Driver Alerting System from Visual Behavior and Machine Learning

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***Abstract*— Many existing systems are available for drowsy detection system, but these systems were implemented by vehicle movement based and physiological based method. According to physiological based approach working with few sensors such as ECG and EEG which is increases the system cost and size. Therefore, to overcome this issue we are proposed vehicle based approach to driver drowsiness detection. The advantages of machine learning techniques, in this system, we are not using any kind of sensors, with help of facial landmarks it can monitoring driver drowsiness. In visual behavioral approach we can calculate the aspect ratios of face descriptors such as Eye, Mouth and Nose ratios can return the threshold values of three aspect ratios and these threshold values compare with adaptive threshold values then if any facial landmarks threshold values satisfy with adaptive threshold values then this system can detect driver drowsiness and generate the alarm to notify the driver. As well as regarding offline purpose, we are implementing the machine learning classifier NB, SVM, KNN and FLDA algorithms to determine the accuracy of visual behavioral method. Finally, the experimental results shows the high precise detection of driver drowsiness with visual behavior and KNN classifier providing 97% more accuracy compare with remaining classifier to detection of driver drowsiness.**

Keywords*— *Visual behavior, Machine Learning, Support Vector Machine (SVM), Eye Aspect Ratio(EAR), Mouth Opening Ratio(MOR), Nose Length Ratio(NLR), Naive Bayes (NB), Fisher's Linear Discriminant Analysis(FLDA), K-Nearest Neighbor (KNN).

I. Introduction

Machine learning languages provide simple and effective libraries for artificial intelligence. Due to this it can implement easy methods for achieving our requirements. In this system we need to detect driver drowsiness without adding any sensors to drivers, because of course by adding sensors also we can detecting driver drossiness like which comes under vehicle and physiological based technologies [1-9] but using this technique the system can get high cost and system size will be increased by attaching sensors to drivers and vehicles which comes under vehicle based technique. This is not recommended to detecting driver drossiness. There are also ways to detect drowsiness by using deep learning[24-34] which are not as effective as using machine learning[10-23].

By using of visual behaviors we can easily and safe detecting driver drowsiness and make him/her alert for not to get sleeping. For this achieving this system we just attach the web camera only which is less cost, later taking the input images from camera we can first find face detection [10] by using HAAR cascade helping file and detecting facial landmarks on images. After finding landmarks it can perform visual behaviours like eye aspect ratio and mouth open aspect ratio and nose length aspect ratio formulas by getting threshold values.

By taking the threshold values first it checks yawning if it is greater than 0.6 and check head bending which is less than 0.7 and greater than 1.2 then if both results are given YES and the eye aspect ratio also exceeded then it will generate drowsy alerts as well as if both mouth and nose ratios returns “NO”, then if eye ratio satisfy then it can generate drowsy alert and make the driver active. In this scenario no need to use any sensors for detecting here only with visual behavior our system can detect driver drowsy and reduce system cost and size.

II. Literature Review

The authors *Seok-Woo Jang et al.* .[8] used expensive ad good sensors to get good accuracy of drowsiness. Inclination detection vibration sensor, CO2 sensor are used as sensors. Along with CO2 sensor, Air freshener: operation for indoor ventilation and drowsiness prevention, car speaker (music) are activated when drowsiness is detected.

The authors *C. Y. Chen et al.* [11] introduced driver tiredness detection system by help of eye tracking. Here first observing the face image from color camera for finding the skin color and take out to as gray image which wouldn’t have any colored image only black and white color image then apply the canny edge detection algorithm for discover eye frames. After discover eyes it can calculate the white points of edges for every twenty frames if it has any driver tiredness detection then it can invoke the sound alarm and beware to driver for harmlessness driving.

The authors *J. Mellor et al.* [12] were introduced Non-intrusive drowsiness detection by SVM classify. In this method, it follows training dataset with attributes nose, mouth and eye static values and target column value like drowsiness status yes or no. The application starts with by running color camera can open and read image, identify the face landmarks from that image incessantly get 3 threshold values and predict the drowsiness status then it can alert it is

Non-intrusive drowsiness detection.

