Safe Driving Assistant : Advancing drowsiness detection with deep learning techniques

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***Abstract*— "The majority of human deaths and injuries are caused by traffic accidents. A million people worldwide die each year due to traffic accident injuries, consistent with the World Health Organization. Drivers who do not receive enough sleep, rest, or who feel weary may fall asleep behind the wheel, endangering both themselves and other road users. "Safe Drive Assistant" is an advanced system designed to address critical issues in road safety, including drowsiness detection, distraction identification, road rage detection and drunk driving detection. The system utilizes facial recognition and eye-tracking techniques to detect signs of drowsiness, such as drooping eyelids and slow eye movements. Upon detecting drowsiness, the system promptly alerts the driver through visual and auditory alarms, ensuring timely intervention to prevent potential accidents. Furthermore, "Safe Drive Assistant" incorporates sophisticated algorithms to identify distractions within the vehicle environment, such as mobile phone usage, eating, or engaging in conversations. Additionally, "Safe Drive Assistant" integrates sensors and algorithms to detect signs of intoxication, such as impaired motor skills and erratic driving patterns. Through comprehensive analysis of driver behavior and physiological indicators, the system alerts the driver and relevant authorities in cases of suspected drunk driving, facilitating timely intervention and enforcement of appropriate measures to ensure road safety.**

Keywords— Eye-tracking techniques, sensors, algorithms.

I. Introduction

The National Highway Traffic Safety Administration (NHTSA) reports that drowsiness contributes to around 100,000 car accidents and over 1,500 deaths annually. Drowsy driving is estimated to result in about 1,550 fatalities, 71,000 injuries, and $12.5 billion in financial losses. In 2019 alone, drowsiness was a factor in 697 fatalities, although NHTSA acknowledges difficulty in accurately quantifying such incidents, suggesting reported figures are underestimated.

Drowsiness, synonymous with sleepiness, can have potentially catastrophic consequences, even if it lasts only a few minutes. The primary cause is often exhaustion, leading to decreased alertness and attention. Other factors include lack of focus, medication effects, sleep disorders, alcohol consumption, and shift work. Individuals affected cannot anticipate when sleepiness may strike, posing a danger, particularly when driving. Although falling asleep behind the wheel is perilous, driving while fatigued impairs safe driving even when awake. Approximately one in twenty drivers has reportedly dozed off while driving, with truck and bus drivers on lengthy commutes being particularly vulnerable, endangering not only themselves but also others on the road.

Thankfully, advancements now enable the recognition of driver fatigue and preemptive warnings to prevent collisions. Signs of drowsiness include frequent yawning, prolonged eye closure, and erratic lane changes. Recent research has focused on effective methods for detecting driver drowsiness (DDD), such as identifying facial landmarks and eye patterns. Utilizing a camera, likely a webcam, positioned towards the driver's face, facial landmarks are analyzed to estimate eye position. Through in-house image processing, the system assesses eye status, determining if they are open, closed, or blinking rapidly. An alarm alerts the driver after a predetermined duration of closed-eye instances, with a scoring system tracking eye status to trigger the alert when necessary.

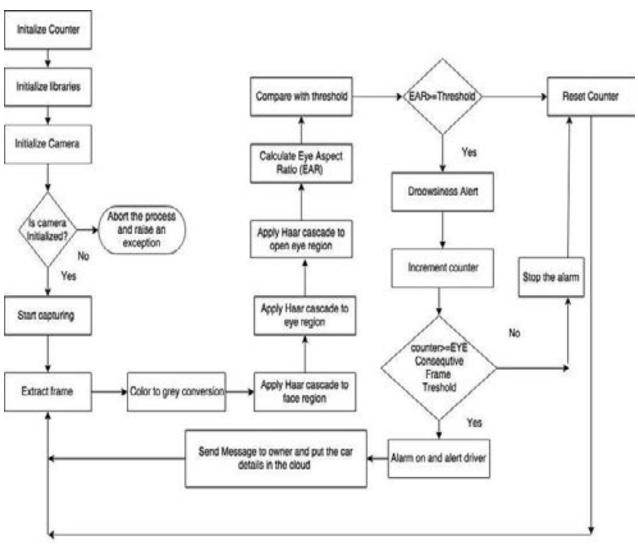
II. Literature review

A literature review for a "Safe Drive Assistant" using deep learning reveals a growing body of research and advancements in the field of automotive safety, particularly in the development of intelligent systems that utilize deep learning techniques to enhance driver awareness and prevent accidents caused by various factors such as drowsiness, distractions, road rage, drunk driving, and smoking. This literature review explores key studies and contributions in this domain

