Deep Learning for Monitoring Drivers Distraction from Physiological and Visual Signals

Dr. Y. Narasimha Rao[1], S. Sri Vani[2], Ch. Haripriya[3], N. Sai Dinesh[4], D. SaiManisha[5]

[1]Professor and HOD, Department of Computer Science and Engineering

[2,3,4,5] Student, Department of Computer Science and Engineering

[1,2,3,4,5]QIS College of Engineering and Technology, Ongole.

ABSTRACT

Drowsy driving is one of the major causes of road accidents and death. Hence, detection of driver's fatigue and its indication is an active research area. Most of the conventional methods are either vehicle based, or behavioural based or physiological based. Few methods are intrusive and distract the driver, some require expensive sensors and data handling. Therefore, A conceptual based driver's drowsiness detection system is developed with acceptable accuracy. In the developed system, a webcam records the video and driver's face is detected in those images employing image processing techniques. Facial landmarks on the detected face are pointed and subsequently the eye aspect ratio and mouth opening ratio are computed and depending on their values, drowsiness is detected based on developed adaptive thresholding. Machine learning algorithms have been implemented as well in an offline manner. A sensitivity of 95.58% and specificity of 100% has been achieved in Support Vector Machine based classification.

Keywords: Drowsinessdetection, SVM(Support Vector Machine), OpenCV, EOR(Eye Aspect Ratio), MOR(Mouth Opening Ratio)

1. INTRODUCTION

Automobiles have evolved into a necessary form of transportation for the general public. According to 'Statista' global vehicle statistics, the worldwide motor vehicles rate from 2017 to 2019 was 95 million units. The selling rate in 2018 was 1 billion.

Until March 2020, the worldwide automotive sales rate was 60.5 million units. With an increase in the number of vehicles on the road, the likelihood of traffic and accidents rises. Every year, traffic crashes are a significant cause of mortality. In all states, the National Crime Record Bureau (NCRB) records 496,762 road-related traffic collisions [1]. According to the World Health Organization (WHO), about 1.35 million people have died as an estimate of road traffic injuries globally [2]. Approximately 20% to 30% of these accidents are caused by fatigued driving. The most deadly feature of traffic accidents is drowsy driving.

The methods for detecting drowsiness are divided into subjective and objective detection methods. Drivers get no input during objective detection, and detection is based on the drivers' physical characteristics, while subjective detection is based solely on the drivers' physical characteristics. Contact and non-contact detection are the two methods of objective detection. The proposed system is based on the non-contact method, which is less expensive than the contact method.

Drowsy driving is one of the major causes of deaths occurring in road accidents. The truck drivers who drive for continuous long hours (especially at night), bus drivers of long-distance route or overnight buses are more susceptible to this problem. Driver drowsiness is an overcast nightmare to passengers in every country. Every year, a large number of injuries and deaths occur due to fatigue related road accidents. Hence, detection of driver’s fatigue and its indication is an active area of research due to its immense practical applicability. The basic drowsiness detection system has three blocks/modules; acquisition system, processing system and warning system. Here, the video of the driver’s frontal face is captured in acquisition system and transferred to the processing block where it is processed online to detect drowsiness. If drowsiness is detected, a warning or alarm is sent to the driver from the warning system.

By monitoring Visual Behaviour of a driver with webcam and machine learning SVM (support vector machine) algorithm we are detecting Drowsiness in a driver. This application will use inbuilt webcam to read pictures of a driver and then using OPENCV SVM algorithm extract facial features from the picture and then check whether driver in picture is blinking his eyes for consecutive 20 frames or yawning mouth then application will alert driver with Drowsiness messages. We are using SVM pre-trained drowsiness model and then using Euclidean distance function we are continuously checking or predicting EYES and MOUTH distance closer to drowsiness, if distance is closer to drowsiness, then application will alert driver. In this project, I used Python and OpenCV to detect drowsiness of the driver.

2. LITERATURE SURVEY

Steps for face landmark detection, object tracking, and methods for driver drowsiness detection may be utilised in contact or non-contact approaches in different approaches. The methods' nature is mostly determined by the application area.

Many researchers have experimented with different technologies such as monitoring underlying steering tendencies, monitoring car location in lane, monitoring the driver's eye/face, physiological testing, and so on. The majority of approaches use driver eye/face monitoring and physiological measurements. Driver eye/face monitoring is used in the 2019 research, which generates a "DriCare" warning for the driver [3]. The system is efficient, and its efficiency can be verified using a publicly available dataset on driver drowsiness recognition. The following are some of the research projects that led to the creation of the proposed work.

