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AI-Based Driver Monitoring and Automated Emergency Response System

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Abstract— *Driver drowsiness and fatigue are serious road safety issues because they can reduce a driver's attention and reaction time. This paper presents an AI-Based Driver Monitoring and Automated Emergency Response System that monitors the driver through a laptop camera using MediaPipe Face Mesh. It detects signs of drowsiness by checking prolonged eye closure, yawning, and unusual head movements. The system uses Eye Aspect Ratio (EAR) to detect eye closure and Mouth Aspect Ratio (MAR) to identify yawning. When signs of fatigue are detected, an audio warning is played, and the driver is asked to confirm whether they are okay. If the driver does not respond within 5 seconds, the system automatically sends a WhatsApp alert with the driver's approximate location to a registered family member or trusted friend. The system is developed using Python, OpenCV, MediaPipe, Pygame, Winsound, PyWhatKit, and Requests. It works without requiring a training dataset or a separately trained machine-learning model. Overall, this system aims to improve road safety by identifying signs of driver fatigue and helping provide timely emergency assistance.*

Keywords—*Driver Monitoring, Drowsiness Detection, Computer Vision, MediaPipe Face Mesh, Head Tilt Detection, Emergency Response, WhatsApp Alert, Real-Time Monitoring.*

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I. INTRODUCTION

Road accidents are a major safety concern, and driver fatigue is one of the factors that can make driving dangerous. When drivers feel tired or sleepy, they may lose concentration and take longer to react to situations on the road. Signs such as keeping the eyes closed for too long, frequent yawning, and unusual head movements can indicate that a driver is becoming drowsy. Identifying these signs early can help warn the driver and prevent potentially dangerous situations. With the development of Artificial Intelligence (AI) and Computer Vision, cameras can now be used to monitor a driver's condition in real time. By analysing facial features, a system can identify changes in eye movement, mouth movement, and head position that may indicate fatigue. Facial landmarks help make this possible by identifying important points on the face and measuring changes in their positions. This paper presents an AI-Based Driver Monitoring and Automated Emergency Response System that continuously monitors the driver using a laptop camera. The system uses OpenCV for image processing and MediaPipe Face Mesh to identify facial landmarks. It uses the Eye Aspect Ratio (EAR) to detect prolonged eye closure and signs of drowsiness, while the Mouth Aspect Ratio (MAR) helps identify yawning. The system also measures the head roll angle to detect unusual head tilting. These measurements are compared with predefined threshold values and time-based conditions to identify possible signs of fatigue. When the system detects a potentially unsafe condition, it plays an audio warning to alert the driver. The driver is then given a few seconds to confirm that they are okay. If the driver responds within the given time, the emergency process is cancelled. However, if there is no response within the defined time limit, the system treats the situation as a possible emergency and automatically sends a WhatsApp message to a registered family member or trusted friend. The message includes the driver's approximate location through a Google Maps link, helping the recipient identify where assistance may be needed. Overall, the proposed system aims to improve driver safety by identifying early signs of fatigue, warning the driver, and helping notify a trusted person when the driver does not respond. It provides an additional safety measure that may help reduce delays in seeking assistance during potentially dangerous situations.

II. RELATED WORK

Driver monitoring systems have been widely explored as a way of improving road safety by identifying signs of driver fatigue and reduced alertness. Traditional approaches mainly depend on physical or vehicle-based measurements, while computer-vision-based approaches can directly observe the driver's facial

behaviour. Several vision-based systems use facial features such as eye closure, blinking, yawning, and head movement to identify possible driver fatigue. Eye-based methods commonly analyse the distance between different eye landmarks to determine whether the eyes are open or closed. Similarly, mouth-based measurements can be used to identify yawning, which can be an indication of fatigue. Recent computer-vision frameworks such as MediaPipe Face Mesh make facial landmark detection easier by providing a large number of facial reference points in real time. These landmarks can be used to calculate measurements such as EAR, MAR, and head orientation without requiring a separate facial-landmark dataset. However, detecting drowsiness alone may not be sufficient in an emergency situation. If a driver becomes unresponsive after a warning, there should also be a mechanism for contacting someone who can provide assistance. The proposed system therefore combines driver-condition monitoring with an automated emergency notification mechanism. Unlike systems that focus only on detecting fatigue, the proposed approach provides an additional response step by allowing the driver to confirm their condition before sending an emergency WhatsApp notification.

