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Driver Drowsiness Detection using MATLAB

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Abstract:- Driver drowsiness is critical toroad accidents and fatalities worldwide. Various systems utilizing image processing, computer vision, and machine learning techniques have been proposed to address this. This paper consolidates the findings from few relevant studies focusing on drowsiness detection in drivers. The proposed systems aim to detect signs of drowsiness, such as eye closure and facial expressions, and issue timely alerts to prevent accidents. By analyzing these studies, thispaper provides insights into the methodologies, challenges, and advancements in drowsiness detection technology, paving the way for more robust and effective systems in the future.

Keywords:- *Face Detection, Eye Detection, Driver Drowsiness Detection, Techniques of Face and Eye Detection.*

I. INTRODUCTION

Driving while tired is a major concern, and a hidden dangerlurks within it: micro sleep. These momentary lapses in consciousness, though brief, can have devastating consequences behind the wheel. Even on a seemingly clear road, a micro sleep can render a driver completely unprepared for unexpected situations. We will examine data that reveals the prevalence of sleep deprivation as a major cause of accidents. Existing laws and anti-fatigue devices, while well-intentioned, have their shortcomings. By harnessing the power of image processing, we can potentially develop a system that monitors drivers for signs of drowsiness and intervenes before a micro sleep occurs. This innovative approach has the potential to significantly improve road safety and prevent accidents caused by drowsy driving [1]. Alarming statistics reveal drowsy driving as a major culprit in road accidents. To combat this threat, this paper proposes a novel Driver Drowsiness Detection System (DDDS) that leverages facial expression analysis. Unlike intrusive methods that monitor physiological signals or vehicle behavior, this system utilizes computer vision technology to monitor the driver's face, specifically focusing on their eyes. Eyes are a reliable indicator of drowsiness due to their prominent position and changes in blinking patterns and closure duration. This non-intrusive and potentially cost-effective approach has the potential to significantly improve road safety by detecting drowsiness earlyon and prompting timely warnings to the driver, ultimately preventing accidents and saving lives [2].

II. TECHNIQUES FOR FACIAL FEATURE ANALYSIS

By analyzing a driver's facial expressions, particularly the eyes and mouth, we can glean valuable insights into their levelof alertness. This section will explore various techniques employed in facial feature analysis for driver drowsiness detection.

A. Face Detection

Local Binary Pattern (LBP) is a simple yet very efficient texture operator that labels the pixels of an image by thresholding the neighborhood of each pixel and considers the result as a binary number. LBP's effectiveness in representing facial images for various tasks like expression recognition and face recognition. While a simple histogram approach using LBP codes captures textural information, it loses crucial spatial details about where these patterns occur on the face.

To address this limitation, the approach utilizes local descriptions. The facial image is divided into smaller regions, and LBP descriptors are extracted from each region independently. These regional descriptors are then combined to form a global description of the face. This method offers a hierarchical representation:

- **Pixel-Level**: Individual LBP codes capture patterns atthe pixel level.
- **Regional Level**: LBP codes are summed within each region, providing information about a specific facial area.
- **Global Level**: Regional histograms are concatenated to create a global description of the entire face. As mentioned in figure 1.

➢ *This Approach Offers Several Advantages:*

- **Robustness:** Local feature-based methods are more resistant to variations in pose or illumination compared to holistic methods that analyse the entire face at once.
- **Flexibility:** Regional divisions don't need to be rigid grids; they can be of varying sizes, and shapes, and even overlap partially.

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➢ *The Success of LBP-based Face Description has Led to its Widespread Adoption in Facial Analysis Applications:*

- **Facial Expression Recognition**: By extending the 2D LBP approach into the spatiotemporal domain (LBP-TOP), researchers achieved excellent performance in facial expression recognition.
- **Illumination-Invariant Face Recognition**: Combining LBP features with near-infrared (NIR) imaging and Adaboost learning resulted in a robust face recognition system under varying lighting conditions.
- **Gabor Filter Integration**: Extracting LBP features from images filtered with Gabor filters of different scales and orientations yielded outstanding results in face recognition.
- **Spatiotemporal LBP for Video Sequences**: LBPs were used for face and gender recognition from video data, demonstrating their effectiveness in dynamicscenarios.
- **Visual Speech Recognition**: The LBP-TOP approach achieved leading-edge performance in visual speech recognition without requiring complex lip segmentation.

Overall, LBP-based facial image representation has become a well-established technique due to its robustness, flexibility, and effectiveness in various facial analysis tasks. By capturing spatial information alongside texture details, it offers a powerful tool for applications like expression recognition, illumination-invariant face recognition, and visualspeech recognition [3].