A. Facial Features Recognition

In the detection of drowsiness, facial landmarks are a crucial but difficult phase. It's been used to handle issues like face alignment, head posture estimation, face swapping, and blink detection, among others. It is often used to identify and describe prominent regions of the face, such as the brows, nose, and mouth.

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The authors of this research, **Y. Sun, X. Wang, and X. Tang,** offer a novel work for approximating **the positions of face important points using convolutional networks** with three carefully built levels [4]. There are two advantages: first, texture context data is applied over the whole face to locate every crucial location. Second, since networks are capable of predicting all key points at the same time, the geometric restrictions between key points are implicitly encoded. As a result, the technique may avoid local minimums caused by ambiguity and information corruption in tough image samples with occlusions, huge posture changes, and harsh illumination. For precise and reliable facial point detection, many network designs are required. The results were shown in three levels of convolutional networks: initial detection, customised outcomes using the second and third levels, and final results.

There are several limitations. levels of networks that improve accuracy. Convolutional networks with great performance are one of the advantages. It also increases the accuracy of current methods and cutting-edge industrial software, as well as the reliability of early estimates. The disadvantage is that although sharing weights of neurons on the same map locally improves performance, it does not work well on images such as faces when weights are shared worldwide, and it is also precise in certain unusual positions and emotions.

B. Visual Object Tracking

Visual object tracking is the process of following a single item's journey over all frames of a video such that we only see its position in the first frame. It's one of the most important aspects of computer vision.

D. S. Bolme, J. R. Beveridge, B. A. Draper, and Y. M. Lui studied a simpler tracking approach in their research [5]. A new correlation filter**, the Minimum Output Sum of Squared Error (MOSSE)** filter, is developed, which produces durable correlation filters when initiated with a single frame. Under rotation, scale, illumination, and partial occlusion, excellent performance may be achieved by utilising modified ASEF, UMACF, or MOSSE filters.

By employing the "Peak-to-Side" lobe ratio, the strength of a correlation peak may be utilised to identify occlusions or tracking failures, avoid the online update, and reacquire the trace if the item returns with a similar shape. The following algorithm may be just as precise as the previous one while being significantly faster. Advanced correlation filters perform as well as complicated trackers, and the filter-based strategy is 20 times quicker, processing 669 frames per second. As a consequence, they are not very resistant to changes in the look of the target and fail to solve complex tracking difficulties.

M. Danelljan, G. Häger, F. S. Khan, and M. Felsberg investigate the topic of accurate and **resilient scale approximation for real-time visual tracking** [6]. They used the Discriminative Scale Space Tracker (DSST), a programme that learns several correlation filters for unambiguous translation and scale evaluation. The computational cost of tracking methods is proposed to be reduced using several strategies. As a result, we may search a broader target space without sacrificing real-time performance. The tracking performance has increased noticeably, and the speed has doubled.

C. Driver Drowsiness Detection

There are two ways of methods for detecting drowsiness: contact and non-contact methods. To assess degree of drowsiness, the driver must wear or touch some physical parameter in contact approaches, but in non-contact approaches, the driver does not need to touch physical items. Non-contact methods are less expensive and easy to use.

S.-J. Jung, H.-S. Shin, and W.-Y. Chung's research [7] looks at employing e**mbedded electrocardiogram (ECG) sensors** with electrically conductive fabric electrodes on the steering wheel to monitor a driver's health. To monitor the driver's health status, exhaustion, and drowsiness state from physiological alterations in biomedical signals, ECG readings are captured at 100Hz from palms and wirelessly relayed to a distant station coupled to a server computer in a private area network. However, the pipeline was followed by a contact approach, which might be inconvenient and time-consuming for users.

G. Li, B.-L. Lee, and W.-Y. Chung's research [8] is based on physiological signs, one of which is the brain reflected by Electroencephalographic (EEG) data, which is directly associated to drowsiness. A posterior probabilistic model based on SVM was utilised, as well as a smartwatch-based wearable EEG device. Instead of discrete class labels, the drowsiness score is calculated using a probability value of 0 1. However, the EEG channel settings and ground truth employed are ambiguous, and the detection accuracy is not accurately indicated.

B. Warwick, N. Symons, X. Chen, and K. Xiongproposed a **wireless wearable sensor to be employed in the research of Driver Drowsiness systems** [9]. The collection of physiological data using the biosensor and the analysis of measured data to discover the essential parameters associated to drowsiness are the two steps of designing a drowsiness system. The creation of a drowsiness detection algorithm and a mobile app to inform drowsy folks is the second stage. The pulse rate and breathing rate of a driver have been found to be strong markers of drowsiness.