The authors *C. W. Chang et al.* [13] invented video frame-based drowsy driver detection method where it can identify the face landmarks despite the driver wore the spectacles. In previous systems, we should remove the spectacles to mark the facial landmarks. Due to this reason it would not to identify driver drowsy perfectly but using this method 95% precisely can finding the driver drowsiness with wear the glass/without glass.

The authors *A. S. Baquhaizel et al.* [14] were implemented detection of driver drowsy system. Here this report depicts how to detect the eyes, and also how to identify if the eyes are open or closed. When the face landmarks are found, the eyes are found by processing the horizontal averages in the face landmark, for example When the eyes are obtained, ascertaining the distances between the potency alterations in the eye landmark recognize whether the eyes are opened or shut then the system infer that the driver is getting tidiness and alert a warning alarm to driver.

The *J. N. Borole et al.* [15] were developed eye blink drowsy detection. In this detection system it can get image from camera and with help of cascade network model file this system can detect face landmarks. While driver driving the vehicle first it located the eyes and starts to count eye blinking time, compare with mentioned adaptive threshold value if it is outrival then it is preventing accidents by generate alert message to driver for not to sleeping.

Different enhanced CNNs were used to detect drowsiness like Staked Deep CNN [28], SoftMax layer in CNN classifier [29], convolutional and temporal neural network architectures [30], deep cascaded convolutional neural network [33] and residual-based deep 3D convolution neural network [34].

The *Jing-Ming Guo et al*. [35] developed a method where they used both deep learning and artificial intelligence to detect drowsiness of driver. In this paper, a hybrid of long short-term memory (LSTM) and CNN classifier is used. Then the classification is done using machine learning.

III. System Implementation

A. System Model

From the Figure.1 First web camera can run and for few seconds it can read the frames extracted later it can generate image and on that image it can face detecting from that finding facial landmarks like as eyes, mouth and head by helping of that finding ratios of three ratios and compare with three threshold if it any threshold match then it can generate drowsy alert to driver not to sleep.

