JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Drivers Drowsiness Detection system using OpenCV

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Abstract: Drowsy driving poses a serious safety risk on the road, potentially resulting in accidents, injuries, and fatalities. This occurs when a driver becomes excessively fatigued or sleep-deprived, causing them to lose focus and alertness while driving. All drivers, regardless of age, are susceptible to drowsy driving, which can happen at any time of day. Contributing factors include lack of sleep, extended driving hours, shift work, and certain medications. Additionally, drowsy driving can be worsened by alcohol or drug use, as well as underlying medical conditions like sleep disorders. The impact of drowsy driving can be significant, with studies indicating that it may be involved in up to 40% of motor vehicle accidents. We set out to address this problem by creating a system that employs a mix of software and hardware to instantly identify and stop drowsy driving. We employed a camera to capture data on the driver's eye movements. We created algorithm to analyze this information instantaneously and identify patterns suggestive of drowsy driving. To notify the driver and avert a potential mishap, the system can take several steps if drowsiness is detected, including playing an alarm as well as displaying a warning message. This technology may play a significant role in lowering the prevalence of sleepy driving and improving road safety.

Keywords- Computer Vision, Driver drowsiness, Image processing, Eye detection

1. INTRODUCTION

Drowsiness, characterized by a state of sleepiness, can have catastrophic consequences, even if it lasts only for a few minutes [1]. The main cause of sleepiness, which lowers alertness and attention, is exhaustion. Lack of concentration, the use of medications, sleep difficulties, drinking alcohol, and shift work are further contributing factors. It might be difficult to forecast when sleep may overtake a person because tiredness is unexpected. Undoubtedly, it is perilous to fall asleep behind the wheel, but even being sleepy when awake can make driving less safe. Shockingly, it is estimated that one in twenty drivers has experienced falling asleep behind the wheel [2].

Long-haul trucks and bus operators with strenuous jobs lasting from ten to twelve hours are among the most susceptible to drowsy driving. These individuals not only endanger themselves but also pose a significant threat to other drivers on the road. Driving long distances while sleep-deprived or when one should be asleep can induce drowsiness, and in such cases, the driver's drowsiness is primarily responsible for any resulting accidents [3]. Police and hospital investigations have identified tiredness as a significant factor in roughly 100,000 auto accidents and more than 1,500 fatalities per year, as reported by the National Highway Traffic Safety Administration (NHTSA). Each year, it is estimated that driving while fatigued results in about 1,550 casualties, 71,000 injuries, and $12.5 billion in damages in terms of money [4]. 697 fatalities were caused by tired drivers in only 2019 alone. However, it is significant to highlight that correctly estimating the precise number of collisions and fatalities brought by sleepy driving is difficult, and the stated numbers are likely underestimates [5].

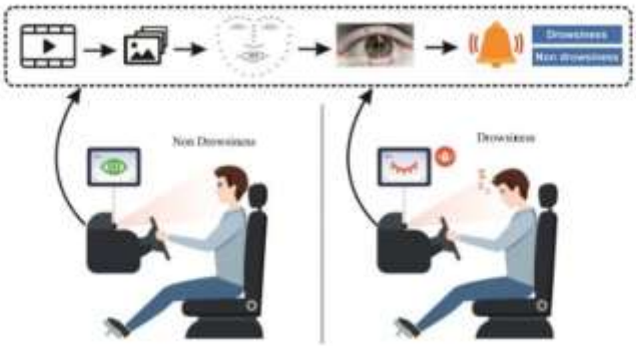

Fig A. Camera positioning

Fortunately, advancements in technology have made it possible to detect signs of drowsiness in drivers and provide timely warnings to prevent collisions. Drowsy drivers often exhibit symptoms such as frequent yawning, prolonged eye closure, and erratic lane changes. Extensive research has been conducted on methods to effectively identify driver drowsiness (DDD). To prevent accidents, researchers have proposed various approaches for early detection of drowsiness. In our research, the detection of drowsiness begins by identifying the driver's face, followed by analyzing the position and blinking pattern of the driver's eyes using a "Shape predictor including 68 landmarks" to assess facial features. To record facial landmarks and determine the position of the driver's eyes, a camera—typically a webcam—is pointed in their direction. In-house image processing is used in this procedure to examine faces and eye configurations. The system

locates the positions of the eyes, detects if the eyes are open or closed, and keeps track of the blinking frequency. An alarm is sounded to notify the driver after a set amount of time with closed eyelids. An open eye lowers the score, whereas a closed eye raises it, according to the system's scoring method. An alarm sounds to alert the driver if the score exceeds a predetermined level.
This study is divided into the following sections: a methodological part, explanation of the experimental findings, conclusion, and references.

