions in detecting drivers who experience drowsiness based on the results of *the eye aspect ratio* value. *Threshold* is a threshold value used to separate sleepy and non-sleepy conditions based on eye movements and head movements. The application of *the threshold* (Asdyo, B., Kanigoro, B., & Rojali, 2023) to the system, will make automatic decisions about the driver's drowsiness by providing a notification of the drowsiness detection system if drowsiness is detected with a visual and audio notification display in the form of a ringing sound to attract the driver's attention so that the driver can take responsive action when detecting signs of drowsiness in the driver using *the following pseudocode*:

```
if(eyeAspectRatio < EYE_ASPECT_RATIO_THRESHOLD):
    COUNTER += 1
    if COUNTER >= EYE_ASPECT_RATIO_CONSEC_FRAMES:
        pygame.mixer.music.play(-1)
        cv2.putText(frame, "Anda Mengantuk!!", (150,200),
        cv2.FONT_HERSHEY_SIMPLEX, 0.7, (255,255,255), 2)
else:
    pygame.mixer.music.stop()
    COUNTER = 0
```

In that *piece of Pseudocode*, if the eye aspect ratio is below the threshold, *increment the COUNTER variable* to track how many frames in a row with the eye aspect ratio below the threshold. If *the COUNTER* reaches or exceeds a certain value (*EYE_ASPECT_RATIO_CONSEC_FRAMES*), the program will initiate the playback of an audio or alarm sound aimed at waking the driver who is experiencing drowsiness. The system also displays the text "You're Sleepy!!", if the eye aspect ratio returns above the threshold, music playback or *alarm sound* is stopped, and *the COUNTER* is set back to 0.

Results and Discussion

The result of the acquisition of facial data on the detection system using a camera connected to a laptop device. The acquisition was carried out using *a webcam* camera that was placed using *a holder* and positioned on the left side of the driver so as not to obstruct the view while driving and with the position of both eyes visible so that the eyes could be detected accurately.

A. Results of Determining Facial Patterns

The results of determining the face pattern are carried out based on the use of distance using *Euclidean Distance* and *eye aspect ratio* to identify eye conditions (closed or not). When the system detects a metric value dropping below the threshold value, the system can identify that a person is experiencing drowsiness or fatigue. Results of creating face detection using *Haar Cascade Classifier* The system successfully recognizes and tracks human faces in images or videos to detect drowsiness. In this sleepiness detection system in the manufacture of face detection *Haar Cascade* Identify signs of drowsiness on the face and eyes.

Determination of face pattern using *eye aspect ratio* 0.28. An EAR value of 0.28 is used as the threshold limit in the detection of drowsiness because it is a value that can cause significant changes in the state of the eye, indicating that the eyes are beginning to close or are half-closed.

B. Results of the Face Detection System

In the face detection system, the system successfully extracts *facial landmarks* to find out the characteristics on a person's face for the purpose of detecting drowsiness. The system successfully detects face points to identify the location of important points on the face as can be seen in the results of the extraction of facial point landmarks **Figure 7**.

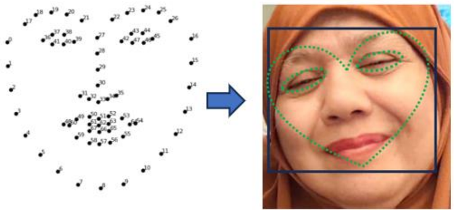


Figure 7. Results of the Face Detection System

C. Results of Threshold Determination and System Notification

In determining *the threshold* and notification, the sleepiness detection system has been tested based on facial patterns at a distance of 30 - 40 cm with 5 attempts to ensure that the system can produce the right warning or action when a person experiences the condition. In this test, the duration of the alarm sounded 2 – 5 seconds. **Table 1** shows the results of the *threshold* and system notification trials.

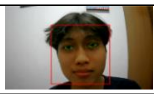
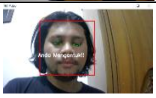
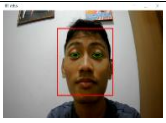
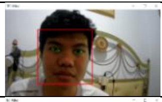
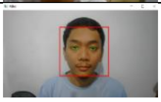
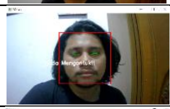
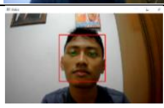
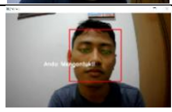
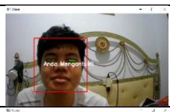
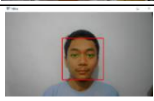
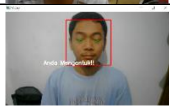
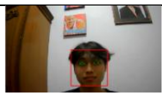
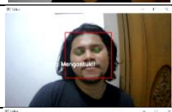
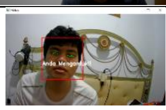
Table 1. Threshold Determination and Notification

