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Driver Drowsiness Detection System

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ABSTRACT: Driver drowsiness is a significant factor contributing to road accidents, leading to severe injuries and fatalities. This project proposes a web-based Driver Drowsiness Detection System that utilizes computer vision and machine learning techniques to monitor a driver's alertness in real time. The system captures facial features using a webcam, analyzing eye closure duration, yawning frequency, and head position to detect signs of drowsiness and distracted driving.

If drowsiness is detected, the system triggers an alert mechanism (such as an alarm or visual warning) to wake the driver. This system aims to improve road safety by reducing driver fatigue-related accidents, offering a cost-effective and accessible solution for both individual drivers and transportation industries. Additionally, the platform includes a secure user dashboard to record historical alerts and track driver statistics over time.

KEYWORDS: Driverdrowsiness,eyedetection,yawndetection,fatigue,computervision,MediaPipe,Eye Aspect Ratio, Mouth Aspect Ratio, Distracted Driving.

I. INTRODUCTION

Roadaccidentscausedbydrowsydrivingareagrowingconcernworldwide,leadingtosevereinjuries,fatalities, andeconomiclosses. Studies indicate thatdriverfatiguecontributestoasignificantpercentageoftrafficaccidents, especiallyonhighwaysandduringlong-haultransportation.Severalreal-worldincidentshighlightthedevastating impact of drowsiness behind the wheel, emphasizing the need for an effective solution to detect and prevent fatigue-related crashes.

AccordingtotheU.S.NationalHighwayTrafficSafetyAdministration(NHTSA),drowsydrivingisresponsiblefornearly100,000roadcrashesand1,500deathsannually[1].Fatigue-relatedaccidentsoccurduetolackofsleep, long driving hours, alcohol consumption, and mental stress. Reports indicate that human error accounts for 94% of all accidents, emphasizing the need for automated driver fatigue detection systems [2]. A study in China revealedthatdrowsinesscontributedto8.1% oftotalhighwaycollisionsin2003, whiletheSocietyofAutomotive Engineers (USA) states that 1 in 8 road deaths is linked to driver drowsiness [3]. In Bangladesh, 4,580 fatalities occurredduetoroadaccidentsin2018,markinga7%increasefrom2017[4].InIndia,althoughspecificdataon driver fatigue-related accidents has been limited since 2017, earlier statistics indicate that in 2015, there were 3,081 accidents due to sleep, fatigue, or sickness of the driver, resulting in 706 fatalities and 3,383 injuries [5].

Sleepconsistsofthreemainstages:Wakefulness,Non-RapidEyeMovement(NREM),andRapidEyeMovement (REM). The first stage of NREM is the transition from wakefulness to sleep, commonly known as the drowsy state, where micro-sleeps and unconscious transitions occur. Studies suggest that drowsiness-related accidents often happen between 12AM to 7AM and during mid-afternoon hours [6]. Fortunately, it is possible to detect driver drowsiness in its earlystages and alarm the driver toavoid any potential accident.Drowsy drivers exhibit various signs, which include repeated yawning, frequent eye closure, and repeatedly departing street lanes.[7]

To address this issue, Driver Drowsiness Detection Systems utilize Computer Vision andArtificial Intelligence (AI)tocontinuouslymonitoradriver'sfacialexpressionsand behavioralpatterns.Byanalyzingeyemovements, blink rate, yawning frequency, and head position, the system can determine signs of fatigue. If drowsiness is detected, an alert mechanism is triggered to wake the driver and reduce the risk of accidents.

This research paper focuses on the development of a web-based Driver Drowsiness Detection System using Machine Learning and OpenCV.The proposed system aims to provide a cost-effective andefficient solution for improving road safety.

In this study, we propose a comprehensive, real-time Driver Drowsiness and Distraction Detection System. Our approach utilizesOpenCVand Google's MediaPipe Face Mesh to continuously processentire real-time webcam video frames. By extracting precise facial landmarks, the system calculates the Eye Aspect Ratio (EAR) for objective blink rate analysis and MouthAspect Ratio (MAR) for yawning frequency detection. Furthermore, we integratedheadposeestimation(PitchandYaw) todetectdistracteddrivingbehaviors,suchasthedriverlooking away from the road [8].

Unlike traditional standalone scripts, our solution is deployed as a full-stack web applicationbuiltwithReactandFlask.ItutilizesaFirebasedatabasetoprovideasecureuserdashboard,enabling drivers and fleet managers to track historical drowsiness alerts and driving statistics seamlessly [8].