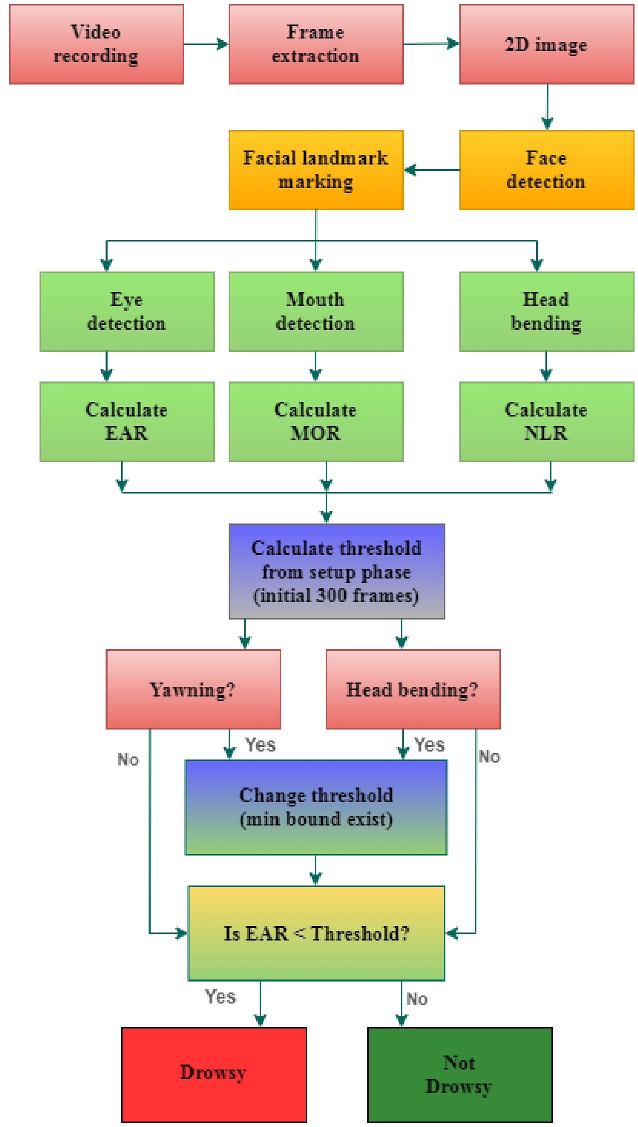

Figure.1 System Architecture

B. Drowsy Detection with Visual Behavior

In this system, we are performing drowsy detection system with visual behavior based approach. In this approach, this system first capture the image from camera and that frame or image can be resize and convert to gray color image. On this gray color image it can apply the frontal face detector for face detection. Later for detection of facial landmarks, the face detection image will pass to shape predictor. After facial land marks localization which is shown on figure.2, then it can start to calculate the aspect ratios of Eye, Mouth and Nose to get each category threshold values. These threshold values will be compare with adaptive threshold values and if any condition is satisfy then this system can detect driver drowsiness and generate the alarm sound to beware of driver. The below formulas will be determining aspect ratios as follows:

$$EAR = \frac{(p_2 - p_6) + (p_3 - p_5)}{2(p_4 - p_1)} \qquad (1)$$

$$MOR = \frac{(p_{15} - p_{23}) + (p_{16} - p_{22}) + (p_{17} - p_{21})}{3(p_{19} - p_{13})} \qquad (2)$$

$$NLR = \frac{nose\ length(p_{28} - p_{25})}{average\ nose\ length} \qquad (3)$$

From the Eq. (1) – (3) p_1, p_2 ,p_3,….p_{28} are belongs to facial land marks points. Using these landmarks points we can calculate the three aspect ratios of threshold values.

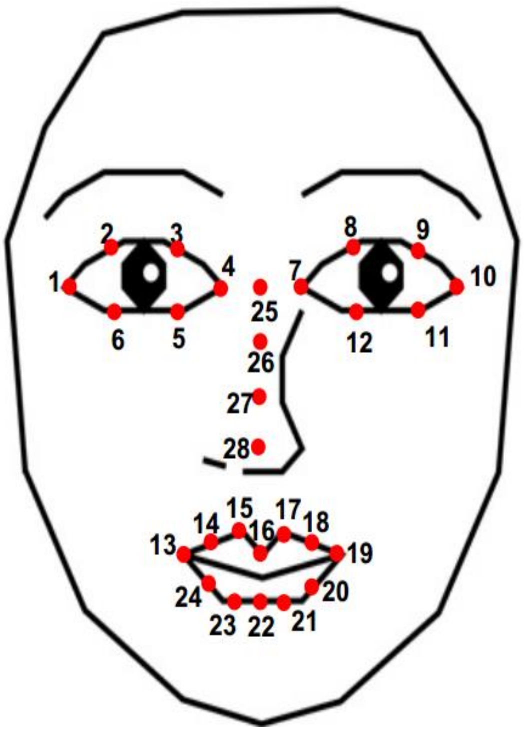

Figure.2. Facial Region of Interest points

Table.1 Drowsy Driver Region of Interest Points of Facial

Face Parts	Landmark Points
Right eye	[1-6]
Left eye	[7-12]
Mouth	[13-24]
Nose	[25-28]

Table.2 System predefined threshold values

Facial Threshold Parts	Facial Threshold values
At Head Bending, (NLR < 0.7 OR NLR > 1.2)	Threshold = Threshold + 0.001 *Max bound exist
EAR from setup phase (average of 150 greatest values out of 300 frames)	0.34
Threshold = EAR - offset	0.34 – 0.45 = 0.295
At Yawning, (MOR > 06)	Threshold = Threshold + 0.002 *Max bound exist

C. *Drowsy Detection with Machine Learning*

- *Bayesian Classifier*

In this system the naïve bayes algorithm [17] can be used for driver drowsy detection. This algorithm follows the bayes rule to hear disease prediction. It is fastest and easily predictable classifier and it calculates posterior probability events with other events and this algorithms uses mostly for text classifications. This classifier MultinomialNB is importing from sklearn.naive bayes package.

- *SVM*

The support vector machine classifier [18] is an important classifier because of its classification advantages. The SVM classifier while classification of features, first it can draw the margins between different classes and the hyper plane line can separate with support vectors which means the nearest classes to that hyper plane line. Here this system can separate hyper plane with POSITIVE and NEGATIVE features and select the nearest support vectors and build the training model to detection driver drowsiness.