M. Omidyeganeh, A. Javadtalab, and S. Shirmohammadi'sresearch [10] uses **a camera to record face appearance**. Face extraction from an image, eye detection, mouth detection, and warning creation in a drowsy state are the four steps of the system. The system's limitation is that, since it uses a non-contact technique, it is dependent on things such as light, camera, and so on.

The primary goals of this paper are to address all of the aforementioned flaws.

3. SYSTEM DESIGN

By monitoring Visual Behaviour of a driver with webcam and machine learning SVM (support vector machine) algorithm we are detecting Drowsiness in a driver. In this application will use inbuilt webcam to read pictures of a driver and then using OPENCV SVM algorithm extract facial features from the picture and then check whether driver in picture is blinking his eyesor yawning mouth then application will alert driver with Drowsiness messages if drowsiness is detected. We are using SVM pre-trained drowsiness model and then using Euclidean distance function we are continuously checking or predicting EYES and MOUTH distance closer to drowsiness, if distance is closer to drowsiness, then application will alert driver

Driver drowsiness monitoring system at first, the video is recorded using a webcam. The camera will be positioned in front of the driver to capture the front face image. Linear support vector machine (SVM) for object detection. After detecting the face, facial landmarks like positions of eye, nose, and mouth are marked on the images. From the facial landmarks, eye aspect ratio, mouth opening ratio and position of the head are quantified and using these features and machine learning approach, a decision is obtained about the drowsiness of the driver. If drowsiness is detected, an alarm will be sent to the driver to alert him/her.

4. METHODOLOGY

SVM based driver fatigue prediction system is proposed to increase driver safety. The proposed system has five stages: PERCLOS, count of yawn, internal zone of the mouth opening, count of eye blinking and head detection to extract attributes from video recordings. The classification stage is done with Support Vector Machine (SVM). While the YawDD dataset is used during the training phase of the classification, real-time video recordings are used during the test phase.

Feature Extraction Driver's face features must be extracted to calculate Perclos, eye blinking, and detect yawning, internal zone of the mouth opening, head position. As the first part, we detected the eye and mouth position and these areas were extracted. Secondly, we calculated Perclos and eye blinking for eye areas. Next, we detected yawning and internal zone of the mouth opening for mouth area. Finally, we marked the position of the driver's head. Facial landmark.

Support Vector Machine (SVM) SVM is a classification algorithm separating data items. This algorithm proposed by Vladimir N. Vapnik based on statistical learning theory [18]. SVM, one of the machine learning methods, is widely used in the field of pattern recognition. The main purpose of the SVM is to find the best hyperplane to distinguish the data given as two-class or multiclass. The study was carried out in two classes. Whereas label 0 means that the driver is tired, label 1 means the driver is non-tired. Thus, it is aimed to distinguish tired drivers (driver fatigue) from non-tired drivers.

After detecting the facial landmarks, the features are computed as described below.

Eye aspect ratio (EAR): From the eye corner points, the eye aspect ratio is calculated as the ratio of height and width of the eye as given by

$$\text{EAR}=\frac{(\boldsymbol{p_2}-\boldsymbol{p_6})+(\boldsymbol{p_3}-\boldsymbol{p_5})}{\boldsymbol{2}((\boldsymbol{p_4}-\boldsymbol{p_1})}$$

Mouth opening ratio (MOR): Mouth opening ratio is a parameter to detect yawning during drowsiness. Similar to EAR, it is calculated as

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$$\text{MOR}=\frac{(p_{15}-p_{23})+(p_{16}-p_{22})+(p_{17}-p_{21})}{3(p_{19}-p_{13})}$$

After computing all the features, the next task is to detect drowsiness. In the beginning, adaptive thresholding is considered for classification. Later, machine learning algorithms are used to classify the data. Table II illustrates this calculation for determining the adaptive threshold. If values are less than this adaptive threshold value, then drowsiness is detected and will activate an alarm to alert the driver until the driver wakes up.