To systematically evaluate stages of drowsiness and facilitate the development of automatic early drowsiness detection systems, a precise measurement scale for drowsiness levels is necessary. Many methods have been proposedinthatdirection.OneofthewidelyusedscalesintheliteratureistheKarolinskasleepinessscale(KSS) [11,12,13]. Shahid et al. define KSS as “a scale that measures the subjective levels of sleepiness at a particular time during the day” KSS is a nine-point scale that measures drowsiness through verbal descriptions of drivers [11]. The nine KSS scores are summarized in table 1.

Karolinskasleepinessscale,adaptfrom[11].

Scale	Verbal Description
1	Extremelyalert
2	Veryalert
3	Alert
4	Fairlyalert
5	Neitheralertnorsleepy
6	Somesignsofsleepiness
7	Sleepy,butnoefforttokeepalert
8	Sleepy,someefforttokeepalert
9	Verysleepy,greatefforttokeepalert

Wierwille and Ellsworth proposed another drowsiness evaluation scale [21].They definedrowsiness stages on a five-levelscale,asshowninTable2.AccordingtoSaitoetal.,atlevelone,rapideyemovementandastableeye blinkingperiodcanbe observed [22].At level two, slow eye movement occurs.The driver may touchhisface at levelthree,aswellasyawnandslowlyblink.Asforlevelfour,thedriver’sunnecessarymovementsareobserved; he frequently yawns, blinks more, and breathes deeply. Finally, the eyes are almost closed at the fifth level, and the head nods.

This scale is also widely used because these levels are determined based on analyzing the driver’s facial expressions. When comparing this scale results with the subjective reports of the drivers, they show a high correlation, which indicates that this evaluation scale could be an alternative to the KSS scale [22,23].

II. LITERATURE REVIEW

Drowsy driving is one of the common causes of fatalities in car accidents. Truck drivers that travel for lengthy periods of time (especially at night), long-distance bus drivers, and overnight bus drivers are more vulnerable to thiscondition.Passengersineverycountryfacethenightmareofdrowsydrivers.Fatigue-relatedtrafficaccidents result in a substantial number of injuries and deaths each year.As a result, due to its wide practical application, detectingandindicatingdriverdrowsinessisahottopicofresearch.Driverdrowsinessisdefinedasthedetection of any abnormal change in these parameters. Nonintrusive driver tiredness detection uses cameras to analyze behaviors like blinking, yawning, and head movement.[9]

Severalfactors,includingthedrivers'age,maritalstatus,annualmileage,numberofdailytrips,andordinaryand aggressive infractions, were found to impact accident involvement in the study.[10].

III. DROWSINESS DETECTION TECHNIQUES

Overtheyears,researchershaveproposedvarioustechniquestomonitordriverfatigueusingnonintrusivecamerafeeds.Thesemethodsareprimarilycategorizedbasedonthespecificfacialfeaturestheytrack,suchaseyestates, head postures, and mouth movements.Abrief review of the major detection categories used in recent studies is discussed below.

A. EYEBLINK IN GBASE DTECHNIQUES

Inthiseyeblinkingrateandeyeclosuredurationismeasuredtodetectdriver'sdrowsiness.Becausewhendriverfeltsleepyatthattimehis/hereyeblinkingandgazebetweeneyelidsaredifferentfromnormalsituationssotheyeasilydetectdrowsiness.Inthissystemthepositionofirisesandeyestatesaremonitoredthroughtimetoestimateeyeblinkingfrequencyandeyecloseduration.[14].Andinthistypeofsystemusesaremotelyplacedcamerato acquire video and computer vision methods are then applied to sequentially localize face, eyes and eyelids positions to measure ratio of closure.[15]. Using these eyesclosure and blinking ratio one can detect drowsiness of driver.

B. FACE BASED TECHNIQUES

Teyeb et al. [18] proposed the Drowsy Driver Detection using Eye Closure and Head postures. Firstly, video is capturedusingwebcamandforeachframeofvideo,followingoperationsareperformed.TodetecttheROI(face and eyes), viola-jones methodisused.The face ispartitionedin tothree areasand thetopone presenting theaye area is browsed bythe Haarclassifier.Then todetect theeyestate,Wavelet Network basedonneuralnetworkis used to train the images then the coefficients learning images is compared with the coefficients of the testing images and tells which class it belongs. When the closed eye is identified in the frames then the eye closure duration is calculated, if the value exceeds the pre-defined time then the drowsiness state is detected. Then the developed system estimates the head movementswhich are:left, right, forward,backwardinclination and leftor right rotation. The captured video is segmented into frames and extract the images of head and determines the coordinates of image.Then the images are compared to determine the inclined state of head and same case with otherheadpostures.Finally,thesystemcombinestheeyeclosuredurationandheadpostureestimationtomeasure thedrowsiness.To evaluatethesystem,experimentisperformed on10volunteersin varioussituations.And results show that the systems achieve the accuracy of 80%