- *KNN*

The K-nearest neighbor classifier [16] is a different learning classifier compare with another machine learning classifier, because it follow the Euclidian distance formula to calculate the distance. This classifier while prediction it calculates the distance between with each records then it returns the distance and store it like this follow the last record and it can return the predictable output value which distance is less to compare with all distances and that one become our detection of output like drowsy or not drowsy. It is also import the *KNeighborsClassifier* module from this *sklearn.neighbors.*

- *FLDA*

Linear Discriminant Analysis (LDA) [19] is a dimensionality decrease method. As the name suggests dimensionality decrease methods lessen the number of dimensions (for example variables) in a dataset while holding as much data as could be expected. The classifier with a linear decision boundary is created by fitting class contingent densities to the information and utilizing Bayes' rule. The model fits a Gaussian density to each class, expecting that all classes share a similar covariance matrix. So through machine learning techniques, we are detecting the driver drowsiness. Compare to all classifiers the *K-NN* classifier with 97% accurately perform the driver drowsiness detection.

Aside from utilizing thresholding, the machine learning algorithms are utilized to identify drowsiness also. We are executing machine learning in an offline way on the stored information. Two third information is utilized for preparing and one third is utilized for testing the algorithms. The EAR, MOR and NLR esteems are stored as test information alongside real drowsiness esteems. From that test information we figure accuracies for SVM, FLDA, NB, KNN calculations by comparing them and the trained information.

IV. EXPREMENTAL RESULTS

A. *System Testing Results*

Figure.3 Detection of facial landmarks

From the figure.3, this system is showing the facial landmarks detection. Here it has detected Eyes, Nose and mouth region of interest points.

Figure.4 Drowsy Detection due to Eye closed

The figure.4 depicts about drowsy detection due to Eye closed state. Here it has detected facial landmarks and calculates the Eye aspect ratio to get threshold value and due to exceed the adaptive threshold value then the system detected drowsiness.

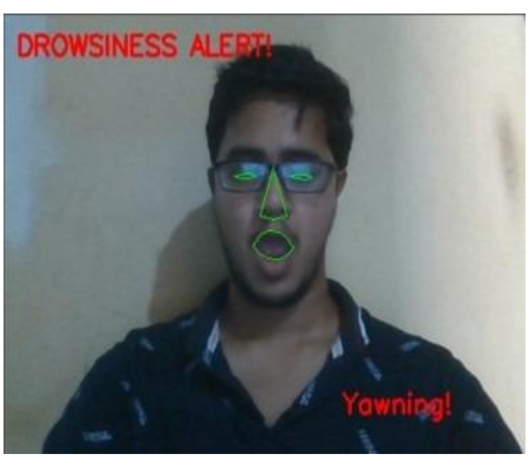

Figure.5 Drowsy Detection due to Yawning

The figure.5 depicts about drowsy detection due to Yawning state. Here it has detected facial landmarks and calculates the Mouth aspect ratio to get threshold value and due to exceeding of the threshold value the system detected drowsiness.

Figure.6 Drowsy Detection due to Head Bending

The figure.6 depicts about drowsy detection due to Head bending state. Here it has detected facial landmarks and calculates the Nose length ratio to get threshold value and due to exceeding of the threshold value the system detected drowsiness.

B. *Evaluations*

Table.3 Classification Metrics of Classifiers

Algorithm	**Accuracy**	**Recall**	**F1 score**	**Precision**
FLDA	0.93	0.84	0.88	0.86
Bayesian	0.88	0.81	0.84	0.83
SVM	0.95	0.88	0.93	0.90
KNN	0.97	0.90	0.94	0.89

