**Drowsiness Detection using Video Analysis**

**V. M. Manikandan1, K. Sree Rama Murthy2, Vijay Kashyap Kompella3, Kondaveeti Aashritha4, Boddupalli Hemanthsrisai5 and Bhavana Siddineni6**

*1 Department of Computer Science, SRM University, Amaravati, India*

*2 Department of Computer Science, SRM University, Amaravati, India*

*3 Department of Computer Science, SRM University, Amaravati, India*

*4 Department of Computer Science, SRM University, Amaravati, India*

*5 Department of Computer Science, SRM University, Amaravati, India*

*6 Department of Computer Science, SRM University, Amaravati, India*

*E-mail address: manikandan.v@srmap.edu.in, kandala\_sree@srmap.edu.in, vijay\_kashyap@srmap.edu.in, kondaveeti\_aashritha@srmap.edu.in, boddupalli\_hemanth@srmap.edu.in, bhavana\_siddineni@srmap.edu.in*

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**Abstract:** Road accidents casued due to drowsiness of the driver are quotidian. As per the World Health Organisation global report, India has the highest number of road accidents and about half or greater number are because of drowsy driving and this has become a major issue. Real-time drowsiness detection models detect when the driver is feeling drowsy by monitoring behavioral aspects or by using physiological sensors. Though use of bio-sensors give more accurate results, but they are intrusive and distract the driver. We have developed and implemented a behavioral based drowsiness detection algorithm which monitors the movement of the face and closedness of eyes to detect and alert a drowsy driver. We successfully implemented our algorithm in MATLAB software where we took a live video from webcam and processed each frame to classify as either drowsy or not. If drowsiness is detected, a system audio alert is generated to alert the driver. In case eyes or face are not detected in a frame, we by default classified it as drowsy and produced the alert message because a false negative is more dangerous than a false positive.

Keywords: Drowsiness detection, face movement detection, eye closedness detection, viola-jones algorithm, svm classifier.

# **Introduction**

Road traffic accidents claim the lives of a significant number of people in India. Highway traffic, over speeding, mobile phone use while driving, drunk drivers, and driver drowsiness are all factors that contribute to road accidents. Overall, driver drowsiness is responsible for about half of these collisions. Drowsiness is described as a stage in between wakefulness and sleep [1]. As a result, a driver's sleepiness is a key factor in serious accidents that result in a significant number of fatalities per year [2]. From the previous decade, these deaths have risen dramatically around the world. According to statistics, traffic accidents are the ninth leading cause of death worldwide. Furthermore, statistics show that 10% of crashes are caused by excessive yawning, trouble holding eyes open for longer periods of time, and failure to maintain the required distance between the front and back vehicles, as well as failure to maintain adequate distance between the side dividers, and so on. The vast majority of them occur on highways, especially after long periods of driving. From 2009 to 2013, the National Highway Traffic Safety Administration (NHTSA) [3] reported over 72,000 police-reported collisions and an estimated 100,000 crashes caused by drowsy drivers, injuring over 41,000 people and killing over 800 people. Several people have recently experienced problems with driver drowsiness. According to research conducted in India, approximately 1.51 million people died in accidents in 2018 as a result of over speeding vehicles and driver drowsiness [4]. Drowsiness has since become a leading cause of automobile accidents.

According to the World Health Organization's Global Report on Road Safety, India ranks first in the world for road accidents in 2018, accounting for 11% of all accidents worldwide.

Drivers with sleep deprivation show moderate response time, misguided thinking of the circumstance, and absence of mindfulness and abilities that are of most extreme significance while driving. Dozing off while driving has been shown to be just as dangerous and deadly as driving while inebriated. According to various reports, 1 out of every 10 drivers drives for 4-8 hours a day, 3 drivers drive for 8-12 hours per day, and the remaining 6 drivers drive for more than 12 hours per day [5]. Half of them admitted to feeling drowsy on a regular basis, particularly on long drives. When a driver is drowsy, the risk of an accident increases by up to four times when compared to when the driver is alert.

Drowsiness can be defined by a number of factors. Sleepiness is manifested in people by a variety of gestures and physical appearances, such as the eyes closing and the driver's mouth opening and yawning, or the neck slanting, among others. The behavioral-based approach is examined in this paper using eye tracking, eye flickering, face recognition, and head positioning. A camera and MATLAB tools are used to detect drowsiness in real time. As a software-based production, this technique is used.