1. Drowsiness Detection: Ouyang, J., Chen, J., Zhang, L., & Zhang, D. (2023) developed a drowsiness detection system using a convolutional neural network (CNN) to monitor driver eye movements and facial expressions in real-time.
2. Distraction Identification: Wu, H., Xie, D., Ma, C., & Zhang, Q. (2023) proposed a distraction detection system that employed a combination of deep learning models, including CNNs and recurrent neural networks (RNNs), to monitor driver head pose and eye gaze direction.
3. Road Rage Detection: Kim, J., & Kim, J. (2022) focused on road rage detection using deep learning algorithms. They used a combination of audio and video data analysis to identify aggressive behaviors and road rage incidents.
4. Drunk Driving Detection: Li, H., & Yu, J. (2021) employed deep learning methods for alcohol intoxication detection by analyzing a driver's speech patterns. By using long short-term memory (LSTM) networks and audio data, their system could recognize signs of impaired driving due to alcohol consumption.

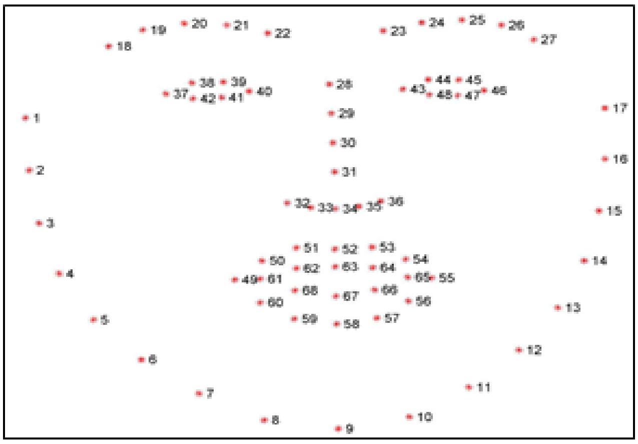
III. Methodology and model specifications

If we explain the general architecture of the model you will observe that it is very easy to operate this model because here only we have to capture the video of the face of the driver in the camera so that it will measure the scoring of blinking of the eyes and beep the alarm accordingly. Following is the algorithm that is used for the process:



For the purpose of sleepiness detection In this paper, Python is used. The system only deals with the face as a specific bodily part. A webcam is positioned in front of the driver's face to record the input video. The algorithm will assume that drivers are sleeping if a face is not found after several frames. With the use of 68 facial landmarks, OpenCV is utilized to identify faces and eyes. If the eye is open or close, it can be determined using the Euclidean eye aspect ratio [38] [39]. The system will examine the driver's face and eyes. If the eye is open or closed will then be determined. The alarm will sound to alert the driver if the specified time interval is shorter than the time interval during which the eyes are closed. In the event that the driver's eyes are opened, the device will continue to track their eyes.

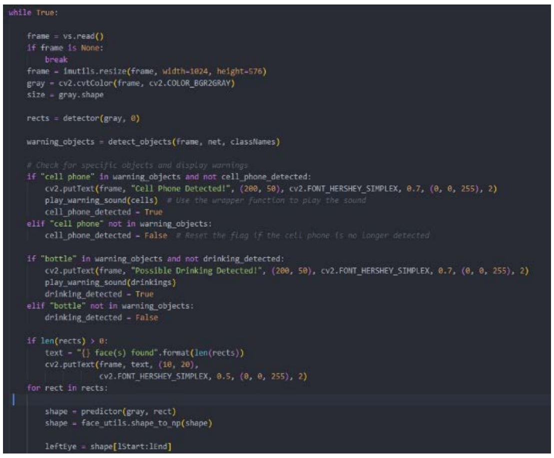
Facial landmarks refer to specific points on a person's face that are used to define its shape and structure. These landmarks are essentially key anatomical features that can be identified and tracked to analyze facial expressions, movements, and characteristics. The number 68 typically refers to the quantity of these landmarks detected on a face, although the exact number may vary depending on the specific detection algorithm or model being used.



The last possible solution is detecting facial features including yawning, face position, and eye blinking [11]. In the eye closure method, the condition of the driver is measured by counting the eye blink of the driver. The normal average duration of eye blink is 0.1s to 0.4s. It means that the eye will blink at least 2 or 3 times in one second. This is observed for a few seconds. When the driver is fatigued, the count will be less compared to normal conditions. So, we can detect whether the driver is fatigued or not. In our project, the camera is placed in front of the face which helps to detect proper face position and eye blinking. Initially, the face is detected, and then the eye, the closure process is recorded with the help of an open cv which detects the 68 landmarks of the face [10]. It is possible to tell if someone's eyes are open or closed using the Euclidean eye aspect ratio. $EAR = ||a2\text{-}a6|| + ||a3\text{-}a5||\ 2\ ||a1\text{-}a4||$