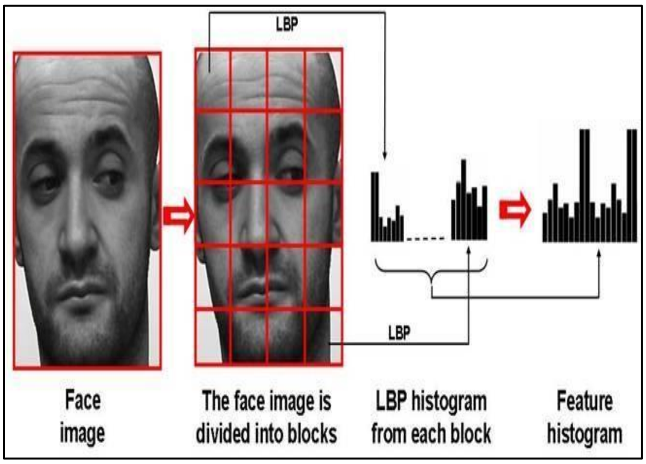

Fig 1: Face Description with Local Binary Patterns [3]

B. *Eye Detection Units*

Drowsiness detection systems use cameras to monitor eye blinking. Frequent blinks suggest drowsiness, but accurate eyedetection is crucial to avoid misinterpreting squinting or other eye movements. This ensures the system only triggers alarms when a driver is truly drowsy and also allows for calculations of blink duration, another indicator of fatigue. For the most reliable drowsiness assessment, these systems might consider additional factors like head movements and facial expressions [4].

III. FACE DETECTION ALGORITHM

Paul Viola and Michael Jones proposed the first method known as the Viola-Jones object detection framework in 2001.This framework, originally inspired by the challenge of face detection, is versatile enough to be trained for various object classes. It is renowned for achieving high detection rates while processing images rapidly. The framework's success isattributed to three key innovations:

A. *Haar Features Equations*

The Viola-Jones algorithm breaks down faces into simple building blocks called Haar features. These features are like tiny templates made of two or three rectangles arranged in specific ways. By comparing the brightness within these rectangles, the algorithm can identify basic patterns that commonly appear in faces, like edges for eyes or the bridge of the nose**.** The algorithm uses Haar features as building blocks to identify faces. Each feature calculates a value based on the difference in brightness between rectangles within it. This value is obtained by multiplying the weight (importance) of each rectangle by its area and summing them up. These features are then grouped into stages. Each stage acts like a filter: it adds up the values from all its included Haar features and compares the sum to a specific threshold (also learned by the system). Images that pass the threshold in one stage move on to the next, while those that fall below are discarded as non-faces. There's no fixed number of features per stage. The Viola-Jones system, for instance, used stages with 2 to 10 features, leading to a total of 38 stages and a whopping 6060 features to comprehensively detect faces as shown in figure 2 [5].

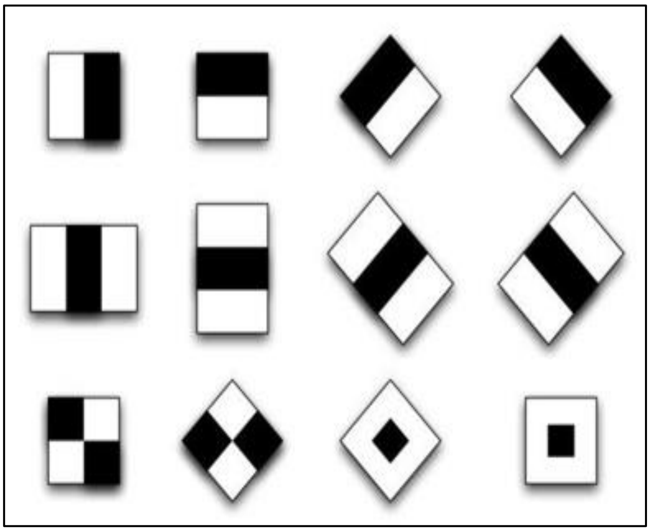

Fig 2: Haar-Like Features [5]

B. *Internal Images*

To speed up the computation of Haar-like features across the entire image, the algorithm utilizes integral images. An integral image efficiently stores the summed pixel values for all rectangular regions within the original image. This allows for calculating the feature value at any position with a simple lookup. The Viola-Jones algorithm, developed by Paul Viola and Michael Jones, doesn't directly utilize the concept of an internal image. The algorithm relies on features extracted fromthe image itself, such as Haar-like features, which capture basic variations in brightness and contrast within rectangular regions. These features are calculated efficiently and compared to pre-trained models to identify potential objects (like faces) in the image. There's no internal image representation created within the algorithm. It operates directly on the features derived from the original image [6].

IV. DROWSINESS DETECTION

Cars are being equipped with drowsiness detection systemsthat use cameras to monitor a driver's eyes, mouth, and head position for signs of fatigue, while also analyzing voice patterns for changes that indicate tiredness. Additionally, some systems employ advanced technologies like monitoring brainwaves and heart rhythms, analyzing facial wrinklepatterns, tracking steering wheel movements for unusual patterns, and even using special sensors to detect increased blinking or prolonged eye closure.