III. SYSTEM ARCHITECTURE

The proposed system is organised into four main layers: the Camera/Input Layer, Facial Landmark Processing Layer, Driver Condition

Detection Layer, and Emergency Response Layer. These layers work together to capture the driver's facial information, process the detected landmarks, identify unsafe conditions, and initiate an appropriate response. The overall system architecture is shown in Fig. 1.

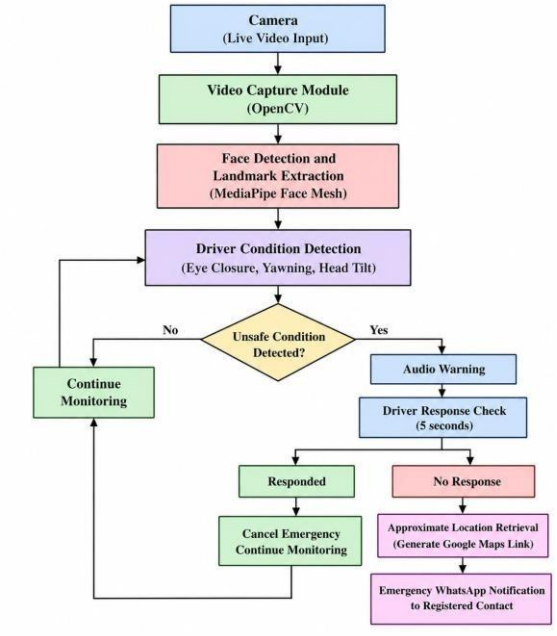


Fig.1. System Architecture

A. Camera/Input Layer

The Camera/Input Layer provides the real-time video input required for monitoring the driver. A laptop camera is used to continuously capture video frames containing the driver's face. OpenCV is used to access the camera and process the captured frames. The processed frames are then passed to the facial landmark processing layer for further analysis.

B. Facial Landmark Processing Layer

The captured video frames are analysed using MediaPipe Face Mesh to detect the driver's face and identify facial landmarks. Important points around the eyes, mouth, nose, chin, and sides of the face are used to calculate the Eye Aspect Ratio (EAR), Mouth Aspect Ratio (MAR), and head roll angle. These measurements help identify possible signs of driver fatigue.

C. Driver Condition Detection Layer

This layer analyses the extracted facial landmarks to identify possible signs of fatigue. The Eye Aspect Ratio (EAR) is used to detect prolonged eye closure and drowsiness. The Mouth Aspect Ratio (MAR) is used to detect yawning, while the head roll angle is used to identify abnormal head tilt. Predefined threshold values and

frame- or time-based conditions are applied to determine whether the detected condition is potentially unsafe. When drowsiness, yawning, or abnormal head positioning is detected, the system activates the warning mechanism.

D. Emergency Response Layer

The Emergency Response Layer manages the actions taken when the system detects a potentially unsafe condition. It first plays an audio warning and asks the driver to confirm that they are okay. If the driver responds within the given time, the emergency process is cancelled and monitoring continues. If there is no response, the system automatically sends a WhatsApp alert with the driver's approximate location through a Google Maps link to a registered family member or trusted friend, helping them provide assistance if needed.

IV. PROPOSED METHODOLOGY

The proposed methodology follows a step-by-step process to monitor the driver in real time. The system captures the driver's face using a camera and processes the video frames with OpenCV and MediaPipe Face Mesh. It then identifies facial landmarks and calculates the Eye Aspect Ratio (EAR), Mouth Aspect Ratio (MAR), and head roll angle. These values are checked against predefined thresholds to detect signs of drowsiness, prolonged eye closure, yawning, and unusual head tilt. When any unsafe condition is detected, the system plays an audio warning and waits for the driver's response before sending an emergency alert.

A. Face Landmark Detection

The system begins by capturing live video through the laptop camera. OpenCV reads and processes each frame before sending it to MediaPipe Face Mesh to detect facial landmarks. These landmarks represent different parts of the face, including the eyes, mouth, nose, chin, and sides of the face. The detected dimensions and used to analyse eye closure, mouth opening, and head position.

B. EAR-Based Drowsiness Detection

The Eye Aspect Ratio (EAR) is used to detect prolonged eye closure and drowsiness. EAR represents the relationship between the vertical and horizontal distances of selected eye landmarks. For each eye, the EAR is calculated as:

$$EAR = \frac{||p2 - p6||}{2 \times ||p1 - p4||}$$

where p1, p2, p3, p4, p5, and p6 represent the selected eye landmark points.