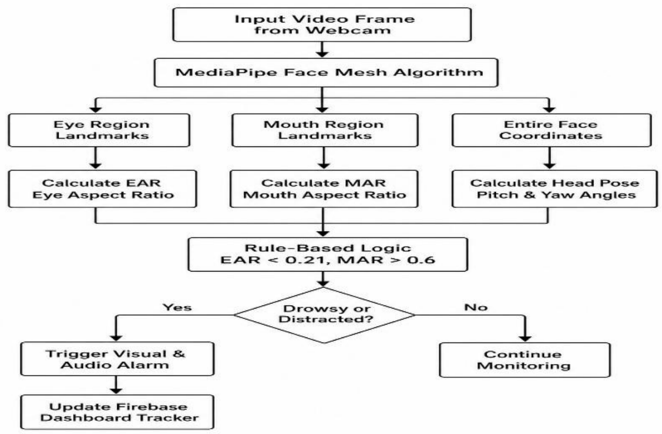
C. YAWNING BASED TECHNIQUES

This technique involves calculating the Mouth Aspect Ratio (MAR), which is the ratio of the vertical distance between the upper and lower lips to the horizontal distance between the mouth corners. By monitoring changes in the MAR, the system can detect when the driver's mouthis open, indicating a yawn.An increase in the MAR beyond a certain threshold signifies a yawning event.[16] Advanced systems employ Convolutional Neural Networks (CNNs) to analyze visual data and detect yawning. These models are trained on datasets containing images of yawning and non-yawning individuals, enabling the CNN to learn distinguishing features associated withyawning.Thisapproachallowsforreal-timedetectionofyawningbyprocessingvideoframescapturedfrom in-vehicle cameras.[17]

When the MAR exceeds the threshold, it means the driver has yawned. In this way, the system analyzes video frames to detect the driver's drowsiness.

IV. SYSTEM ARCHITECTURE

ThesystemuseswebcaminputandMediaPipetoextractfacialfeatures.EAR,MAR,andheadposearecomputed to detect drowsiness, triggering alerts and updating the dashboard[8].



V. COMPARATIVE STUDY OF DROWSINESS DETECTION

The number of motor vehicles has increased steadily in emerging countries during the last ten years. Traffic accidentreportsindicatethatriskydrivingbehaviours,suchasdrunkendrivingorfatigueddriving,areresponsible formostaccidents.Accordingto studies,sleepy driving isacontributing factor in20%ofallaccidents.Drowsiness is a condition when the level of consciousness is lowered as a result of fatigue or sleep deprivation, and it can make a driver fall asleep silently. Drowsy driving results in a loss of control by the driver, which can cause the vehicle to drift off the road, hit an obstacle, or overturn.

In order to extract and synthesize the methods and features that have been utilized in the drowsiness detection process, past studies have conducted Systematic Literature Reviews (SLR).According to comparative analyses, the mostusedfeaturesarefacialexpressionslike yawning,closing ofthe eyes,andheadmotions.Theseinsights show that techniques ranging from Eye Aspect Ratio (EAR) and Haar Cascades, to Support Vector Machines (SVM) and facial landmark libraries (like dlib and MediaPipe) are frequently utilized [19].

With the improvement in ComputerVision technologies, various intelligent systems are developed to determine drowsiness. For instance, some previous studies [20] suggested frameworks utilizing Viola-Jones detection algorithms combined with deep convolutional semantic networks to extract active features. While deep learning offers strong results, it often requires high processing power. This paper provides a comparative assessment between traditional deep-learning methods and real-time geometric-based fatigue detection systems.

Aconcisesummaryofthemajortechnologiescomparedinrecentdetectionsystemsincludes:• EyeAspectRatio (EAR):Monitors eye closure by calculating accurate geometric distances between eye landmarks; a decreasing EARdirectlyindicatesdrowsiness.• MouthAspectRatio(MAR):Analyzestheratiooflipdistancestoprecisely detect yawning frequency in real-time.

- MediaPipe&dlib Libraries: Provides robust facial landmark tracking (like 468 facial points) to monitor eye, mouth, and head orientations instantly.
- DeepLearning&SVMs:Employsheavyneuralnetworkstoclassifycomplexbehavior,offeringhighaccuracy butrequiringsubstantialtrainingdataandmuchhighercomputationalresourcescomparedtorule-basedgeometric thresholding [5].

