

Drowsiness Detection System in Real Time Based on Behavioral Characteristics of Driver using Machine Learning Approach

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Abstract: Drowsiness is among the primary reasons for driver caused traffic accidents. The interactive systems that have been designed to minimize road accidents by notifying the drivers are referred to as Advanced Driver Assistance Systems (ADAS). Most significant ADAS include Lane Departure Warning System, Front Collision Warning System and Driver Drowsiness Systems. In the current research, an eye state detection based ADAS system is introduced to identify driver drowsiness. To start, Viola-Jones algorithm method is utilized for identifying the face and eye regions in the current work. The eye region, detected in the present method, is classified into open or closed through utilization of a machine learning approach. Ultimately, eye conditions are inspected at time domain using percentage of eyelid closure (PERCLOS) metric and drowsiness states are calculated by Support Vector Machine (SVM). The above proposed methods are tested on 7 real individuals and drowsiness conditions are detected better accuracy, respectively.

Keywords: Driver Drowsiness Detection, Advanced Driver Assistance Systems (ADAS), Viola-Jones Algorithm, Eye State Detection, Face and Eye Detection, Machine Learning, Support Vector Machine (SVM).

I. Introduction

Drivers Drowsiness is one of the leading causes of road traffic accidents. As per most surveys 25- 30% of road accidents occur due to driver drowsiness, and due to this reason, numerous lives are lost, numerous properties get damaged, and these figures are on the rise day by day [1]. Drowsiness (also sleepiness) is a condition where an individual has a desire to sleep and is a condition of sleep wake cycle [2]. A latest survey conducted by National Highway Traffic Safety Administration (NHTSA) puts approximately 56,000 road accidents due to sleep deprived drivers that occur every year in the U.S.A., causing 40,000 injuries and 1,550 deaths [3]. It takes an ample amount of hard work and dedication to prepare an efficient mechanism capable of measuring sleepiness and responding accordingly towards road accidents. Some developments have been achieved in the design of intelligent cars to avoid such mishaps [4]. With mounting interest in smart vehicles, the development of strong and viable fatigue and drowsiness detection systems has become the topmost priority. ADAS is one of the active safety systems that aims to warn the drivers to assist them in preventing traffic accidents. The primary aim is to assist the reduction of traffic accidents using newly established technologies; that is, integrating new systems for improving vehicle security and, simultaneously, reducing the harmful situations that occur during driving owing to human faults [5]. Most surveys indicate that ADAS can avoid between 40% of road accidents depending on the type of ADAS and the accident scenario type [6].

Methods employed for the detection of driver drowsiness can broadly be categorized into three categories. The first group consists of methods based on the analysis of biomedical signals like brain, muscle, and cardiovascular activity. These methods, in general, need electrodes that are placed on the driver's body, which is largely deemed uncomfortable to the driver. The technique in the second category predominantly assesses driving performance through monitoring changes in car side position, speed, steering wheel, and other CAN bus signals. The benefit in these methods is that the signal is significant, and signal acquisition is extremely simple. The third type of approaches solve the issue of detecting drowsy drivers employing computer vision methods on the human face [7-9]. This type consists of driver visual analysis-based methods employing image processing methods. The reason these methods work is that drowsiness, appearance of driver and head/eye movement are considered here in this work, Viola-Jones [10] algorithm is implemented for eye pair and face detection. The second step is a sophisticated and effective method of computing Percentage of eyelid Closure (PERCLOS) of the driver. PERCLOS refers to the ratio of time for which the subject's eyes are closed during a period of time [11]. The second part of this paper makes a comparison among some work concerned with this study. The third part of the paper introduces the methods of driver's face detection, eye pair's detection and detecting drowsiness. Experimental results are discussed in the fourth part. The concluding part of the paper is presented in the fifth part.