2. LITERATURE REVIEW

In the quest to enhance the efficiency and speed of sleepiness detection, several strategies were implemented. This section focuses on the methods and techniques previously utilized to identify drowsiness. Analyzing driving patterns while considering variables like vehicle specifications, roadway conditions, and driving behavior is one strategy. Driving styles can be evaluated by counting the wheel movements and lane position variations [6][7]. To keep a car in its lane, one must consistently maintain control of the steering wheel. Krajewski et al. [6] observed a correlation between micro-adjustments and fatigue, achieving an 86% accuracy in detecting driver drowsiness. Another method involves monitoring lane deviation to infer tiredness by tracking and analyzing the vehicle's position relative to the lane [8]. However, driving pattern-based methods rely heavily on the specific vehicle, its driver, and the road circumstances.

An alternative set of method utilizing physiological data from detectors like electrocardiograms (ECG), electroencephalograms (EEG), and electrooculograms (EOG). EEG signals provide insights into brain activity, with delta, theta, and nascence signals being the primary indicators of driver fatigue. These signals typically increase whereas nascence signals alter very little when a driver is feeling sleepy. This method was determined to be extremely accurate by Mardi et al. [9], with a precision rate of more than 90 percent. However, its biggest disadvantage is that it is obtrusive, requiring the driver to wear several detectors, which could be uncomfortable. However, non-intrusive biometric signal systems are much less accurate.

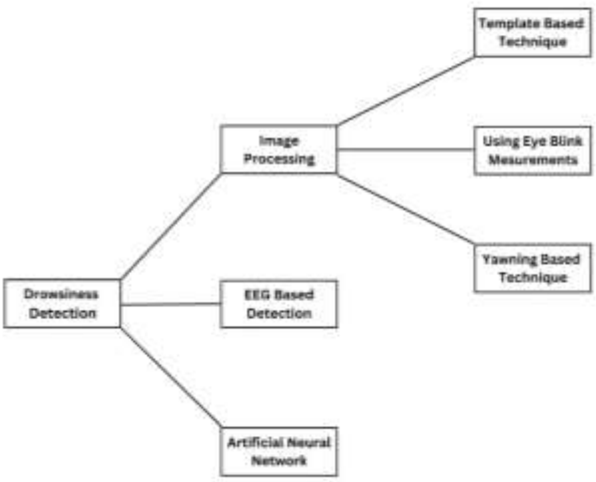

Fig B. Block Diagram

A. Images Processing Based Techniques:

Image processing-based techniques utilize drivers' face images to determine their state. By analyzing facial features, such as closed eyes or head nodding, researchers can determine if the driver is awake or dozing off. These techniques can be classified into three sub-categories.

- Template Matching Technique: In this technique, one can use the states of eye i.e. if driver closes eye/s for some time then system will generate the alarm because in this techniques system has both close and open eyes template of driver. This system can also be trained to get open and closed eye templates of driver.

Fig C. Open and Close eye template

- Eye Blinking Technique: In the eye-blinking technique, the rate of eye blinking and the duration of eye closure are measured to detect a driver's drowsiness. When a driver feels sleepy, their eye blinking pattern and the gap between their eyelids change from normal situations, making it easier to detect drowsiness. This system monitors the position of the irises and the state of the eyes over time to estimate the frequency of eye blinking and the duration of eye closure [5]. A remote camera is used to acquire video in this type of system, and computer vision methods are applied to locate the face, eyes, and eyelids positions sequentially to measure the ratio of closure [11]. By analyzing the ratio of eyelid closure and blinking, drowsiness of the driver can be detected.
- Yawning based technique: Fatigue can also be detected by analyzing the frequency of yawning, which is a common symptom. Typically, a yawn is characterized by a large vertical opening of the mouth. This opening is larger in yawning compared to speaking. By tracking the face and then the mouth, one can detect yawning. In a study [6], the researchers detect yawning based on the rate of mouth opening and the amount of change in mouth contour area, as shown in figure 3.