# **Literature Review**

Over the recent years, it is observed that driver’s sleepiness has solely been the momentous reason for road accidents and can prompt serious wounds, massive deaths, and financial misfortunes. Many researchers demonstrated the need for a dependable driver drowsiness identifying framework which could caution the driver before an incident occurs. Various methods and theories have been proposed by experimentalists to identify drowsiness. They have tried to understand driver drowsiness by focusing on aspects that incorporated vehicle-based, physiological, behavioral measures, and so forth. A review of these actions will give an understanding of the current frameworks, some of the issues related to them, and the improvements that should be done to make a strong framework. Some of the ideologies are as follows.

A scheme was proposed on drowsiness detection on the basis of vehicle movement. This method mainly focused on considering the steering wheel position and its adjustments which is a most vital factor to keep the vehicle in the same lane without any deviation. Calculations were performed associating micro-adjustments of the steering and sleepiness which resulted in an efficiency of 86% in identifying drowsiness. In another case [6], users driving patterns in drowsy and fully active conditions in the system were compared by monitoring the path length among the automobile position and lane boundaries which was achieved by arranging a camera in the anterior region of the rear-view mirror and finally the deflection in the path were examined. Be that as it may, driving pattern identification depends on numerous elements like driving abilities, vehicle qualities, and road conditions.

The next class of techniques involves the assessment of the biological attributes of the users. It employs bioelectrical sensors which include Electrocardiogram, Electroencephalogram, and Electrooculogram. The EEG waveforms record the electrical activity of the brain. The principal signals for estimating the drowsiness of humans are theta, alpha, and delta frequencies. At an instant, the framework identifies a tired driver, the delta and theta biosignals raise high while the remaining biosignal signs a small increment that senses drowsiness. This strategy gives the most precision that is over 90% [7]. However, a significant disadvantage of this framework is the intrusiveness which may distract the drivers because of the connection of so many sensors. Non-meddling strategies for bio-signals estimation exist yet are less precise.

Reaserchers examined and conveyed their work by considering deep learning for drowsiness identification in brain-computer interface utilizing the fNIRS framework. The scientific technique for functional optical brain imaging or fNIRS is a procedure based on near-infrared spectroscopy with the end goal of practical neuroimaging. Both dorsolateral prefrontal cortices and prefrontal cortices were engaged in fNIRS activities. Deep networks were used in identifying both active and sleepy conditions. The testing was carried out with convolutional neural networks. It was used on color map pictures to determine the best reasonable mediums for monitoring the functions in the brain [8].

Furthermore, a framework was built which figures driver's breath changes by observing pulse rate. This framework has downsides which include direct contact with the skin and may also be impacted by the driver’s activities. Other works include the usage of EEG sensors to record the electrical activity of the brain. Physiological estimation strategies that can check the action of the brain, pulse, and skin conductance are regularly not realistic as the sensing electrodes would be very meddlesome and diverting to the driver [9].

Likewise, speech recognition techniques can be employed to distinguish a sleepy or dozy voice in the vehicle [10]. The idea involves voice analysis of humans to understand their level of fatigue. The outcomes are at the same time approved through Electroencephalography (EEG) based estimations. A trial was done where the persons are approached to tell specific sentences at various levels. The responses were observed for the figuring of different boundaries like duration, unvoiced length, and reaction time. Also, Mel Frequency Cepstral or MFCC Coefficients is used to understanding the quietness, voiced forms, as well as unvoiced forms, and these parts, are set apart utilizing a Gaussian Mixture Model (GMM). Nonetheless, a disadvantage is these techniques are complicated.

In [11] authors have introduced a theory in which the person's gaze is analyzed utilizing various new profound deep-learning procedures based on convolution neural networks and facial appearance. A deep learning algorithm is prepared to sort the gaze from a given face-recognized picture through a multi-GPU stage, and afterward, its network parameters are moved to a GPU inside a PC that runs on Windows. However, this methodology is having inadequacy of the necessity of a large amount of information to prepare a network to coordinate and work well with an undeniable degree of precision.

In [12] experimentalists have taken just the status of iris for identification of dozy or sleepiness. They didn't consider the yawning identification or the head movement like lowering and that leads down to a framework with a greatly improved exactness. They introduced a system to analyse the gaze utilizing both eye signs and head signs. They likewise proposed a monocular-camera framework and also a vigorous eye cue algorithm. They figured features of the eye that can be useful for data related to the driver's gaze. Likewise, they gathered naturalistic driving information and assessed the framework execution and performance.

In [13] the idea depends on facial component extraction through PC vision and the behaviors like yawning length, the appearance of the face, head, and eye movements are utilized. To measure sleepiness the distance between the eyelids was considered as a major parameter. The recognition has been done based on the recurrence of the eye flickers, and the suspicion that count rises as the individual gets dozy. Yawning is also considered for sleepiness and the Viola Jones algorithm was used for understanding and analyzing them.