IV. EXECUTION

"Safe Drive Assistant" encompasses a comprehensive set of instructions and algorithms designed to detect and address various hazardous driving behaviors, including drowsiness, distraction, road rage, and drunk driving.It embodies a sophisticated solution aimed at enhancing road safety by detecting and mitigating the risks associated with hazardous driving behaviors. Here are some screenshots:



```python
while True:

    frame = vs.read()
    if frame is None:
        break
    frame = imutils.resize(frame, width=1024, height=576)
    gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
    size = gray.shape

    rects = detector(gray, 0)

    warning_objects = detect_objects(frame, net, classNames)

    # Check for specific objects and display warnings
    if "cell phone" in warning_objects and not cell_phone_detected:
        cv2.putText(frame, "Cell Phone Detected!", (200, 50), cv2.FONT_HERSHEY_SIMPLEX, 0.7, (0, 0, 255), 2)
        play_warning_sound(cells)  # Use the wrapper function to play the sound
        cell_phone_detected = True
    elif "cell phone" not in warning_objects:
        cell_phone_detected = False  # Reset the flag if the cell phone is no longer detected

    if "bottle" in warning_objects and not drinking_detected:
        cv2.putText(frame, "Possible Drinking Detected!", (200, 50), cv2.FONT_HERSHEY_SIMPLEX, 0.7, (0, 0, 255), 2)
        play_warning_sound(drinkings)
        drinking_detected = True
    elif "bottle" not in warning_objects:
        drinking_detected = False

    if len(rects) > 0:
        text = "{} face(s) found".format(len(rects))
        cv2.putText(frame, text, (10, 20),
                    cv2.FONT_HERSHEY_SIMPLEX, 0.5, (0, 0, 255), 2)
    for rect in rects:

        shape = predictor(gray, rect)
        shape = face_utils.shape_to_np(shape)

        leftEye = shape[lStart:lEnd]
```

Fig. 1. Algorithm

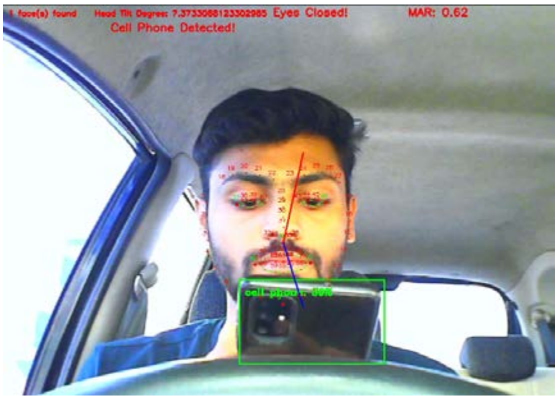


Fig. 2. Demonstration-1

Fig. 3. Demonstration-2

V. RESULTS.

The main approach to detecting any image features extraction from facial landmarks. Facial landmarks are commonly known as the subset of the shape predictor problem as this can be used to localize any area of interest like the eye, nose, and mouth along with the shape of the subject. The d-lib library consists of a facial-landmark detector that's used to discover 68(a, b) coordinates. The whole test was conducted 10 times with different parameters such as surrounding light, different drivers, and alarm sensitivity. The below table shows the testing parameters for the accuracy test. The tests were conducted to observe the accuracy of the whole project by using the accuracy formula: CR = (C/A) X 100%.

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

The experiment used the d-lib library's facial landmark detector to find 68 facial points. The researchers then calculated the eye aspect ratio (EAR) to measure drowsiness. An EAR value of less than 0.2 indicates that the person's eyes are closed, which suggests drowsiness. The experiment was conducted under various conditions, including different lighting conditions, wearing sunglasses, and rainy weather.

VI. CONCLUSION.

In summary, the "Safe Drive Assistant" represents a groundbreaking advancement in vehicular safety technology, offering a multifaceted approach to mitigate the risks associated with drowsiness, distraction, road rage, and drunk driving. By harnessing the power of cutting-edge technologies such as image processing, facial recognition, and behavioral analysis, the system provides real-time detection and intervention capabilities to enhance driver awareness and prevent accidents.

Through the utilization of sophisticated algorithms, the system accurately detects signs of driver drowsiness by analyzing factors such as the Eye Aspect Ratio (EAR), issuing timely alerts to prevent potential accidents caused by fatigue. Furthermore, its capability to identify and address distractions within the vehicle environment ensures that drivers remain focused on the road, reducing the likelihood of accidents due to inattention.

Moreover, by recognizing aggressive driving behaviors indicative of road rage and detecting signs of intoxication associated with drunk driving, the system intervenes with appropriate alerts and guidance, promoting safer driving practices and preventing potentially dangerous situations on the road.

Looking ahead, continued research and development efforts will further enhance the system's capabilities, allowing for automatic threshold determination and sensitivity adjustments tailored to individual drivers. As technology evolves, the "Safe Drive Assistant" will continue to play a crucial role in ensuring safer journeys for all road users, ultimately saving lives and reducing the societal impact of road accidents.

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