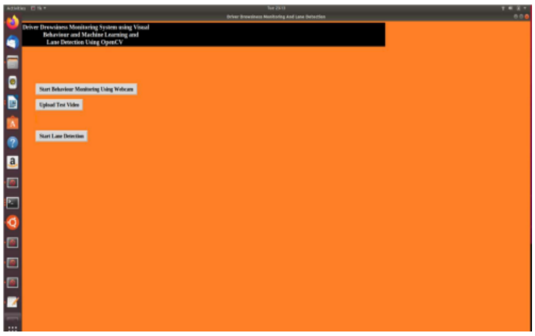
Table II: Threshold for the computed parameters

EAR from setup phase (average of 150 maximum values out of 300 frames)	0.34
Threshold=EAR- offset	0.34-.045=0.295
At Yawning,(MOR> 0.6)	Threshold=Threshold +0.002 *Max bound exist

4.Results

This section aims to analyse the performance of the proposed classification model through several statistical measurements. For further processing of drowsiness detection, the webcam is linked to the pc. Subsequently, the feature values are stored for statistical analysis and classification as well. The feature values are subsequently also stored for statistical measurement and classification.

In the below screen click on 'Start Behaviour Monitoring Using Webcam' button to connect application with webcam, after clicking button will get below screen with webcam streaming and starts capturing the drivers face.



In below screen we can see web cam stream then application monitor all frames to see person eyes are open or not. In the below image the person eyes are open and the system keeps on counting the score.The eyes of driver are being captured by the usind Eye aspect ratio.

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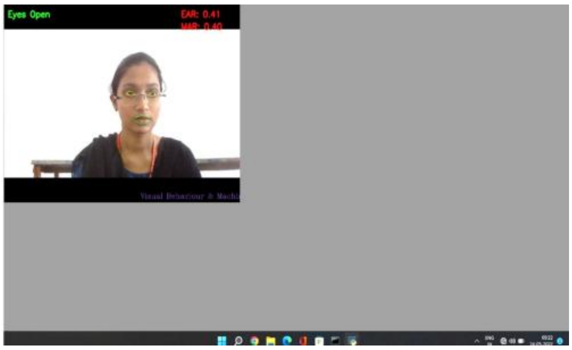
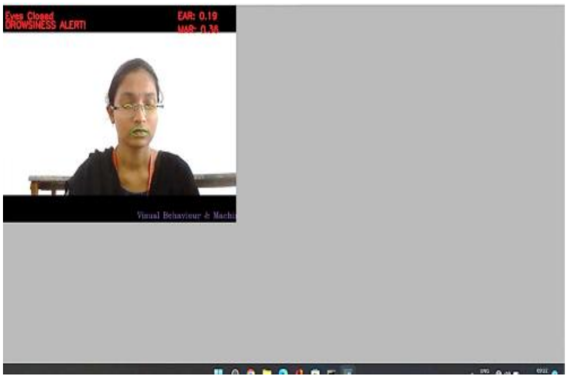
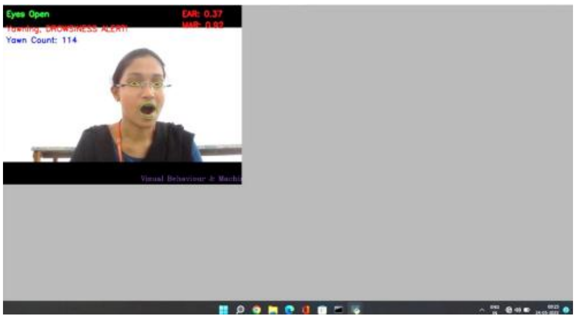


It keeps on counting the score by observing the eye aspect ratio. If the obtained vales for persons eyes are compared with the threshold values. As the person eyes are closed for few seconds i.e., reached the threshold values it shows a drowsiness altering message and alerts him by ringing an alarm.



The position of mouth is calculated by using MOR Mouth opening ratio is a parameter to detect yawning during drowsiness. Similarly, if mouth starts to yawn, then also will get drowsiness alert message and rings an alarm and keep on counting the number of yawns.



5. CONCLUSION

Driver drowsiness monitoring system has been proposed based on visual behaviour and machine learning. Here, visual behaviour features like eye aspect ratio, mouth opening ratio are computed from the streaming video, captured by a webcam. An adaptive thresholding technique has been developed to detect driver drowsiness in real time. The developed system works accurately with the generated synthetic data. Subsequently, the feature values are stored and machine learning algorithms have been used for classification. Bayesian classifier, FLDA and SVM have been explored here. As SVM and FLDA have provided better accuracy, work will be brought out to execute them in the developed method to perform the classification (i.e., drowsiness detection) online. The system will also be applied in hardware to enable its mobility to the vehicle system, and driver pilot studies will be performed to validate the system created. To sup up, the system has been able to present a detection system of a driver drowsiness based on facial expression.

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