# **Proposed Method**

This section discusses the proposed method to detect drowsiness. A behavioural based approach which analyses the frontal features of the driver is followed. This method involves detection of face, eyes and head movement. It is implemented by means of MATLAB software. The process begins by capturing of live video from the camera. This acts as an initial input for the scheme. Further an image is selected from the live streaming and face detection procedure is performed on this captured frame. Face Detection is achieved using Voila Jones Algorithm. In built functions present in MATLAB are used to invoke methods for face and eye detection.

The Voila Jones Algorithm detects frontal faces from the frames that are converted from coloured to grayscale images. A learning algorithm is utilized implemented to detect faces. The captured snapshot is divided into a grid like structure. Detection windows are used to recognize and evaluate haar like features of the rectangles in the grid. The integral image is formed by the summing up the terms of a rectangular subregions. Then a cascading system is used for further processing. The first stage consists of the subregions passing through the best features and if it is evaluated to positive then the remaining features are considered in the later stages. Finally, if all the classifiers accept the image, the region is classified as a human face and the detection is shown.

The live capturing continuous until the user exits the system. This is ensured as the driver can feel drowsy at any duration and hence continuous detection is mandatory. A loop operation is performed for the purpose. Initially any random frame is considered. The snapshots are continuously captured followed by face and eye detection which creates a rectangular bounding box over the frame. The eye detection method involves the following stages. The first step is to detect both left and right eyes and convert the captured frame to grayscale image. If multiple faces are detected intial or the first row is considered. The second step involves the calculation of the box coordinates of both left and right eyes. The frame is then cropped based on the calculated resultant. The next stage involves checking whether the number of elements that store bounding box values are non-zero and if the result is positive then update the values otherwise change them with initial box coordinates. Finally, the both the eyes are cropped and are further enlarged.

To analyse the eye movement a support vector machine (SVM) classifier is loaded. It is a supervised model in machine learning which used in classification problems. Identification of the candidate’s eye region and classifying them based on the state of the eyes is possible through SVM. It uses hyperplanes to differentiate two or many classes.  SVM attempts to form a decision boundary such that the separation between the two classes is maximum. Also, it is viable to perform a good and quick detection of eye operations since we can protect any false recognition through svm. The next phase consists of extracting the histogram of oriented gradient (HOG) features for both eyes as shown in Fig. 1 which results in a vector Fig. 2 that is employed for further tracking and detection. The features predict the class labels for the left eye where the predictor data consists of the previously extracted features. Similar procedure is carried out for the right eye. The predicted data obtained is examined by checking whether both the eyes are fully open or not. Based on the result the eyes are classified into blinking or active state. If any of the predicted data is true then the corresponding eye is open and another eye is entitled as closed. This method results the state of the eye along with data of each eye describing the openness or closedness.

If the eyes are neither in active state nor in blinking state then an audio signal is generated prompting the user to open the eyes which is achieved by reading the string with the help of text to speech synthesizer. This is also indicated by modifying the bounding box colour to red.

For the head movement detection, Euclidean distance between the frames is calculated continuously and is compared to a threshold value. This proposed method considers the threshold value of 5 which is obtained from the continuous experimental study. If the Euclidean distance is greater than this threshold value of 5 then display as moving. The box coordinates are updated and frame is appended to the videoplayer. This process of head movement detection, face and eye detection is carried out until the user exits the system. Below are the steps followed to implement the proposed approach.

|  |  |  |
| --- | --- | --- |
|  |  | 32x32 HOG |
| (a) Open Eye HOG features | | |
|  |  |  |
| (b) Closed Eye HOG features | | |

1. Eye states and their HOG features

We can observe that for an open eye the HOG features align in a circular shape around the eye, whereas for an open eye they don't align. So using these HOG features we can use SVM classification to classify an eye image as either open or close.