II. Literature Survey

By using Machine learning the Driver Fatigue Detection System Based on Colored and Infrared Eye Features Fusion, Yuyang sun, Peizhou Yan, in the year 2020, this paper presents a novel method for real-time driver fatigue detection using both colored and infrared cameras mounted above the dashboard. By capturing face images, the method labels facial landmarks and segments the eye-area to calculate key features such as eye aspect ratios, blink frequency, and PERCLOS. To minimize the impact of lighting changes, a photosensitive device adjusts the weight matrix for both colored and infrared features. The approach was tested using video samples of drivers in a test vehicle, and the classification model demonstrated high accuracy in detecting

fatigue both during the day and at night, highlighting its potential for improving road safety.

In deep learning Emotion Analysis: Bimodal Fusion of Facial Expressions and EEG, Huiping Jiang, Rui Jiao, in the year 2021 This study explores multi-modal emotion recognition using EEG signals and facial expressions, aiming to improve accuracy over single-modal methods. Three models were tested: a single-mode EEG-LSTM model, a Facial-LSTM model combining facial expressions with EEG, and a multi-mode LSTM-CNN model. The classification accuracies were 86.48%, 89.42%, and 93.13%, respectively. The Facial-LSTM model improved accuracy by 3% over the EEG-LSTM, and the LSTM-CNN model further increased accuracy by 3.7% compared to the Facial-LSTM model. These results highlight the benefits of combining multiple modalities for more accurate emotion recognition, reflecting the diversity of human emotional expression.

Aim & Objective

The function of the drowsiness detection system is to help prevent accidents in passenger and commercial cars. The system will identify the initial signs of drowsiness before the driver has completely lost all alertness and notify the driver that they are no longer able to drive safely.

III. System Analysis

Proposed System: This study focuses on detecting driver drowsiness through eye-state analysis using deep learning and AI. The goal is to identify sleepiness, prevent accidents, and issue alerts. The first approach uses deep learning to analyze a series of driver images, while the second combines deep learning and AI to extract key features, which are then evaluated by a fuzzy inference system to determine if the driver is drowsy.

Advantage:

- The given system obtained greater than 95% correct output.
- Easy method to identify the drowsiness.
- Technically feasible for practical application.
- Whomever, Installed the App will receive a notification regarding the driver's active status.

Existing system: Recent sleepiness detection methods, like EEG and ECG, are costly and impractical for driving scenarios. A camera-based system is more suitable, but identifying the physical signs of drowsiness is essential for accurate detection. Challenges like lighting intensity and head tilting can affect the detection of eyes and mouth. This project reviews existing research and proposes a method to detect drowsiness using video or webcam by analyzing each frame of the recorded video.

Disadvantage:

- Drowsiness or fatigue is one of the leading causes of road accidents.
- Driver consumption of alcohol and mental stress. Both of which can result in catastrophic disaster. Road rage is now in multiples of the previous years, and it causes distress to drivers.

IV. Modules

A. Pre-processing: In this work the input videos are recorded from 7 live people. Figure 2 provides the original-colored frames. Because of the outdoor condition, there is a varied lighting condition. This is why the frames inside the video have to be pre-processed for image enhancement purposes. Histogram stretching is used in enhancing the images by improving their contrast which otherwise is low in these images.

B. Feature Extraction: Apply methods such as Eye Aspect Ratio (EAR) and Mouth Aspect Ratio (MAR) to derive useful features from the eye and mouth areas of the driver's face. These features may be employed to identify drowsiness indicators like slow blinking, yawning, and nodding.

C. Face and Eye Detection: The Viola-Jones algorithm is applied for both eye and face detection because it is highly efficient and comes at a low computational expense. Frontal face views are necessary, and it processes in real time by utilizing key elements: integral image, Haar-like features, AdaBoost, and cascade classifier. Haar-like features are the rectangular patterns that detect contrast differences in image regions. The integral image enables fast feature computation. AdaBoost chooses the most appropriate features through a process of aggregating weak classifiers to create a strong one, enhancing detection speed and accuracy. The cascade classifier eliminates non-face regions in stages increasingly strict than the last. Histogram of Oriented Gradients (HOG) is employed for feature extraction, which detects object structure by calculating gradient orientation histograms across local blocks. This increases detection accuracy by representing shape and edge features effectively.

