Driver Drowsiness Detection with Autonomous Speed Control and Parking System

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Abstract: As the prevalence of road accidents continues to rise; the need for advanced safety mechanisms has become imperative. This paper explores the development of a driver drowsiness detection system integrated with autonomous parking functionality. Leveraging state-of-the-art computer vision techniques and machine learning models, the system monitors human behavioral cues such as eye movements, yawning, and head posture to detect signs of fatigue. Upon identifying drowsiness, the system triggers alerts and initiates autonomous vehicle control, guiding the car to a safe parking location. Challenges such as variability in drowsiness expression and limitations of vision-based techniques are addressed. By combining innovative methodologies with hardware integration, this research demonstrates a robust solution for enhancing roadway safety and mitigating accidents caused by driver fatigue.

Keywords: Drowsiness Detection, Autonomous Parking, Eye Aspect Ratio (EAR), Yawn Detection, Head Posture Estimation, Computer Vision, Driver Safety.

I. INTRODUCTION

Road traffic accidents are gradually becoming a very major concern in society, of which one is driver fatigue. Analyses indicate that drowsiness immediately leads to 30–40% of traffic accidents thus demanding preventive measures. The main three contributory causes involve drowsiness, drunkenness, and careless driving, which all in together sum up to result in a very high increase in events threatening life. Mechanisms to detect drowsiness need to be incorporated so that their hazards can be reduced to improve the safety on road. Using high-technology approaches and vision, such technologies track behavioral attributes of a driver - which are eye movements, yawning, or head nodding - day after day. As these precursors call at the right time for such an intervention, conventional types of detections alone may be insufficient whenever drowsiness appears without any overt symptoms thus, they require more comprehensive and multimodal solutions as well.

II. PROPOSED METHODOLOGY

The developed system makes use of a webcam placed appropriately to monitor the driver's face so that there are no obstacles for clear sight, thereby accurately identifying behavior signs. The system will have an advanced 68-point facial landmark model analyzing fine features in the facial structure such as eye movement, mouth expression, and head pose. This makes a deeper analysis of how the driver feels. After the correct identification of facial dynamics, models including eye movements, yawning, and head gestures are integrated with each module specifically designed to address driver behavior elements. All the models are seamlessly merged into a single module that has a critical role in marking the onset of drowsiness by using pattern or event assessment obtained from independent models. It continuously checks the state of the driver and clearly emphasizes the detection of symptoms of drowsiness. When drowsiness has been induced, the system is sensitive enough to warn the driver instantaneously. One fundamental principle steers all this process: the principle EAR. An EAR value that exceeds 0.2 would suggest an active state, while any below 0.2 may imply drowsiness. If the eyes are closed for a more extended period than expected, the system sounds an audible alert to enhance driver alertness. Conversely, if no drowsiness indicators are detected, the system resumes monitoring, recording the driver’s video for continuous analysis. This integrated approach ensures timely notifications and fosters heightened vigilance, enhancing overall safety during driving.

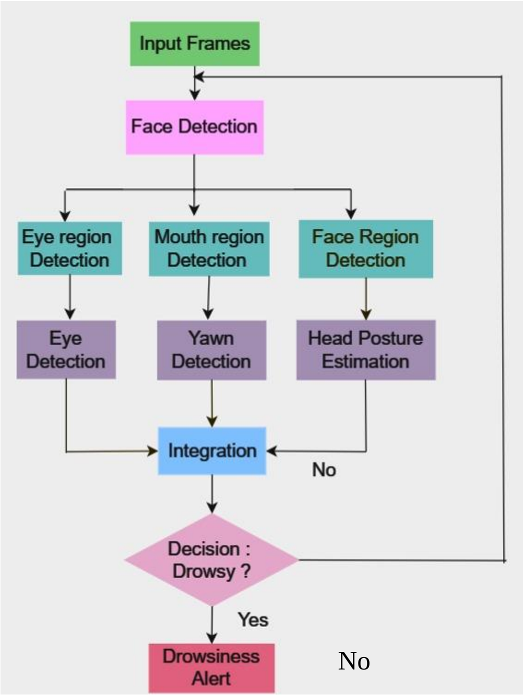

Figure 1: System Flow Diagram

Eye Detection: The approach of the system is to capture ocular features within any given facial region, primarily focusing on eye movements and closures, which are a sign of fatigue. Most effective techniques are extracting an Eye Region of Interest from captured images, focusing on relevant features. It infers that the subject operator might be sleepy if ocular features go unobserved in a steady stream of 20 frames. A critical feature used by these fatigue monitoring systems for the detection of eyes is wherein such critical statistics are evaluated like eye blink rate and average eye closure duration for establishing reliable markers of sleepiness. The video stream is captured from the webcam. The video stream obtained has important frames taken out for the investigation process. The obtained frames are used to determine the eye landmarks using OpenCV with the help of the 468-point facial landmarks model. The rate of blinking and eye closing rate of the driver can be found by using the amount of EAR calculated by the process of detection.