The EAR values of the left and right eyes are calculated separately, and their average value is used for detection:

$$EAR\ AVG = \frac{EAR\ left + EAR\ right}{2}$$

In the proposed implementation, an EAR threshold of 0.40 is used. When the average EAR falls below this threshold, the system considers the eyes to be closed and starts counting consecutive frames. If the condition continues for 25 frames, the system identifies a drowsiness condition. This frame-based approach helps distinguish prolonged eye closure from a normal short blink.

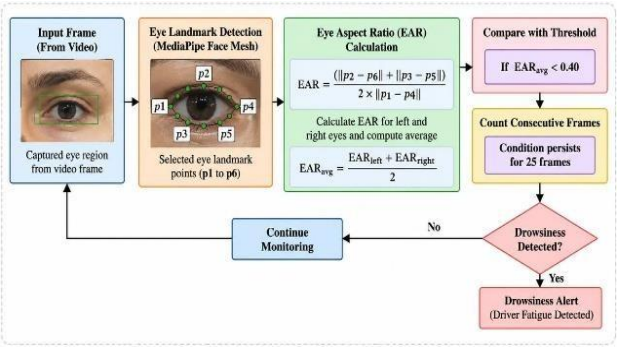


Fig. 2. EAR-Based Eye Closure and Drowsiness Detection

C. MAR-Based Yawning Detection

Yawning is detected using the Mouth Aspect Ratio (MAR). The MAR measures the vertical opening of the mouth relative to its horizontal width. The MAR is calculated as:

$$MAR = \frac{d(p_{top}, p_{bottom})}{d(p_{left}, p_{right})}$$

where \(p_{top}\) and \(p_{bottom}\) represent the upper and lower mouth landmarks, while \(p_{left}\) and \(p_{right}\) represent the left and right corners of the mouth. In the proposed system, a MAR threshold of 0.60 is used. When the MAR exceeds this threshold, the mouth is considered sufficiently open. If the condition remains above the threshold for 15 consecutive frames, the system identifies a yawning or fatigue condition. The use of consecutive frames helps prevent brief mouth movements from being incorrectly classified as yawning.

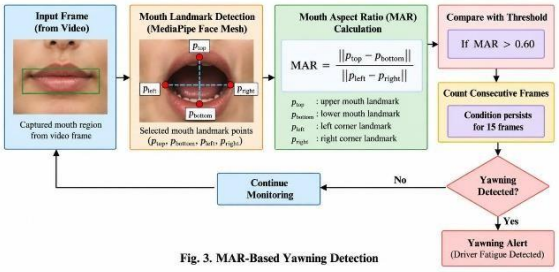


Fig. 3. MAR-Based Yawning Detection

D. Head Tilt and Abnormal Head Position Detection

The system also monitors the driver's head position using facial landmarks. The head roll angle is calculated using the relative positions of the left and right face landmarks.

The horizontal and vertical differences between the two selected face points are calculated as:

$$\Delta x = x_{right} - x_{left}$$

$$\Delta y = y_{right} - y_{left}$$

The head roll angle is then calculated using:

$$\theta = atan2(\Delta y, \Delta x) \times 180 / \pi$$

The absolute value of the angle is considered when determining abnormal sideways head tilt:

$$|\theta| > 25°$$

If the absolute head roll angle exceeds 25°, the head position is considered abnormal. The system also uses the relative position of the nose with respect to the face and chin landmarks to identify abnormal head positioning. The abnormal condition must

persist for approximately 2 seconds before a head-position warning is generated.

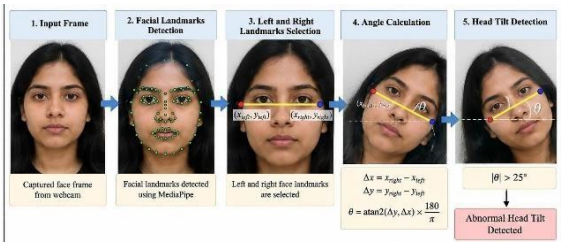


Fig. 4. Head Tilt Detection Using Facial Landmarks

E. Audio Warning

When the system detects drowsiness, yawning, or abnormal head positioning, an audio warning is generated. The purpose of the warning is to immediately attract the driver's attention and allow the driver to become alert. The warning is generated before the emergency notification process so that unnecessary emergency notifications can be avoided when the driver is still responsive.

