Comparative Analysis of Driver Drowsiness Detection using Machine Learning Techniques

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Abstract - A person while driving a vehicle - if does not have proper sleep or rest, is more inclined to fall asleep which may cause a traffic accident. This is why a system is required which will detect the drowsiness of the driver. In this system, it will take the image of face of the driver through the camera on regular intervals and examine the changes that happen in the eye. These images will be processed through an algorithm which will compare them with the dataset of images. If the comparison matches the predefined percentage of match, then drowsiness is detected and alert is sent to driver.

***Keywords*- Machine Learning, Drowsiness Detection, Face Detection, Eye Tracking**

I. INTRODUCTION

Driving while being drowsy has become one of the major reasons of causing road accidents. Drivers who drive at night or for a long distance without resting are more prone to get involved in an accident. Large amount of fatal injuries and deaths occur because of this reason. Hence, it has become an active area of research.

Various systems exist for this purpose which makes use of physiological features, behavioural patterns and vehicle-based features. Physiological features considered here are Electroencephalogram (EEG), Electrooculogram (EOG), Electrocardiogram (ECG), heartbeat, pulse rate etc. Behavioural patterns considered here are visual behaviours of drive like eye blinking, eye closing, yawning, head bending etc. Vehicle based features are metrics like wheel movement, acceleration, vehicle speed, brake pattern, deviation from lane pattern etc. Most of these methods are time consuming and expensive. In this system, we propose an alternate system which uses images for detection of drowsiness using machine learning.

Machine learning is the technology which deals with training the machine so that it can make decisions by itself. The concern of this technology is to allow machines to learn by themselves without any human intervention. Machine Learning is able to analyse large quantity of data. It can work faster with complex data and give more accurate results. The machine learning techniques are usually classified as supervised or unsupervised. These two algorithms are used most commonly. Further, semi-supervised learning and reinforcement learning are less frequently used algorithms. The mentioned techniques are described as of below-

- Supervised Machine Learning

  The algorithms under supervised machine learning predicts future events from the learned information in past. The examples in the training set are labelled. The predicted output can be compared with the labelled data. Error in the output can be detected which id further learnt by machine to avoid the error and predict better output.

- Unsupervised Machine Learning

  In unsupervised machine learning algorithms, unclassified or unlabeled data is used. It is a self-organized learning technique. The algorithm explores hidden structure of the data from the dataset. The output of the algorithm might not be correct initially. The algorithm learns from its errors. Pre-trained data is not available for algorithms under unsupervised learning

- Semi-supervised Machine Learning

  This machine learning algorithm uses both labeled and unlabeled data for training. Most of the data used is unlabeled since fully labeled data is expensive and difficult to acquire. This learning algorithm can be used with methods like regression, classification and prediction. This technique is used when cost associated with labeling the data is high.

- Reinforcement Machine Learning

  In reinforcement machine learning algorithm, machines are trained to make sequence of decisions. These algorithms are used in potentially complex environments. It learns based on trial and error method. If correct output is predicted, reward is given by environment to the learner. Otherwise, penalty is given.

A. *FACTORS CAUSING DROWSINESS*

Drowsiness can be caused by many reasons. Drowsiness while driving may lead to fatal accidents.

Some of the most common causes of drowsiness are as follows-

a. Sleep Deprivation

Many people suffer sleep loss because of not getting enough sleep. Personal and lifestyle choices restrict the sleeping hours. It has negative impacts on brain and can impair functions of brain like memory and decision making which can prove to be harmful during driving.

b. Sleep Disorders

Chronic loss of sleep can increase the probability of sleep disorders. Sleep disorders can interrupt the communication of nerve cells with each other. Sleep disorders like narcolepsy, sleep apnea lead to excessive sleepiness at daytime. If these disorders remain untreated then they can cause sleep disruption.

c. Alcohol Consumption

Consumption of alcohol or certain medication can show sedating effects. It impairs the driving skills of the driver. Alcohol consumption can cause vision to be blurred. Heavy drinking can also cause memory blackout and memory lapses. This proves to be extremely dangerous while driving.

d. Continuous Driving

Driving continuously without taking a break can affect driver's attention, reaction time and operating ability. Driver might feel sleepy. This can induce accidents.