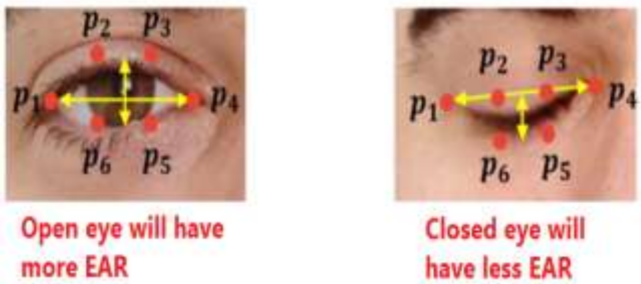

Fig. D, Landmarks of open and close eye [12]

B. Artificial Neural Network based technique: This technique involves using artificial neurons to detect driver drowsiness. However, using only one neuron is not as accurate as using multiple neurons. Some researchers [8] are investigating the optimization of driver drowsiness detection using Artificial Neural Network. Fatigued individuals exhibit certain visual behaviors that can be easily observed, such as changes in facial features like the eyes, head, and face. These visual behaviors, including eyelid movement, gaze, head movement, and facial expression, can reflect a person's level of fatigue. To utilize these visual cues, an artificial neural network is developed to detect drowsiness. The system was tested and achieved a 96% accuracy rate. Figure 5 illustrates the flow of how the artificial neural network system can detect drowsiness.

3. METHODOLOGY

The method we've developed involves identifying facial characteristics including face posture and eye blinking [11]. Here, the driver's condition is evaluated by counting the number of eye blinks. Normally, the average duration of an eye blink is between

0.1 to 0.4 seconds, resulting in at least 2 to 3 blinks per second. However, the blink count falls below normal levels when a motorist is fatigued, which enables us to spot the fatigued driver. According to our concept, a camera would be placed in the vicinity of the driver's face in order to monitor facial expressions and eye blinking. The system first recognizes the face [10] and then uses open cv to recognize the 68 facial landmarks to capture the eye closing process. To assess if the eyes are open or closed, the Euclidean eye aspect ratio is used.

By utilizing these many techniques, we hope to increase the precision and potency of sleepiness detection techniques, opening the door for more dependable systems to lessen the dangers of drowsy driving.

A = distance.euclidean(eye[2], eye[6])
B = distance.euclidean(eye[3], eye[5])
C = distance.euclidean(eye[1], eye[4])
EAR = (A+B)/(2.0*C)

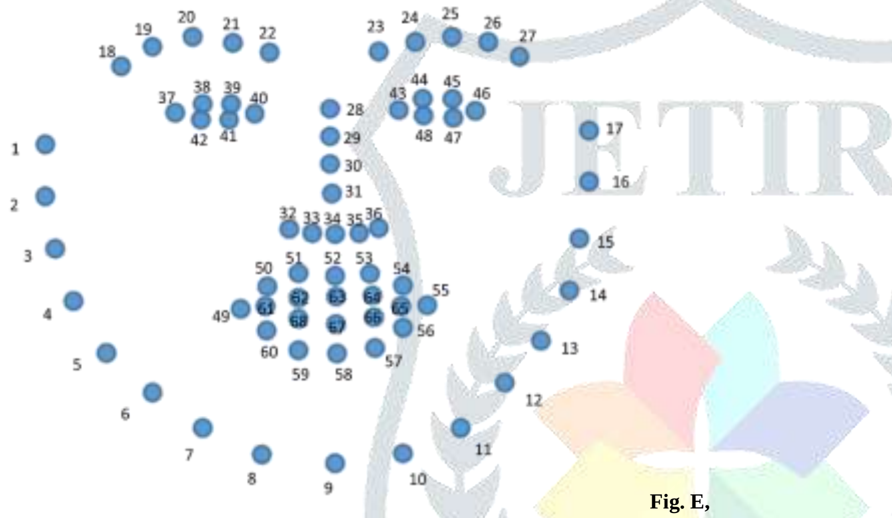

Fig. E, dlib face recognition points [12]

After successfully detecting the eyes, the system proceeds to determine their state, specifically if they are open or not. If the eyes are found to be closed, the alarm will continue to sound until they are opened, as determined by the scoring mechanism that checks whether the score surpasses the predefined threshold. If the driver's eyes remain open, the system will actively track them, ensuring continuous monitoring of their alertness level.

The overall architecture of the model is straightforward and user-friendly. To operate the model, all that is required is capturing the driver's face through a camera, enabling the alarm to be set off based on the system's measurement of the eyes' blink rates [13][14][15]. The development of the Driver Drowsiness system incorporates non-intrusive machine vision-based techniques. A webcam focuses on the driver's face, identifying its presence, and then narrows its attention to the eyes, determining whether they are closed or open. The system closely monitors the eyes for signs of fatigue [36][37]. If weariness is detected, the driver receives a warning signal, prompting them to take necessary corrective actions [16][17][18].