No	Distance	Duration	Alarm	Remark
1	30	2,90	*On*	Succeed
	40	3,37	*On*	Succeed
	50	3,21	*On*	Succeed
2	30	3,01	*On*	Succeed
	40	2,95	*On*	Succeed
	50	4,76	*On*	Succeed
3	30	3,17	*On*	Succeed
	40	2,77	*On*	Succeed
	50	3,49	*On*	Succeed
4	30	2,68	*On*	Succeed
	40	2,80	*On*	Succeed
	50	3,09	*On*	Succeed
5	30	3,11	*On*	Succeed
	40	2.99	*On*	Succeed
	50	3.00	*On*	Succeed

In the Extraction of facial landmarks, the system successfully extracts the points or *Landmark* on the face, and the system successfully identifies and tracks important points on the human face. Every point *Landmark* Represents special features on the face, such as eyes, nose, mouth, and overall face shape. The test in detecting drowsiness was carried out on a total of 100 samples (**Table 1** took a sample of 5 people) using the acquisition of *Webcam* which are installed with a distance from the driver, including: 30 cm, 40 cm, and 50 cm. Variations in duration are also carried out so that this detection system can recognize sleepy conditions in riders based on theory *microsleep* that the duration of the driver being drowsy with *microsleep* about 3 seconds to 5 seconds (Linda Ng Boyle et al,, 2008). This driver drowsiness detection system will issue a notification on the condition of closed eyes with a duration of more than 3 seconds in the form of a warning (*Alert*) on the system that is "You are sleepy!!". This alert will then connect to the *Alarm* on the system and *Alarm* will give a warning in the form of a sound. These alarms and notifications will be in the "off" condition if the driver's eyes are closed, become open again.

Table 2 is the results of the system trials that have been carried out. In the test of drowsiness detection that has been carried out, the results were obtained that the success rate of the system to find out whether the driver is drowsy or not is 98.33% with a very small error rate of 1.67%.

Table 2. System Test Result

Jarak (cm)	Eyes Open	Eyes Close	Remark
30			Succeed
			Succeed
			Succeed
			Succeed
			Succeed
40			Succeed
			Succeed
			Succeed
			Succeed
			Fail
50			Succeed
			Succeed
			Succeed
			Succeed
			Fail

D. Results of the Analysis of the Face Detection System Trial

The results of the trial in this study show better detection system results than previous studies. Some obstacles in detecting faces in previous studies [8] who experienced difficulties in detecting the test image with several face poses that were influenced by lighting and additional attributes outside the face image resulted in a change in the score value as an indication of error in the prediction of the eye condition. The position of the face in previous studies also requires setting a certain limit in order to be captured by the camera [12]. In this study, some of the previous obstacles were handled by automatically adjusting the angle threshold based on the movement of the rider's head because in some positions, a head pointing down or tilting can also indicate a state of drowsiness. The study made several settings based on the angle starting on the head posing with the condition that X is from an angle of 7◦. Then on the head pose down with the condition that X is from an angle −7◦. The head poses to the right with the condition Y from an angle of 7◦ and the head poses to the left with the condition if Y from an angle −7. The analysis of head movements through the observation of facial expressions or signs that can indicate drowsiness from various angles is also an indication of fatigue in the driver, which can be implemented as head position movements in the drowsiness detection system.

The evaluation of training on the drowsiness detection system in this study was carried out using accuracy and *loss records* of the process in the detection system. Training evaluation aims to evaluate the model's performance against training data and validation data. This stage is very important to determine the system in understanding patterns in facial data. The line graph is used to visualize the accuracy and *loss* values at each *epoch* in the drowsiness detection system in this study can be seen in **Figure 8**.