Brainwaves & Heartbeat (ECG & EEG): Fancy tech measures your brain activity and heart rhythm. When drowsy, these signals change, and the system can catch it.

- Facial Feature Forensics (LBP): This decodes tiny details in your face like wrinkle patterns. Drowsiness can alter these patterns, and the system flags it.
- Steering Wheel Snitch (SWM): How you handle thewheel can be a giveaway. The system monitors steering patterns. Shaky or sluggish movements might indicate fatigue.
- Eye on the Prize (Optical Detection): Special sensors track your eyes to see if you're blinking more often or closing them for longer stretches, both signs of drowsiness.[6].

V. REAL-TIME DRIVER DROWSINESS

A. Visual Object Tracking

Visual object tracking is key in computer vision for tasks like human-computer interaction and robotics. It involves estimating an object's location in each video frame based on its previous location. Traditional methods like Lucas-Kanade work well for medium-sized objects with small movements. Newer techniques like MOSSE filters are faster but less precise and limited to grayscale images. Li and Zhu improved MOSSE with color and scale features, while Danelljan et al. addressed deformation and scale changes. Deep learning approaches offer higher accuracy but require time-consuming training, hindering real-time applications. To address this, the proposed MC-KCF algorithm leverages a combination of deeplearning to overcome the limitations of correlation filters and enable real-time driver face tracking as mentioned in figure 3 [6].

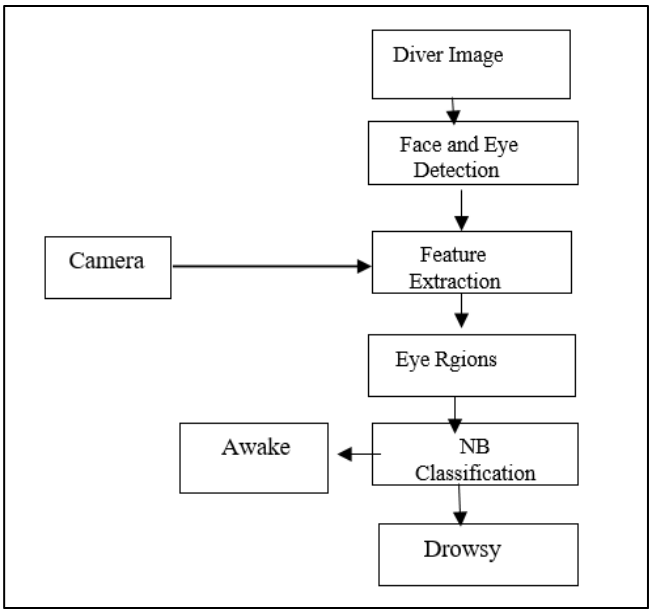

Fig 3: Flowchart [6]

B. Facial Landmark Detection

Facial key-point recognition aims to pinpoint crucial facial features like eyes, eyebrows, lips, and nose. Deep learning has revolutionized this field. Sun et al. introduced the first CNN-based method for fast detection of 5 key points. Zhou et al. improved accuracy by detecting 68 points with a more complex model, but it was computationally expensive. Wu. proposed a data-dependent approach for improved layer-wise CNN training, while Kowalski achieved high performance with the Deep Alignment Network, but this method also required a large, complex model. To balance accuracy and real-time performance, DriCare utilizes Dlib for facial key-point recognition.[7]

VI. YAWNING DETECTION

Instead of directly analyzing every pixel in an image, this mouth detection method relies on classifying images based on simple features. These features, inspired by Haar wavelets, capture variations in brightness and contrast within rectangular regions of the image. The system efficiently calculates these features using the "canny integral image." Despite having a large number of features, the system uses a special training algorithm (adaptation of AdaBoost) to select the mostinformative ones and combine them into a classifier. To speed things up, the system employs a cascade of these classifiers. Each classifier quickly rejects images unlikely to contain a mouth, minimizing the number of features analyzed for each image location. Finally, after identifying potential mouth regions, a grouping step refines these candidates into final detections. Each "weak classifier" in the cascade involves a specific feature, a threshold value, and a polarity indicating how the feature value should be compared to the threshold [8].