For sleepiness detection, Python is used. The system specifically deals with facial features, utilizing a webcam placed in front of the driver's face to record video input. OpenCV, with the assistance of 68 facial landmarks, is employed to identify the face and eyes. The Euclidean eye aspect ratio is then utilized to ascertain whether the eyes Python is used to detect tiredness. The system focuses on facial features and records video information using a webcam that is set up directly in front of driver face. 68 facial landmarks are used in conjunction with OpenCV to recognize the face and eyes. The next step is to determine if the eyes are open or closed using Euclidean eye aspect ratio [38][39]. When the specified time interval for the driver's eyes to be closed is less than the prescribed interval, the system analyses the driver face and eye and sounds an alarm. The device keeps track of the driver's eyes if they are open [19][20][21].
PERCLOS (Percentage of Eyelid Closure over the Pupil over Time), which analyses progressive eyelid closures rather than individual blinks, is also incorporated into the model. In order to decide when to sound the alarm, the system uses PERCLOS scoring [33][34][35].

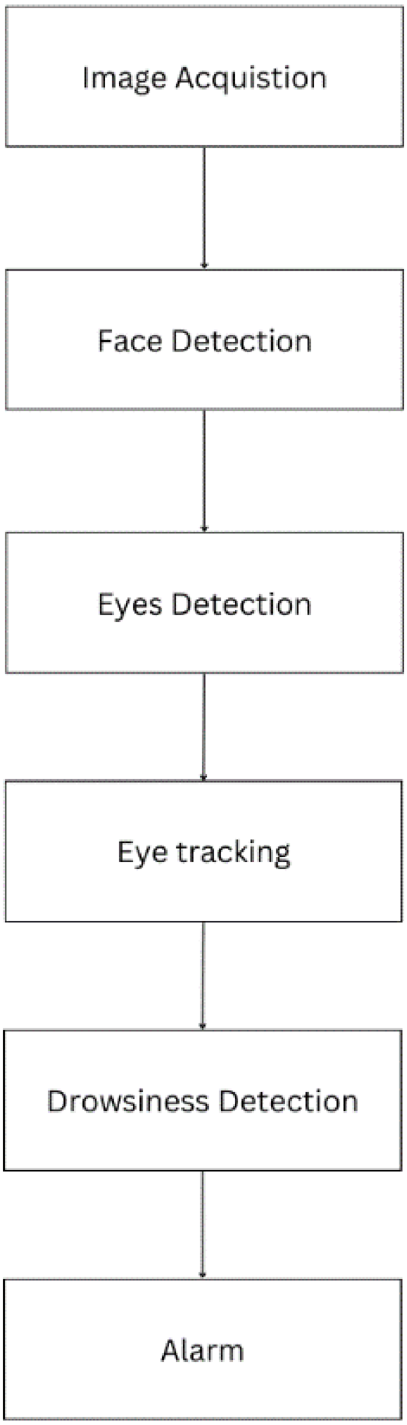

Fig. F Block diagram of the algorithm

The implementation of the model involves importing several libraries, including:

- CV2: OpenCV is a free and open-source library for image processing, computer vision, and machine learning. It makes it possible to analyze photos and movies to find individuals, objects, and more. [22][23][24].

- OS: In order to interface with operating system and easily access OS-specific functionality, the Python OS module is used. [25][26][27].
- Keras: a TensorFlow-compatible a high-level neural networks library written in Python. It prioritizes user experience and has gained widespread industry adoption. It can operate on both CPU and GPU. [28][29][30].
- NumPy: An array-related Python module containing matrices and linear algebraic operations. It is frequently used for mathematical calculations. [31][32].
- Pygame: A Python cross-platform library used for creating video games. It includes music and graphic design features for game development [31][32].
- Matplotlib: A Python library for low-level graph plotting that is mostly used to display graphs and produce data visualizations [33][34]. These libraries play crucial roles in implementing the various functionalities and analyses required for the driver drowsiness detection system.

4. RESULT

The primary method used for feature extraction in image analysis is through facial landmarks. These landmarks are a specific subset of the shape predictor problem, enabling the localization of various areas of interest of face, like nose, the eye and the mouth. Within the dlib library, a face-landmark detector is available, capable of identifying 68 (a, b) coordinates that correspond to these landmarks.

The entire test was run ten times with various parameters, including several drivers, lighting conditions, and alarm sensitivity. The testing criteria used to judge accuracy are displayed in the table below. The tests sought to evaluate the project's overall correctness by applying the formula below:

$$A = (B/C) \times 100\%$$

Here, A represents the correct rate, B denotes the number of successful tests, and B represents the total number of tests conducted. Out of the ten tests, nine were executed successfully and yielded accurate results. However, two tests encountered difficulties due to poor lighting conditions at night, resulting in failure. Consequently, the overall accuracy of the project is approximately 90%.