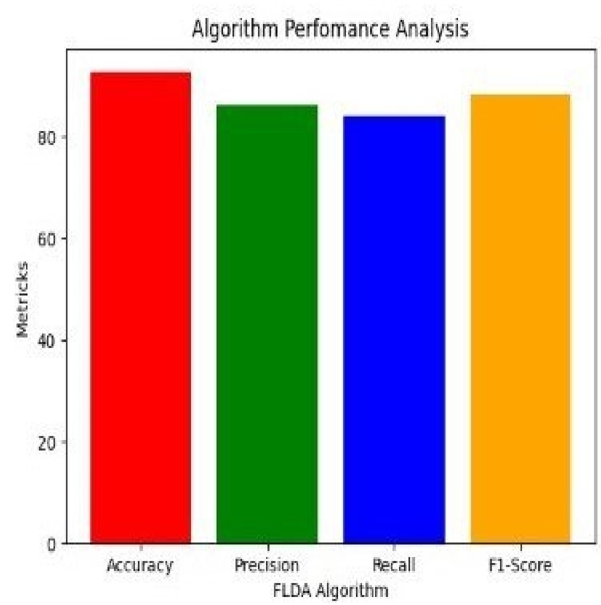

Figure.7 FLDA algorithm performance analysis

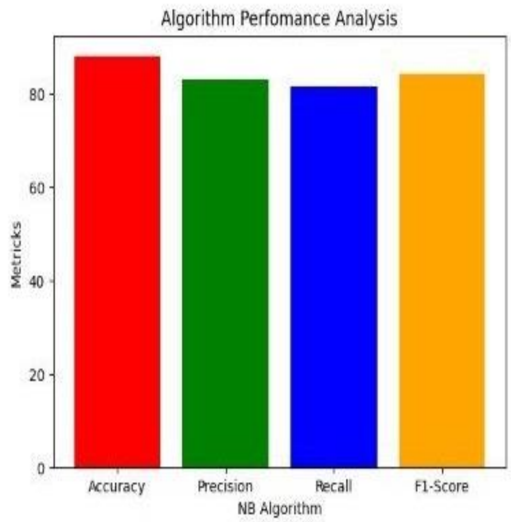

Figure.8 Bayesian algorithm performance analysis

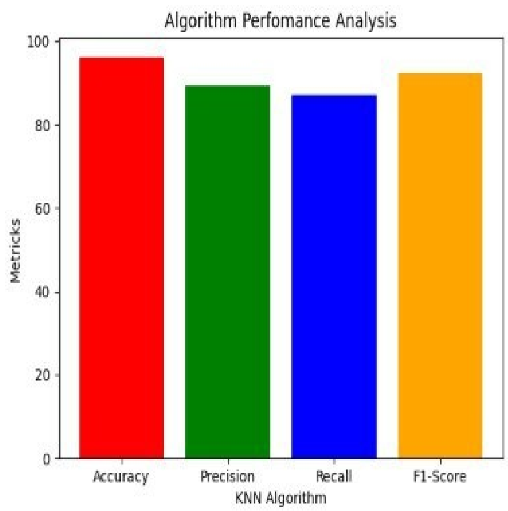

Figure.9 KNN algorithm performance analysis

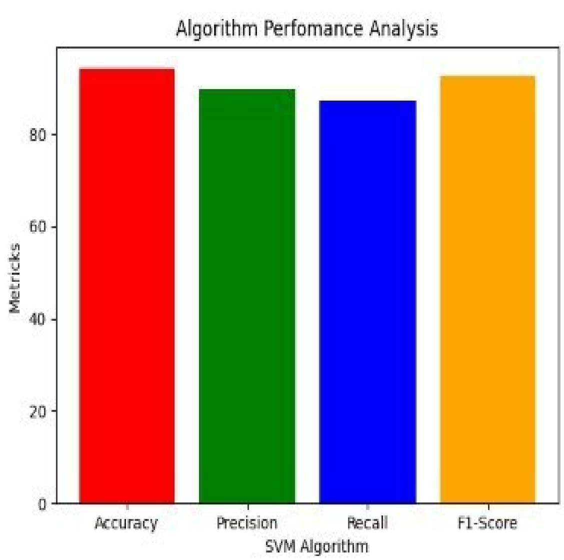

Figure.10 SVM algorithm performance analysis

V. Conclusion

In this system we can get accurately detect driver drowsiness with help of three aspect ratios which is getting from visual behaviors methods as well as we are implemented machine learning technique NB, SVM, KNN and FLDA classifier for predicting drowsy status like normal, yawing, head bending, eye closing with help of training dataset. An adaptive thresholding method has been created to identify driver sleepiness progressively. The created system works precisely with the produced synthetic information. Therefore, the feature esteems are stored also, machine learning algorithms have been utilized for classification. The KNN classifier given 97% accuracy with compares remaining algorithms. So that previous methods like physical or vehicle methods are giving very less detecting driver drowsy results if it is compare with current system.

VI. Refenences

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