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WakeUpWatch – Drowsiness Detection System

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***Abstract*—As the wheels of advancement turn, our commitment to safety intensifies. Enter the domain of drowsiness detection systems – beacons of hope amid the tumult of the asphalt expanse. Leveraging state-of-the-art technologies and methodologies, these systems function as vigilant guardians, ceaselessly monitoring subtle human behavioural cues to pre-empt disasters. In the realm of transportation, where instantaneous decisions determine life or death, the significance of such systems cannot be overstated. By perpetually scrutinizing individuals' alertness and cognitive faculties, these systems act as silent sentinels, ever alert for signs of fatigue. However, the journey toward safer roads is fraught with challenges. Vision-based techniques, encompassing eye detection, yawning, and nodding, provide valuable insights into alertness levels but are not devoid of limitations. Sleep may envelop individuals without customary signs, rendering traditional methods inadequate in specific scenarios.**

***Keywords*—Vision-based, Drowsiness Detection, safety, face landmark model, fatigue, Yawning, Nodding**

I. Introduction

In contemporary society, the escalating prevalence of road accidents has emerged as a profound and pressing societal concern that demands careful examination. The primary catalysts for these severe incidents encompass multifaceted factors such as drowsiness, inebriation, and reckless driving practices, which collectively contribute to a substantial increase in the annual incidence of road accidents. Within this complex landscape, driver fatigue stands out as a prominent and recurrent contributor to the surge in road mishaps. Empirical evidence gleaned from a myriad of research studies reinforces the severity of the issue, revealing a staggering statistic that points to the direct involvement of drowsiness in approximately 30-40% of recorded accidents. This alarming prevalence underscores the imperative need for a nuanced and strategic focus on the implementation of drowsiness detection mechanisms to curb the escalating frequency of car accidents. The adoption of sleepiness detection emerges not only as a pivotal mitigating factor but also as a fundamental measure for bolstering overall driver safety. Leveraging sophisticated methodologies and cutting-edge technologies becomes indispensable in systematically observing and scrutinizing human behaviour, enabling the timely identification of precursory signs indicative of drowsiness. Vision-based techniques, encompassing the meticulous detection of eye movements, yawning, and nodding, are integral components of this proactive detection process, albeit acknowledging the inherent variability in individuals' expressions of drowsiness. In conclusion, addressing the multifaceted issue of road accidents mandates a comprehensive understanding of the intricate nature of the problem. It necessitates the judicious adoption of advanced technologies geared towards the early detection and prevention of incidents related to drowsiness, thereby fostering a safer and more secure road environment for all.

II. Proposed Methodology

The implemented system employs a strategically positioned webcam, ensuring an unobstructed line of sight to the driver's facial region, meticulously observing and scrutinizing myriad driver activities. Progressing through subsequent stages, the system delves into the realm of facial recognition, leveraging an advanced 68-face landmark model to intricately analyse the subtle nuances of facial features. This intricate process extends to the meticulous detection of nuanced facial expressions, encompassing a thorough examination of eye movements, mouth actions and head posture, thereby facilitating a comprehensive and exhaustive analysis of the driver's state.

Upon the successful identification of these intricate facial dynamics, the system seamlessly integrates distinct models, each meticulously tailored for eye movement, yawning and head gestures. These individualized models, collectively addressing the multifaceted aspects of facial behaviour, undergo a harmonious amalgamation and streamlining process into a unified module. This integrated module assumes a pivotal role, serving as the linchpin in undertaking the paramount task of discerning the onset of driver drowsiness. This discernment is achieved by collectively evaluating the occurrences and patterns identified by the individual models, fostering a holistic understanding of the driver's state.

Following this intricate integration process, the composite analysis meticulously gauges the driver's condition, with a particular emphasis on identifying signs of drowsiness. In the event of the system determining a state of drowsiness, it promptly triggers an immediate alert. This alert mechanism functions as a conscientious notification system, promptly apprising the driver and fostering heightened vigilance to ensure safety during their driving endeavours.