It is important to note that the lighting conditions during the experiments significantly influenced both the accuracy and output of the drowsiness detection system. The primary factor influencing these outcomes is the brightness of the light. Therefore, based on our project's average, the accuracy achieved is 90%.

Fig G. Eye detection with open eyes

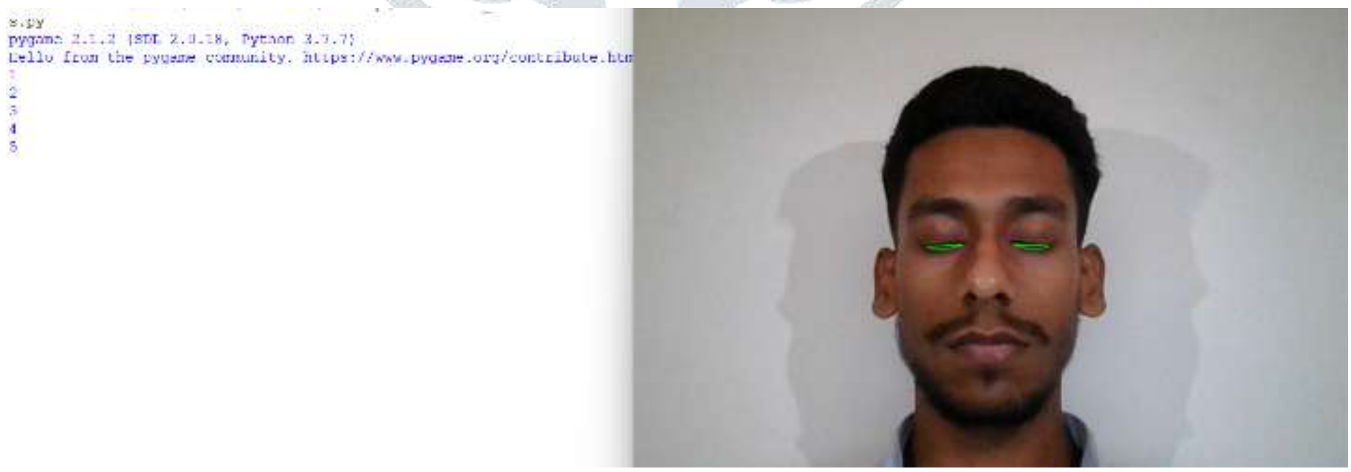

Fig H. Eye detection with close eyes

Fig I. Alarm played, and warning message displayed

INDIVIDUAL	EAR THRESHOLD	ALARM SENSITIVITY	LIGHT	REMARKS	DROWSINESS DETECTION ALARM
A	0.2	48	Bright	Normal	3 out of 3
A	0.2	48	Dim	Normal	3 out of 3
A	0.2	48	Bright	Wear sunglasses	0 out of 3
B	0.25	43	Bright	Normal	3 out of 3
B	0.25	43	Dim	Normal	3 out of 3
B	0.25	43	Dim	Rainy weather	2 out of 3
C	0.22	48	Bright	Wear glasses	3 out of 3
C	0.22	48	Dim	Wear glasses	3 out of 3
C	0.22	48	Very Dim	Night drive	1 out of 3
C	0.22	48	Very Dim	Normal	3 out of 3

5. CONCLUSION

The driver drowsiness detection system technology serves as a crucial vehicle safety measure aimed at preventing accidents and injuries caused by drowsy drivers. Early detection and timely alerts are essential in avoiding potentially fatal incidents. The suggested system detects the size of a driver's eye using there Aspect Ratio, which assesses the level of tiredness, in order to estimate how much sleep the driver has. Through the collection of data on Eye Aspect Ratio, a threshold value is established to identify instances of driver fatigue. An alarm-based alert

system is implemented to notify the driver in such situations. By incorporating this technology into vehicles, we can significantly enhance road safety by mitigating the risks associated with drowsy driving. It provides a proactive solution to address the serious consequences that arise from driver fatigue, potentially saving lives and preventing accidents. Further research and development in this field can lead to advancements in detecting additional

indicators of drowsiness, such as yawning, to improve the accuracy and effectiveness of the system. It is imperative for both vehicle manufacturers and drivers to recognize the importance of driver drowsiness detection systems and prioritize their implementation. By doing so, we can create safer road environments and minimize the tragic consequences resulting from drowsy driving incidents.

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