VI. CONCLUSION

Driverdrowsinessdetectionisacriticalareaofresearchaimedatreducingroadaccidentscausedbyfatigue.Our proposed system leverages machine learning and computer vision to analyze facial expressions, including eye-blinking, yawning, and head pose variations to detect both drowsiness and distracted driving in real-time**.** By utilizing OpenCV and deep learning models, our approach ensures high accuracy without requiring additional external hardware. The system provides instant alerts when drowsiness is detected, helping drivers stay awake and preventing potential accidents.

Deployingthissystemasaweb-applicationwithasecureddatabasedashboardseparatesitfromtraditionalscripts. Thismethodoffersacost-effective,efficient,andscalablesolutioncomparedtotraditionaltechniques,makingit highlysuitableforreal-worldapplications. Withfurthera dvancements inAIandreal-timeprocessing,oursystem can be integrated into modern vehicles to enhance road safety and reduce drowsy driving incidents.

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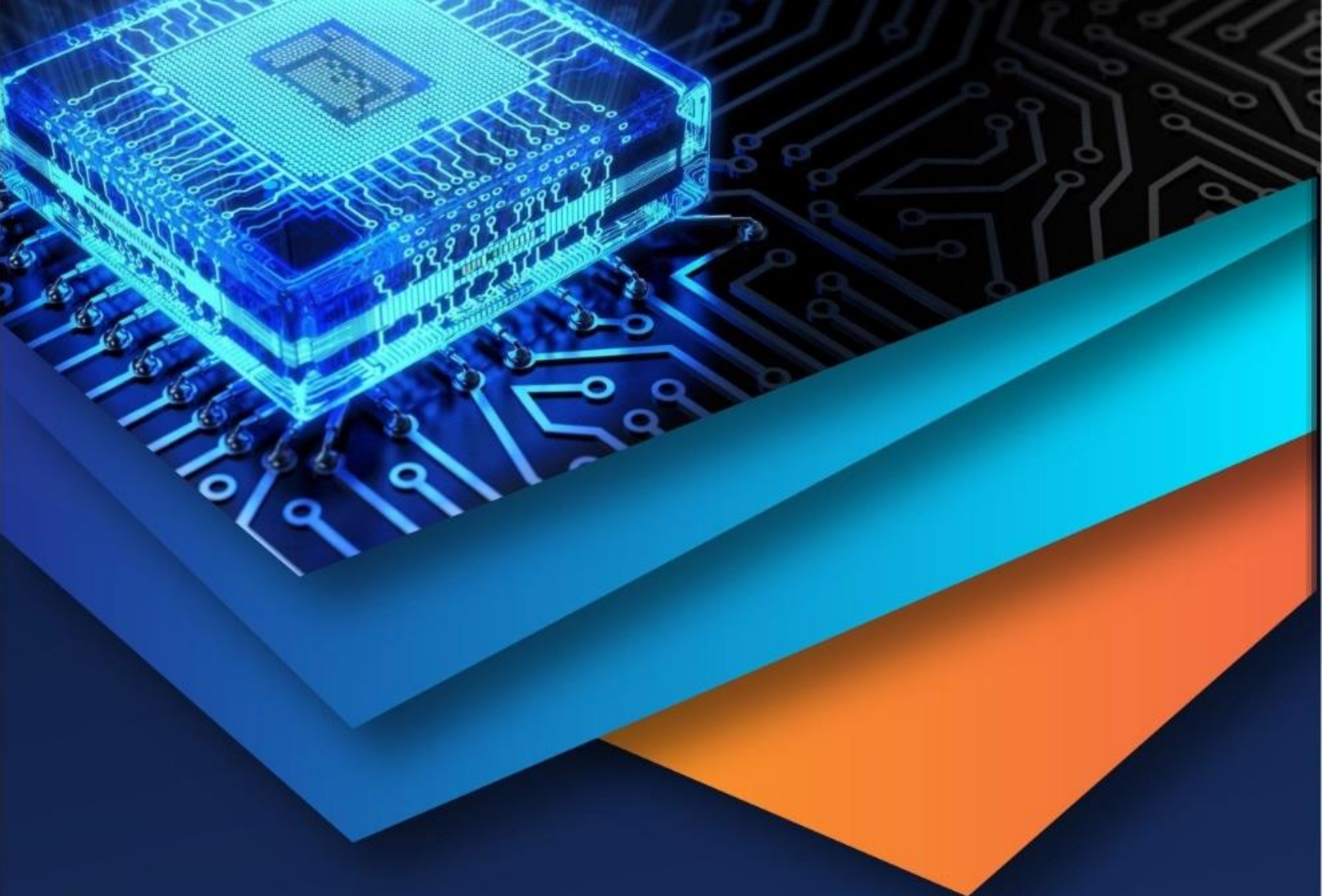

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