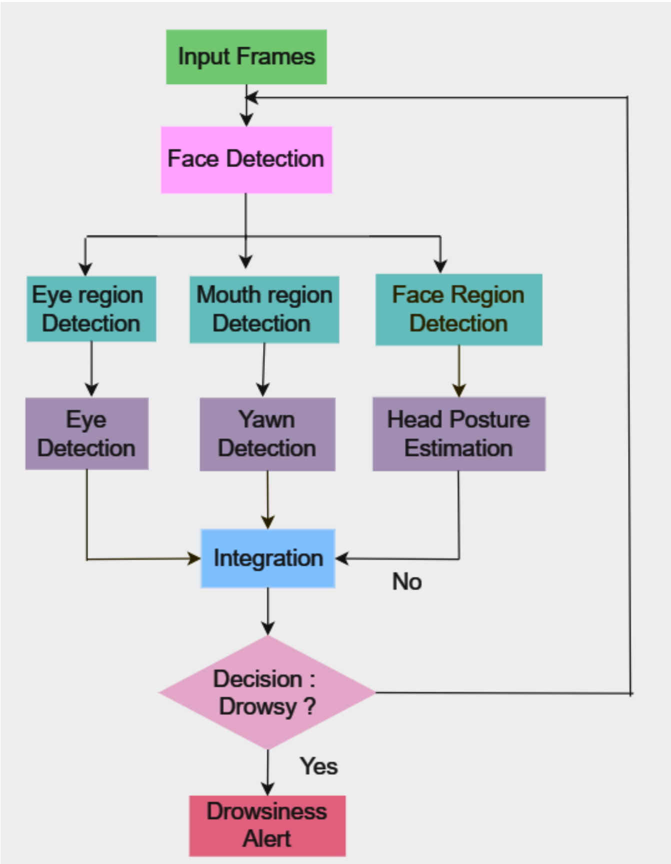

Figure 1. Workflow of the proposed Drowsiness Detection system

Eye Detection - The implemented system is devised to discern ocular features within a specific facial domain. One effective method for eye detection in driver drowsiness detection systems involves utilizing image cropping techniques to extract the Eye Region of Interest (ROI) from captured images [4]. In instances where these features are absent for a continuous sequence of 20 frames, the system infers a potential state of somnolence in the driver. Eye detection assumes a pivotal role within fatigue recognition frameworks, aiding in the assessment of parameters such as eye blinking frequency and eye closure, which serve as markers for levels of fatigue [1]. Acquisition of the video stream is facilitated through a webcam, followed by the extraction of relevant frames for subsequent analysis. Employing OpenCV, eye detection is executed, leveraging the capabilities inherent in the 68-face-landmarks model. By utilizing the Euclidean eye aspect ratio (EAR), an index of eye blinking frequency is derived, thereby facilitating the classification of eye status—whether open or closed. An EAR value exceeding 0.55 signifies the individual's active state, while a value below 0.55 indicates drowsiness, prompting the activation of an alert mechanism to notify the individual of potential fatigue. Should the eyes remain closed beyond a predefined time interval, an audible alarm is triggered to alert the driver. Conversely, in the event of eyes being open, no message is shown, subsequently initiating the recording of the driver's video to perpetuate the monitoring process.

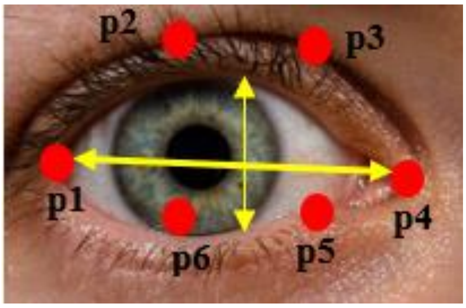

Figure 2. Six facial landmarks associated with the eye

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

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

Figure 3. Person classified as active.

Figure 4. Person classified as drowsy and automated alert generated.