D. Eye State Detection: Eye blinking is identified with the help of Support Vector Machines (SVM) in the method proposed here. SVM classifier is one of the strongest classification algorithms employed for the detection of eye state. With the discrimination between the characteristics of closed and open eye pairs with each other in the best possible manner, the eye state is detected

E. Driver Drowsiness Detection: Driver drowsiness state is determined based on the PERCLOS measure on three levels as indicated in Table 1. SVM, KNN, decision tree classifiers are employed for drowsiness state decision PERCLOS is the rate of eye closure computed at certain time intervals. That is, the proportion of the number of closed eyes among the number of frames over the chosen period to the number of frames for the period.

Table 1 Driver Drowsiness Detection

PERCLOS	LEVELS	EXPLANATION
0.0 to 0.15	No Warning	Awake
0.15 to 0.30	Warning	Distracted
0.30 to above	Danger	Drowsy

V. System Design

1. Architecture Diagram
2. UML Diagram
3. Activity Diagram
4. Use Case Diagram

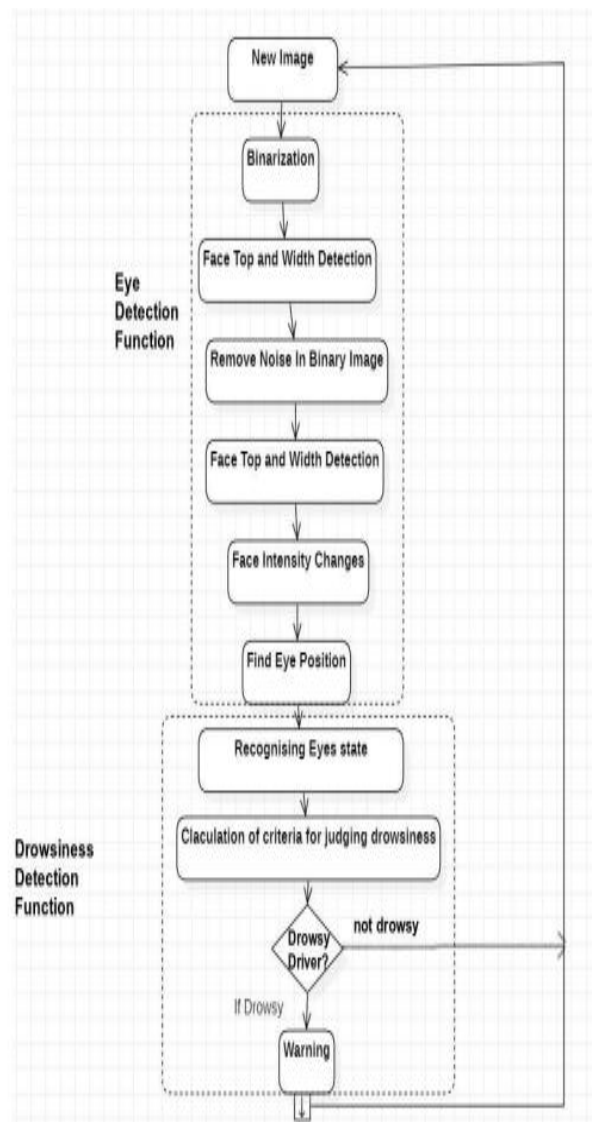


Fig 1: Architecture Diagram

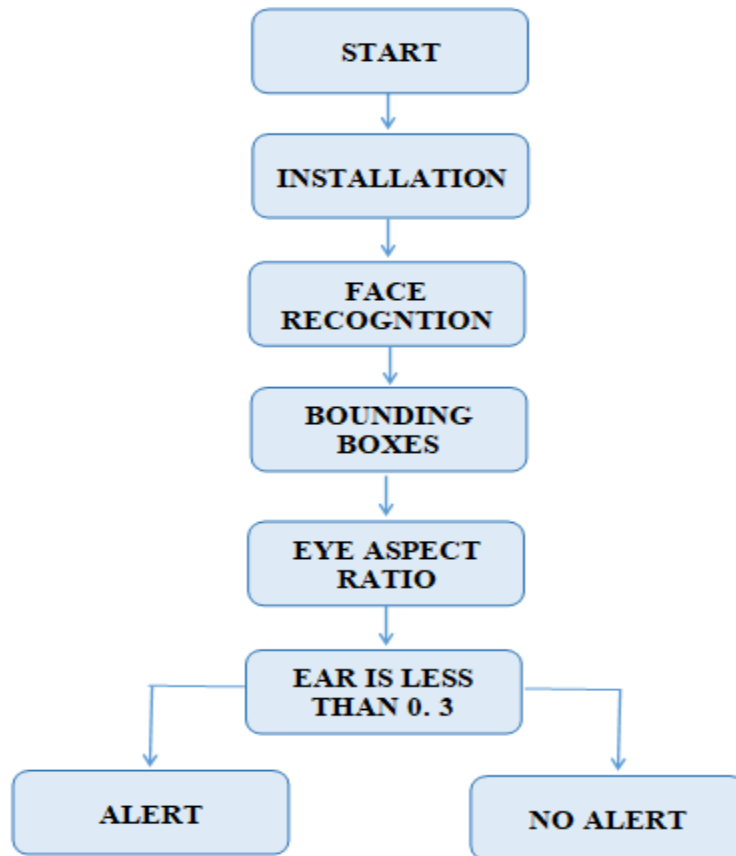


Fig 2: UML Diagram

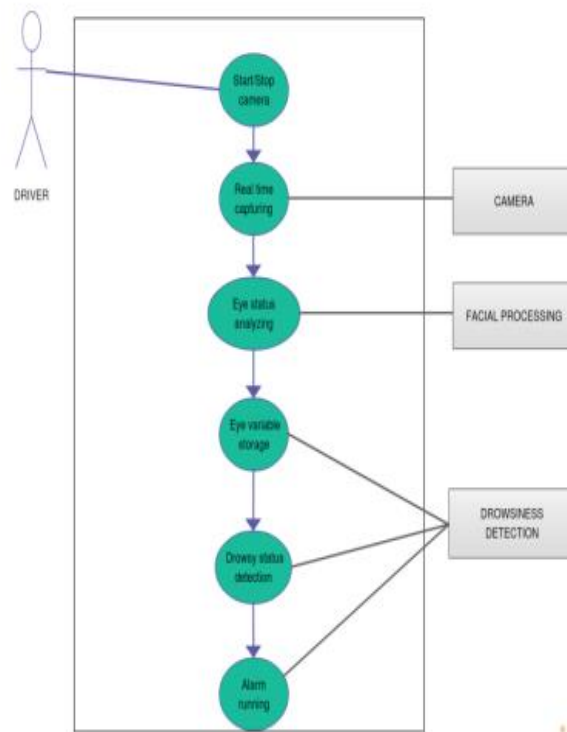


Fig 3: Use Case Diagram

This is a Driver Drowsiness Detection System that employs a camera and face processing to keep track of the driver's eye condition in real time and sound an alarm when drowsiness is established.

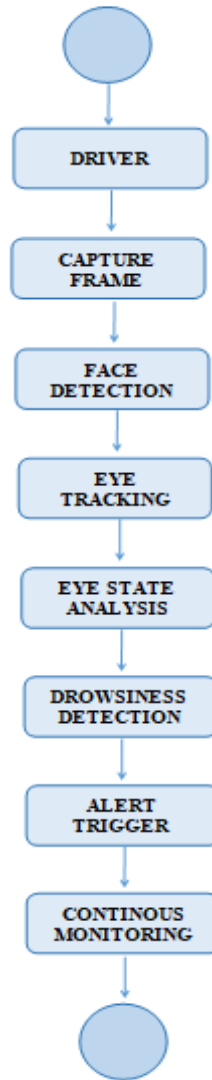


Fig 4: Activity Diagram

Use Case Diagram Flow Explanation:

1. Driver (Stick Figure):

The system tracks the driver through a camera.

2. Start/Stop Camera:

The operation begins with the on/off of the camera to record video of the driver's face.

3. Real-time Capturing:

The system records real-time video input from the camera, continuously capturing the driver's face.