F. Driver Verification

After an unsafe condition is detected, the system activates the driver verification process and displays an "ARE YOU OKAY?" prompt. The driver is given a defined 5-second response period to confirm their condition. If the driver provides the required confirmation, the emergency process is cancelled, and normal monitoring continues. If the driver does not respond within the response period, the system treats the situation as a possible emergency and proceeds to the emergency notification stage.

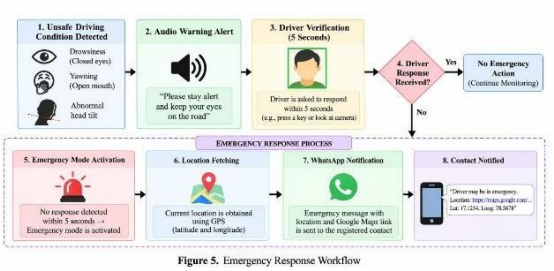


Figure 5. Emergency Response Workflow

Fig. 5. Emergency Response Workflow

G. Emergency WhatsApp Alert

When the driver does not respond within the defined response period, the system initiates the emergency notification process. The system obtains an approximate location using an IP-based location service. The latitude and longitude obtained from the service are used to generate a Google Maps link representing the approximate location. The system then sends an emergency notification through WhatsApp to a registered family member or trusted friend. The message indicates that the driver may require assistance and includes the generated location link.

V. EXPERIMENTAL RESULTS AND ANALYSIS

The developed system was tested in real time using a laptop camera to monitor different driver conditions. The testing focused on detecting prolonged eye closure, yawning, abnormal head tilt, audio warnings, driver responses, and emergency alerts. The system detects drowsiness when the average Eye Aspect Ratio (EAR) falls below 0.40 for 25 consecutive frames. Yawning is detected when the Mouth Aspect Ratio (MAR) exceeds 0.60 for 15 consecutive frames. For head-position detection, the system checks whether the head roll angle exceeds 25° for approximately 2 seconds before generating a warning. When an unsafe condition is detected, the system plays an audio warning and gives the driver 5 seconds to respond. If the driver responds in time, the emergency process is cancelled and monitoring continues. Otherwise, the system obtains the driver's approximate location, creates a Google Maps link, and sends a WhatsApp alert to a registered family member or trusted friend. The test results show that the system combines driver monitoring and emergency alerts in a single process. Using frame-based and time-based conditions helps reduce unnecessary warnings caused by brief eye closure, normal mouth movements, or temporary head movements. Overall, the prototype provides a practical way to identify possible signs of driver fatigue and notify a trusted person when the driver does not respond.

VI. FUTURE ENHANCEMENTS

The current prototype provides real-time monitoring of driver fatigue-related conditions and an automated emergency notification mechanism. However, the system can be further improved to make it more reliable, accurate, and suitable for practical vehicle use.

1. Integration with a Vehicle-Mounted Camera:

The current prototype uses a laptop camera. In the future, the system can be integrated with a camera mounted inside the vehicle to provide continuous monitoring during actual driving conditions.

2. Improved Driver-State Detection:

The system can be extended to detect additional driver conditions such as distraction, prolonged gaze away from the road, and reduced attention. This can provide a more comprehensive understanding of the driver's state.

3. Advanced Machine Learning Models:

Future versions can use trained machine-learning or deep-learning models to improve the detection of complex driver behaviours and reduce false alerts under different lighting conditions.

4. Accurate GPS-Based Location:

The current implementation provides an approximate location. A dedicated GPS module can be integrated to obtain more accurate real-time vehicle coordinates during an emergency.

5. Additional Emergency Contacts:

The emergency-response module can be extended to notify multiple registered contacts. Different notification methods such as SMS or email can also be considered.

6. Improved Environmental Robustness:

The system can be enhanced to work reliably under different lighting conditions, camera positions, spectacles, and facial orientations.

VII. CONCLUSION

The proposed system provides a real-time approach for monitoring driver fatigue and initiating an automated emergency response when the driver does not respond to a warning. It uses MediaPipe Face Mesh facial landmarks to detect prolonged eye closure, drowsiness, yawning, and abnormal head positioning using EAR, MAR, head roll angle, and predefined thresholds. When an unsafe condition is detected, the system provides an audio warning and gives the driver an opportunity to confirm their condition. If there is no response within the defined response period, a WhatsApp emergency notification is sent to a registered family member or trusted friend along with an approximate location link. The prototype demonstrates how computer vision and automated communication can be combined to support driver safety and reduce delays in emergency assistance.

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