Yawn Detection - Accurate detection of yawning serves as a crucial indicator of a driver's state of drowsiness, facilitating prompt alerts to mitigate the risks of accidents [9]. The system is designed to analyse the oral region within a specified facial area. Utilizing a webcam, the system captures video input and subsequently extracts relevant frames for thorough examination. Yawning recognition is performed using OpenCV in conjunction with the 68-face-landmarks model. In the context of yawning detection, the Mouth Aspect Ratio (MAR) emerges as a pivotal metric, representing the ratio of mouth length to mouth width. Our foundational hypothesis posits that individuals experiencing drowsiness tend to yawn and may exhibit diminished control over their oral region, resulting in an elevated MAR compared to their usual state. This enhanced MAR metric serves as a reliable parameter for identifying drowsiness in individuals. Also, a scholarly discourse introduces an innovative approach for driver monitoring systems (DMS), integrating yawning detection as an adjunctive marker of fatigue, employing neuromorphic sensing methodologies [8].

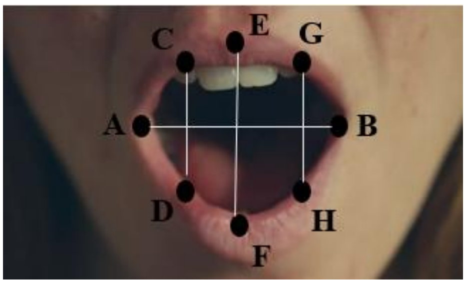

Fig 5. Eight facial landmarks associated with the mouth.

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

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

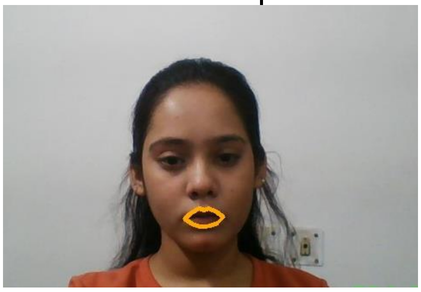

Figure 6. Person classified as active.

Figure 7. Person classified as drowsy and automated alert generated.

Head Posture Estimation - Our methodology calculates the dynamic movements of head rotation within the head coordinate system, ensuring consistent gesture dynamics regardless of pose variations [11]. The system is tailored to analyse the fatigue-inducing aspects of head posture in drivers. Specifically, the configuration of the MediaPipe Face Mesh model includes customized parameters to establish minimum levels of confidence in detection and tracking, ensuring accurate identification of facial landmarks. Upon initialization, the code activates video capture using OpenCV's VideoCapture class, typically sourcing input from a webcam. Subsequently, frames are continuously retrieved from the video stream within the primary loop. Each frame undergoes a crucial process of inversion and conversion from BGR to RGB colour space to ensure compatibility with MediaPipe. Facial landmarks are then detected using the Face Mesh model. Upon detecting faces, the script iterates over each face, extracting relevant landmarks and converting them into both 2D and 3D coordinates. These coordinates are leveraged to compute head pose angles and determine the direction of head tilt. Textual indicators representing head tilt direction and rotation angles (x, y, z) are superimposed onto the frame. Additionally, precise conditional clauses, such as those evaluating x and y values, are employed to assess head tilt direction. If the specified conditions are met, the tilt is identified as downward; otherwise, it is categorized as forward. Moreover, nasal orientation is visually indicated by a line on the frame, while landmarks and their connections are highlighted to enhance visualization.

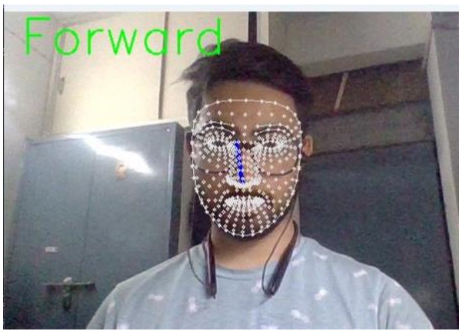

Figure 8. Person's head tilt direction identified as forward.

Figure 9. Person's head tilt direction identified as down.