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VII. HEAD SHAKING AND NODDING

Head pose estimation, which determines a person's head orientation in 3D space, is crucial for analysing human behavior. It has applications like driver drowsiness detection. While 2D video is often used, resolving ambiguities in real-time is challenging. 3D data offers better results, but ideally, we want to estimate pose from regular videos (monocular images). The common approach is to use three rotation angles around different axes. Existing methods often focus on rotations around the vertical axis only [9]. This research proposes a new method for detecting driver drowsiness based on head nodding instead of relying on specific facial shapes. Traditionally, drowsiness detection used features like eyebrowshape, which require complex models and are time-consuming to set up. This approach focuses on the correlation between key facial features that change during nodding. The system analyses pre-labelled images of heads in "head-up" and "head- down" positions. It uses easily calculated parameters like distances between facial points and areas of triangles formed by key points. By analyzing these parameters in the image database, the system identifies thresholds that differentiate between "head-up" and "head-down" states. This allows the creation of a decision tree for real-time detection. Facial features are automatically extracted, and relevant points are used to determine head direction and drowsiness levels. In simpler terms, this method skips building complex facial shape models and focuses on analyzing how distances and areas between key points change during nodding to effectivelydetect drowsiness [10].

VIII. HARDWARE COMPONENTS

- PIC microcontroller: The brain of the system, responsible for processing signals and controlling the relay.
- Camera: Captures video of the driver's face.
- Buzzer: Generates an audible alert for the driver.
- Relay: An electronic switch that allows the microcontroller to control the vehicle's braking system (assumed).
- Two-axis Robot (optional): Potentially used to adjustthe camera's position for optimal viewing.

Software Requirements:

- Embedded C: A programming language for the PIC microcontroller.
- MATLAB: Software used to analyse video footage for drowsiness detection.
- Power Supply: A standard AC power supply is converted to a stable
- DC voltage using a transformer, rectifier, capacitor,and voltage regulator circuit. This DC voltage powers the entire system [11].

IX. TOOLS REQUIRED FOR DETECTION

Head pose estimation, which determines a person's head This project aims to detect driver drowsiness and take corrective actions. A camera mounted inside the vehicle focuses on the driver's face. Using MATLAB software, the system analyses the driver's eyes to detect signs of drowsiness.If drowsiness is detected, an alarm buzzer sounds to alert the driver. However, if the driver fails to respond to the buzzer,the system takes further action. A microcontroller unit (PIC) is used to control a relay, which in turn can automatically stop the vehicle.

X. RESULTS AND DISCUSSION

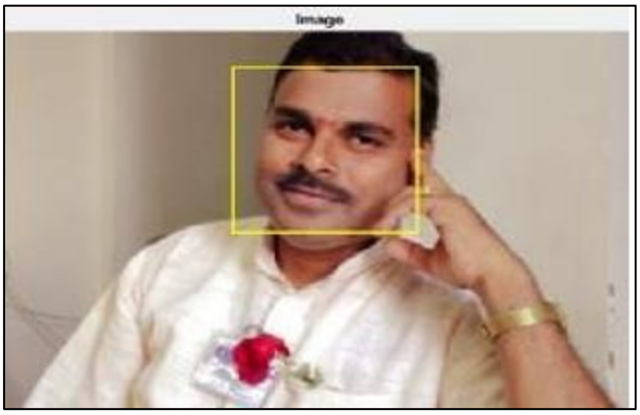

Fig 4: Detection of Face

Figure 4 shows the detection of faces using Viola Johns algorithm.

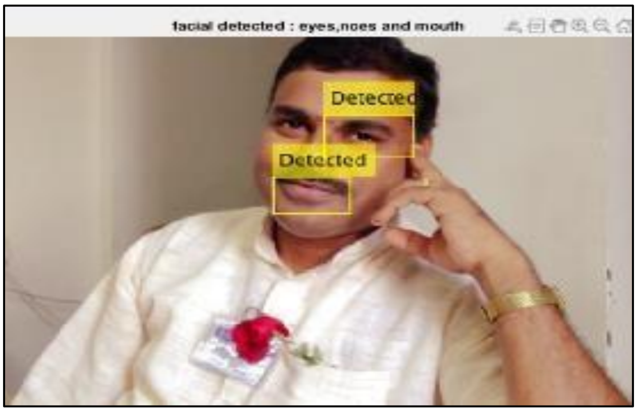

Fig 5: Detection of Eyes and Face

Figure 5 shows us the detection of eyes and mouth when the image is provided as input. It uses Viola Johns's algorithm to detect the features of the face.

Fig 6: Shows That the Driver is Alert

Figure 6 detects if the driver is alert or not. It counts the number of blinks in 10 seconds if the blinks are less than the threshold value then it indicates that the driver is alert.

Fig 7: Shows that the Driver is Drowsy

Figure 7 detects if the driver is drowsy as the blinks crosses the threshold value it alerts the driver to take a break.

XI. CONCLUSION

In this paper, we studied various driver drowsiness detection systems and technologies that hold immense potential for improving road safety. We examined approaches that facial features. While vision-based techniques show promise, the future of this field lies in unobtrusive sensors, robust multimodal detection that combines these approaches, and personalized calibration for improved accuracy. By addressing these areas, driver drowsiness detection systems have the potential to become a widespread safety feature,significantly reducing drowsiness-induced accidents.

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