The Eye Aspect Ratio (EAR) is computed using the following equation:

$$EAR = \frac{|p2 - p6| + |p3 - p5|}{2 \times |p1 - p4|}$$

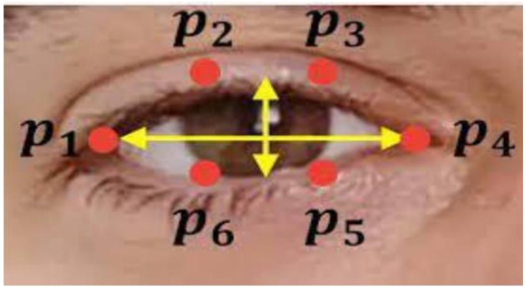

Figure 2: Eye Aspect Ratio Landmarks

Figure 3: Person identified as Active

Figure 4: Person Identified as Drowsy

Head posture estimation: It is an assessment of dynamic head movements and rotational angles within a specified coordinate framework to ensure uniform gesture analysis, regardless of pose variations. This system puts emphasis on the detection of fatigue-associated postures such as head tilts that are considered critical indicators of driver drowsiness. It applies the Media Pipe Face Mesh framework with some customized parameters that allow for accurate detection and tracking of facial landmarks. It initializes video capture with OpenCV's Video Capture class, using the webcam, and then it reads the frames in real-time processing. It also follows other preprocessing steps that involve inversion and BGR color space to RGB color space in alignment with the Face Mesh model. Face landmarks are detected, and the system retrieves 2D and 3D coordinates to calculate head pose angles. In this case, rotational angles (x,y,z) are used to determine both direction and degree of tilt. The system then overlays textual indicators signifying orientation and tilt in the head on the video feed. Conditional logic applied to evaluate the angles provides a description of whether it is descending or advancing head movement except that the line overlay reflects nasal orientation. The system uses detected landmarks with connections to help enhance visualization of head pose and also gives clear feedback of dynamics while ensuring robustness in detection with such approaches for proper head movement that should induce fatigue.

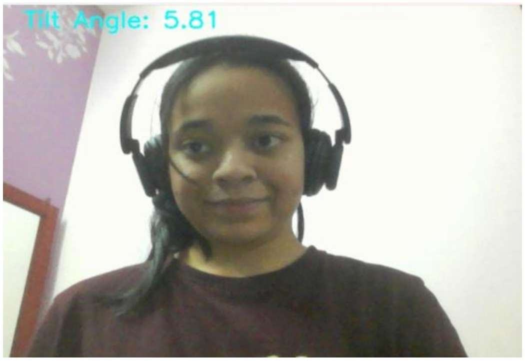

Figure 5: Person Identified as Active

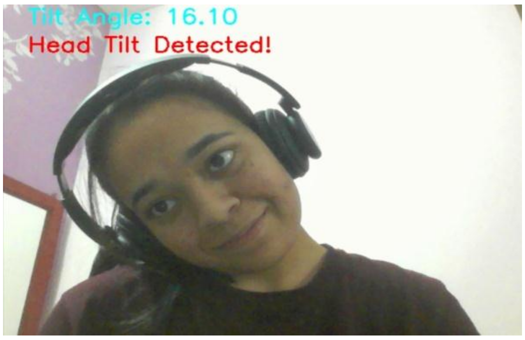

Figure 6: Person identified as Drowsy

Yawn Detection: This is one of the important criteria to determine the drowsiness level of a driver as it can trigger prompt alerts that may lower the probability of accidents. It concentrates on the oral area of the face within an assigned facial area using video input from a webcam. The relevant frames are then processed using OpenCV and the 468-point facial landmarks model to ensure precise yawning detection. An important parameter in this study is the Mouth Aspect Ratio, which is defined as mouth length to mouth width ratio. It is hypothesised that drowsy persons have a greater propensity to yawn and thus have less control over oral space, which increases the MAR compared to its normal value for them. Thus, the increase in MAR is a reliable indicator of fatigue. More recently, new aspects in driver monitoring systems incorporated yawning into the signs of fatigue detection. Advancements such as neuromorphic sensing methods increase more accuracy and reliability in their respective systems and make detection of yawning essential while avoiding accidents.

The Mouth Aspect Ratio (MAR) is computed using following equation:

$$MAR = \frac{|EF|}{|AB|}$$

Figure 7: Person Identified as Active

Figure 8: Person Identified as Yawning

III. RESULTS

The proposed framework relied on computer vision techniques to extract rich facial feature for drowsiness recognition. The system was based on Python, coded in Visual Studio Code, and used OpenCV, which allowed effective pre-treatment and feature extraction of each image. It has integrated functions for eye detection, yawn detection, and head posture assessment to further increase accuracy in detecting fatigue-related responses. As indicated in Figure 10, the system correctly detected the participant to be active in the period of the experiment. Figure 8 indicates an automatic alert that was set off as the mouth is open for a longer duration than the threshold, signifying that the participant had yawned. Also, in Figure 6, head tilted down triggered the alert since sleepiness signs have been identified.

IV. CONCLUSION

Drowsiness detection systems are of paramount importance in improving road safety through timely alert notifications to the driver, thereby minimizing the chances of accidents caused by drowsiness. Non-invasive physiological measurements and advanced sensors incorporated in hybrid systems have been very effective in detecting the symptoms of drowsiness with adequate accuracy to avoid accidents. It measures various critical parameters, such as ocular conditions, and monitors warning signs for drowsiness and alerts drivers about it in real-time, asking them to take appropriate precautionary measures. Continuous research and development continually improve the accuracy and reliability of drowsiness detection and autonomous parking. Some of these roadway safety aspects have significant potential in reducing driver fatigue incidents, which continues to encourage safe roadways for all users. Future advances in technology, along with research efforts, will leave avenues to further improve these systems. The integration of both hardware and software elements is one of the expected developments of this project, and the central node that will be highlighted is a Arduino. It will integrate all the required software and the system will run smoothly. Integration of the Arduino with a strategically mounted webcam on the steering wheel will further improve functionality, efficiency, and effectiveness in the detection and prevention of driver drowsiness.

V. REFERENCES

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