II. VARIOUS DROWSINESS DETECTION SYSTEMS

C. Using Eye features only

This system is based on both Image Processing and Machine Learning. Grey scale images are generated using Haar-Adaboost based algorithm. This system is completely based on eyes and its constraints. Four important constraints considered are Glasses Bridge and eye detection, eyes detection without wearing glasses, eyes detection with glasses, eyelid and eye blinking detection. Images are then trained using OpenCV and a threshold is calculated. Drowsiness is detected only with the help of eyes and head movement.

Eye features that are most commonly extracted from the face are Eye closure analysis and Eye blink rate.

A. Using Vehicle-based features

This system uses car sensors mounted on the acceleration pedal and the steering wheel, which measure the driving behavior such as steering wheel movement (SWM), standard deviation of lane position (SDLP). Vehicle speed and steering wheel movements signals are extracted from the acceleration pedal and the steering wheel sensors, then they are converted and prepared to be merged with FaceLab data.

Steering wheel measurements incline to produce better results than other vehicle-based features. The vehicle-based measurements maybe inaccurate because of their dependencies of nature of the road and driving skills of driver.

B. Using Facial landmarks

In this system, a web camera records a video. Driver's face is continuously detected in frames per second. The facial landmarks like eyes, mouth and nose are examined with Eye Aspect ratio (EAR), Mouth Opening Ratio (MOR) and Nose Length Ratio (NLR) respectively. The system uses Support Vector Mechanism (SVM) and Bayesian classifier for classification. It shows that SVM produces better results than Bayesian classifier.

For computation of each of the features, the driver is initially assumed to be awake. This is called as setup phase. Three hundred initial frames are recorded. For the threshold value, maximum 150 values are considered. Student's t-test had also been performed to check the significance of two classes.

$$EAR = \frac{Height\ of\ Eye}{WIdth\ of\ Eye}$$

1. Eye closure analysis

The methods called Percentage of the eye closure (PERCLOS) and eye aspect ratio (EAR) are involved in eye closure analysis. EAR performs classification of ratio of eye as it decreases and PERCLOS identifies whether eye is closed or open.

2. Eye blink rate

The normal blinking rate of a person is approximately 10 per minute. Frequency of driver's blinking is measured. If blinking rate decreases then drowsiness is detected.

D. Using Physiological and Behavioral features

In this system, many physiological and behavioural features are used together. Behavioral features like head movement, yawning and eye

blinking are detected. Along with them, Electroencephalogram (EEG), Electrooculogram (EOG), Electrocardiogram (ECG), heartbeat and pulse rate are also calculated simultaneously. If most of these values are detected to be below the threshold value, the drowsiness is detected. The system comprises large execution and processing time.

These measurements are taken by adding electronic devices on driver's body. The electronic devices may distract driver. This method can provide accurate results but they have physical limitations.

III. COMPARATIVE ANALYSIS OF DROWSINESS DETECTION TECHNIQUES

The comparison of various machine learning techniques for drowsiness detection mentioned above will help to find the well-suited approach for given business context. The following tables (Table-I and Table-II) provide comparative analysis of machine learning techniques for drowsiness detection. The first table specifies metrics and classifiers used for every method along with its accuracy. The second table specifies pros and cons of every method used in the drowsiness detection systems.

TABLE-I COMPARATIVE ANALYSIS OF DROWSINESS DETECTION TECHNIQUE

Method	***Metric***	***Classifier***	***Accuracy***
Vehicle-based features	Steering wheel movement (SWM) Standard deviation of lane position (SDLP)	Multi-level back propagation neural network	88.02%
Facial landmarks	Eye aspect ratio (EAR) Mouth opening ratio (MOR) Nose length ratio (NLR)	Support Vector Mechanism (SVM)	95.8%
Method	***Metric***	***Classifier***	***Accuracy***
Eye features	Eye closure analysis, Eye blink rate	Convolutional Neural Network (CNN)	95.18%
Physiological and behavioral features	ECG, EEG, Pulse rate	Support Vector Mechanism (SVM), Karolinska sleepiness scale (KSS)	80%