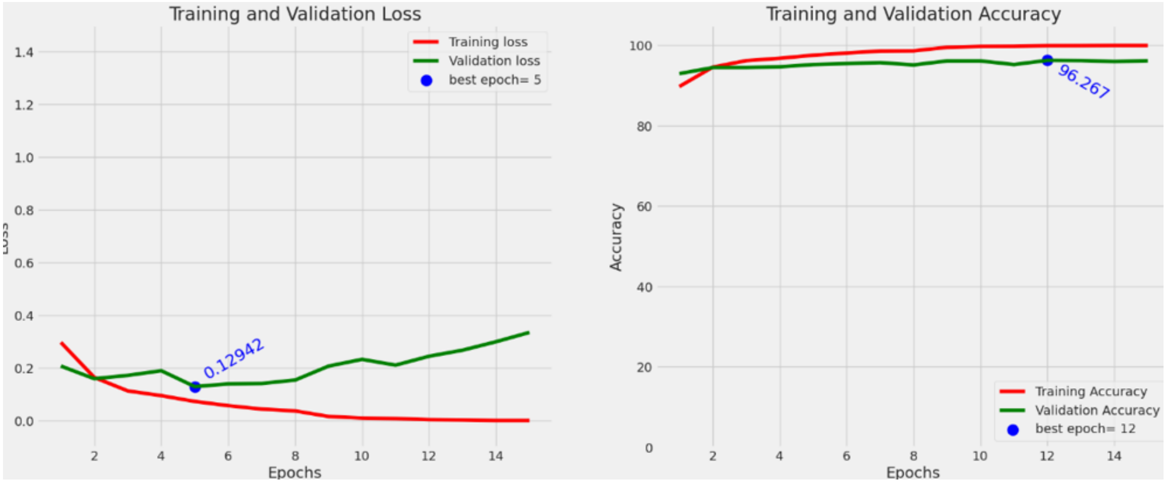


Figure 8. Drowsiness Detection System Training Evaluation Chart

Figure 8 shows the progression of the drowsiness detection system training process over 15 *epochs*. *The loss* of training data showed a steady decline in value from 0.3 to zero and the accuracy of training data also showed an upward trend from 90% to 100%. *The loss* of validation data in this model has a downward trend until *the 8th epoch* and then increases until the last *epoch*. Although the loss trend is not good, this sleepiness detection system has a fairly good initial validation data accuracy of around 92%. The accuracy of validation data has a slow upward trend without any significant decline. *The best epoch* based on *loss* occurred in *the 5th* epoch with a *loss value* of 0.12942. Based on accuracy, *the best epoch* occurred in the 12th *epoch* with an accuracy score of 96.27%. The accuracy and *loss* obtained at this stage indicate that the detection system can be used for further evaluation using test data. **Table 3** shows the difference in accuracy with previous studies where there is an increase in accuracy from previous studies in drowsiness detection.

Table 3. Comparison of Accuracy Results with Previous Research

Author	Detection Pattern Use	Method	Accuracy (%)
H. Cahyadi, C. Supriyadi, and A. Nandar, 2022	Drowsiness detection based on eye and mouth feature recognition and head position analysis	• Haar Cascade classifiers dan Machine Learning	94.70
B. B. Lim, K. Ng, and S. Ng, 2023	Drowsiness detection based on eye and mouth feature recognition and head position analysis	• Eye Aspect Ratio (EAR) • Haar Cascade classifiers • CNN	95.40

Author	Detection Pattern Use	Method	Accuracy (%)
R. Thakur, Shivam, S. Raj, and S. Pandey, 2022	Drowsiness detection based on eye and mouth feature recognition and head position analysis	• Eye Aspect Ratio (EAR) • Haar Cascade classifiers CNN	93
Maukar, 2024	Drowsiness detection based on eye and mouth feature recognition and head position analysis	• Eye Aspect Ratio (EAR) • Euclidean Distance • Haar Cascade classifiers • Facial Culture Analysis through: Eye Movements (blinking longer, eyes that look tired or have no energy, or even eyes that tend to be closed for a certain period of time • Head Movement (Head pointing down or tilted refers to the angular movement pose of the head)	96.27

Conclusion

The test results of the driver's bag detection system show that the drowsiness detection system can recognize signs of drowsiness in the driver. The system formed succeeded in acquiring facial data, determining facial patterns by extracting *facial landmarks* and generating facial points. The drowsiness detection system in this study can also detect changes in eye movements, and facial posture by paying attention to several aspects of facial culture, namely eye movements calculated using *the haar cascade* algorithm and *eye aspect ratio* as well as head movements that refer to the angle threshold of the representation of head movements with several corner threshold poses. In the drowsiness detection test, it was carried out using samples of several drivers with acquisition distances of 30 cm, 40 cm and 50 cm, resulting in a system accuracy of 96.27% with a maximum duration at the farthest distance of 50 meters in less than 5 seconds. This shows that the detection system successfully quickly provides notifications of sleepy riders to avoid accidents.

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