III. Results

As previously elucidated, methodologies rooted in computer vision were employed to extract intricate facial attributes. The coding was executed utilizing the Python programming language within the Visual Studio Code environment. OpenCV served as a pivotal tool for harnessing specialized computer vision functionalities during preprocessing stages. Supplementary dependencies encompassed scipy, dlib, imutis, and mediapipe libraries. In pursuit of enhanced precision, the proposed framework manifests result through the integration of eye detection, yawn detection, and head posture estimation.

Figure 10 shows that the person classified as active while performing the experiment while in figure 11, the mouth is open for a duration and an automated alert is generated Also, figure 12 shows that the eyes are closed for a duration and direction of head tilt identified as down, so an automated alert is generated in this scenario.

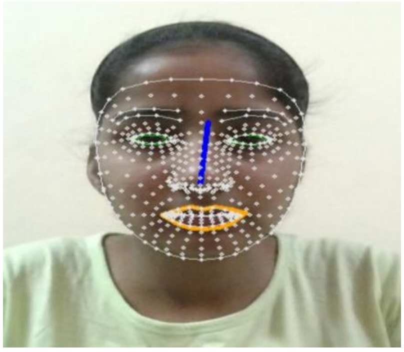

Figure 10. Person classified as active.

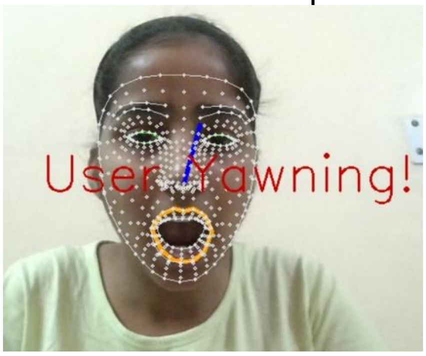

Figure 11. Person classified as drowsy and automated alert generated.

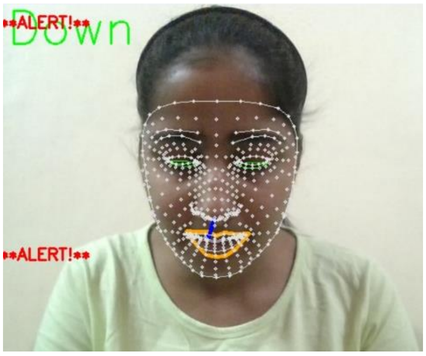

Figure 12. Person classified as drowsy and automated alert generated.

IV. Conclusion and Future Work

Drowsiness detection systems play a pivotal role in enhancing roadway safety by promptly alerting drivers to indications of drowsiness, thus diminishing the likelihood of accidents. By amalgamating non-invasive physiological metrics and alternate sensors, hybrid drowsiness detection systems have showcased efficacy in precisely recognizing driver drowsiness. These systems scrutinize variables such as ocular condition to identify drowsiness, issuing timely notifications that urge drivers to undertake necessary precautions to avert accidents. Persistent endeavours in research and development persistently refine the technology behind drowsiness detection, with a primary emphasis on augmenting detection precision and system dependability. As an indispensable component of roadway safety, drowsiness detection systems hold the potential to curtail the occurrence of accidents stemming from driver fatigue, thus fostering safer thoroughfares for all individuals.

Prospective advancements in technology, coupled with sustained scholarly inquiry, present prospects for further innovation and enhancement in drowsiness detection systems, ultimately bolstering driver safety and diminishing roadway accidents.

In the forthcoming stages of development, there is a deliberate consideration towards evolving this project into an amalgamation of hardware and software elements. This evolution can be realized through the incorporation of a Raspberry Pi, an exemplary specimen of specialized computing equipment. Serving as a central node, the Raspberry Pi will amalgamate all necessary code, thereby coordinating the smooth execution of the project. Through the integration of the Raspberry Pi with a webcam strategically positioned on the steering wheel, the project's capabilities will be enhanced, thereby facilitating an elevated level of functionality and efficiency in its operation.

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