TABLE-II COMPARATIVE ANALYSIS OF DROWSINESS DETECTION TECHNIQUE

Sr. No.	***Method***	***Pros***	***Cons***
1	Vehicle-based features	Non-intrusive	Affected by geometric condition of roads, Unreliable
2	Facial Landmarks	Easy to use, Non-intrusive	Affected by illumination, Facial accessories interrupt the functioning
3	Eye Features	Reliable, Accurate results	Affected by lighting conditions, Presence of sunglass interrupt the functioning
4	Physiological and behavioural features	Efficient, Reliable	Intrusive, Sensors might distract driver

IV. PROPOSED WORK

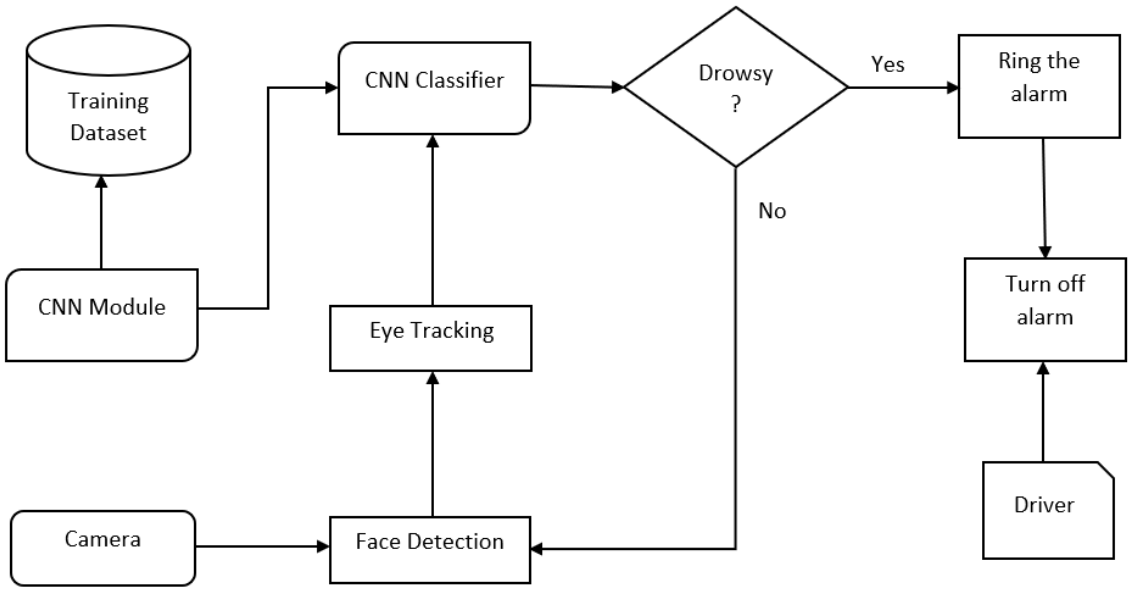

Fig 1. Proposed System Architecture

The above drowsiness detection techniques are based on one or more similar features. Some of these methods are expensive and unreliable. From above mentioned techniques, the method using eye features only is most reliable and generate more accurate results than other methods. The present system uses PERCLOS, AdaBoost and CNN to detect drowsiness. The system is not developed to send alert to driver.

In the proposed system, we use CNN to classify the driver's images. A camera will be placed in front of the driver which will take photos of the driver while driving the vehicle. This camera will be connected to a Raspberry Pi/ Arduino where the processing will take place. These images will be given to the system where CNN will classify them into different classes- drowsy and not drowsy.

A model will be constructed using CNN and dataset containing the images of the driver. This dataset will contain both drowsy as well as non-drowsy images. Once the model is trained, system will start capturing images of driver while driving. If for a given time interval, the percentage of detected drowsy images while driving is more than a threshold percentage of drowsiness then the driver is found drowsy and alarm rings.

V. CONCLUSION

Drowsiness detection systems have risen to be an active research area because of its utility and need for the security of drivers. There are many drowsiness detection systems already which have potential to be developed for better performance. We have identified latest drowsiness detection systems and compared them based on their methods, metrics, pros and cons. In conclusion, we have proposed an enhanced drowsiness detection system which will not only detect drowsiness but also alert driver by ringing the alarm.

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