4. Eye Status Analyzing:

This module examines the driver's eye status (open, closed, blinking patterns) through facial recognition methods.

5. EyeVariableStorage:

Eyestatusrelated variables (such as closure of eyes for a certain period, rate of blinking, etc.) are saved for further analysis.

6. Drowsy Status Detection:

This module utilizes the saved eye data to recognize whether the driver is drowsy or asleep. It uses thresholds or machine learning algorithms.

7. Alarm Running:

When drowsiness is sensed, an alarm is initiated to notify and wake up the driver.

VI. Machine Learning Algorithms used for Drowsiness Detection:

To identify drowsiness patterns, machine learning algorithms can be very precise, deep training and testing have to be done in order for them to be reliable, and they can be unsuitable for real-time use [8].

1. **Neural Networks:** Neural networks are AI models that replicate the human brain's function. They can detect driver drowsiness with high accuracy (up to 97%) by analyzing large datasets of behavior. However, they require substantial data, computational power, and rely on the quality of the training data.
2. **Decision trees** are machine learning models that create a tree-like structure to make decisions. They can be trained on driver behavior to detect sleepiness, and while they are easy to interpret, their accuracy in drowsiness detection is lower (around 80-85%) compared to other techniques.
3. **Support Vector Machines (SVM)** are a machine learning algorithm that uses a hyper plane to classify data. SVM can detect drowsiness with high accuracy (up to 95%) based on driving behavior. However, it can be computationally intensive, and performance depends on hyper parameter selection.
4. **Face landmark detection** uses regression trees to predict constant values, identifying 68 key points on the face, like the eyes, nose, and mouth corners. These features are useful for facial recognition, expression analysis, and detecting sleepiness.

VII. Evaluation Criteria:

There exist various evaluation standards and methods available when evaluating machine learning models such as Support Vector Machines (SVM), Decision Trees, and Neural Networks. The following is some of the most commonly employed ones for every model:

Support Vector Machine Algorithm (SVM):

Most of the work machine learning does currently is things such as classifying pictures, translating words, dealing with lots of sensor data, and forecasting future values from existing values. You can use different approaches to suit the problem you're attempting to solve.

- i. The accuracy measure computes the number of correctly classified instances divided by the total number of instances.
- ii. The performance of the model can be assessed in terms of precision and recall. Precision is the number of positive instances that are correctly predicted, and recall is the percentage of actual positive instances that are correctly pre-dicted.
- iii. F1 score is a measure that weighs precision and recall against each other by taking their harmonic mean.
- iv. Area under the ROC Curve (AUC-ROC) is a performance measure for a classifier. It is computed by finding out the area under the Receiver Operating Characteristic (ROC) curve.
- v. Confusion matrix is a device that gives an overall assessment of the predictions made by a model. It contains four categories: true positives, true negatives, false positives, and false negatives.

Neural Networks:

Accuracy is the ratio of correctly classified instances to total instances. Loss functions (e.g., MSE for regression, categorical cross-entropy for classification) measure prediction errors. A validation set helps track model performance and prevent over fitting. Learning curves show performance over time. Regularization (L1/L2) prevents over fitting by adding penalties to the loss. Activation functions (e.g., sigmoid, tanh, ReLU) impact model performance and should be chosen based on the task.

VIII. Conclusion

In this study, driver drowsiness is determined using the physical changes of the driver. Forming data set is the most important step for the proposed method. In order to make the algorithm more robust, a wider dataset has been created. A total of 7 different people's videos are used to form the dataset which includes 18.125 frames in total. Then Viola Jones algorithm is used to detect the face and eye pairs. The drowsiness of the driver is determined by taking into account the closed and open eyes detected by the PERCLOS approach. In addition, SVM, KNN and decision tree classification methods are used to for eye state and driver drowsiness detection. In this study, it has been observed that illumination intensity changes, head movements, head rotation, iris movements and body shakes can affect the detection of eye condition.

Future Scope

In the future, individuals wearing eyeglasses will be included in the study and dark environment images will be used by using NIR camera. The study will also be strengthened with hybrid methods and finally the output will be implemented on an embedded system

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