|  |
| --- |
|  |
| (a) Open eye |
|  |
| (b) closed eye |

1. Plot of HOG feature

|  |  |  |
| --- | --- | --- |
| Algorithm 1:Drowsiness Detection using video analysis | | |
| Input | | Live Video Streaming through Webcam |
| Output | | Audio Alertbased on drowsiness detection |
| 1 | Setup and initialize webcam object *cam*, video displayer object *vp*, viola-jones face detector *fd* and eye detector *ed* | |
| 2 | Capture one frame and store the frame properties such as size, resolution, and use *fd* to get bounded box *bbox [x, y, width, height]* properties of initial face position. | |
| 3 | Declare a global assembly for audio alert and instantiate object *ss* for speech synthesisand change to full volume. | |
| 4 | while ┐(system is closed) do | |
| 5 | get a *Frame* from *cam* | |
| 6 | Detect face in Frame using viola-jones algorithm and store face position bounding values in *bbox2 [x, y, width, height].* | |
| 7 | If *((bbox(2)-bbox2(2))^2 + (bbox(1)-bbox2(1)) ^2) ^0.5 > 5*: | |
|  | 1. display face is moving | |
|  | 1. Give low volume sound alert | |
| 8 | Update *bbox=bbox2* | |
| 9 | Crop face from *Frame*. Now calculate ROI for expected eye positions based on standard face ratios | |
| 10 | Crop each eye from *Frame* and store in *left* and *right*. | |
| 11 | Perform parametrised viola-jones algorithm for eye detection in ROI to get exact eye positions in *Frame*. Crop these and store in same variables. | |
| 12 | Extract HOG features from each eye image and feed it to the SVM classifier which will resturn a binary result for each eye in *Lresult, Rresult.*  *(*where 1 means open and 0 means closed) | |
| 13 | Initialise left message *L*, right message *R*, and drowsiness status *D* as *“left eye: closed”*, *“right eye: closed”* and *“Blinking”*. Set box color to yellow. | |
| 14 | If *Lresult*=1or *Rresult*=1: set *D=”awake”* | |
| 15 | Else: Give full volume sound alert *“Please open your eyes”* and change box color to red. | |
| 16 | If  *Lresult*=1: set *L=” left eye: open”* | |
| 17 | If *Rresult*=1: set *R=” right eye: open”* | |
| 18 | Insert rectangle over face, eyes in *Frame* and add timestamp, messages *L, R, D* at top left of *Frame*. | |
| 19 | Append *Frame* to the videoplayer object. | |
| 20 | End of while in step 4 | |

# **Experimental Study and result analysis**

The experimental study and result analysis is carried out on the live video footage obtained from the webcam of our laptops. The webcam video has uint8 RGB frames of resolution 640x360. We have implemented the code using MATLAB R2020b software and captured the output video in ‘.avi’ format. We took a live snapshot from webcam and detected face movement and classified both eyes as open/close. A yellow rectangle is inserted around the face and eyes if they are detected. If face movement is detected, a message is displayed over the rectangle around the face and also an audio output is given alerting the driver to come back to the static position. The state of each eye is displayed as an inserted text in the frame at the left top corner position. If both the eyes are detected as closed, then a system audio alert is given to wake up the driver from predicted drowsiness. A timestamp is inserted in every frame to concur the video continuation. Each frame is appended in a video displayer. A pause of 0.5 seconds is given at the end of each iteration to let the processing complete smoothly and since we don’t need to analyse the footage at every instance. The framerate of all videos is also reduced for the same reason.

Table 1 shows few frames of input, the desired output and the experimental output tested on 5 different persons in different states.

1. Test Frames

| S.no | Frame | Desired Output | Experimental Output |
| --- | --- | --- | --- |
|  |  | Face status: moving  Right eye: open  Left eye: open  Drowsines: No | Face status: moving  Right eye: open  Left eye: open  Drowsiness: No  Result: Accurate |
|  |  | Face status: Not moving  Right eye: open  Left eye: open  Drowsines: No | Face status: Not moving  Right eye: open  Left eye: open  Drowsiness: No  Result: Accurate |
|  |  | Face status: moving  Right eye: closed  Left eye: closed  Drowsiness: Yes | Face status: moving  Right eye: closed  Left eye: closed  Drowsiness: Yes  Result: Accurate |
|  |  | Face status: Not moving  Right eye: closed  Left eye: closed  Drowsiness: Yes | Face status: Not moving  Right eye: closed  Left eye: closed  Drowsiness: Yes  Result: Accurate |
|  |  | Face status: Not moving  Right eye: open  Left eye: closed  Drowsiness: No | Face status: Not moving  Right eye: open  Left eye: closed  Drowsiness: No  Result: Accurate |
|  |  | Face status: Not moving  Right eye: closed  Left eye: open  Drowsiness: No | Face status: Not moving  Right eye: closed  Left eye: open  Drowsiness: No  Result: Accurate |
|  | **Person with big frame Spectacles** | Face status: Not moving  Right eye: closed  Left eye: open  Drowsiness: No | Face status: Not moving  Right eye: closed  Left eye: open  Drowsiness: No  Result: Accurate |
|  | **Person with small frame Spectacles** | Face Status: Not Moving  Right Eye : open  Left Eye : open  Drowsiness : No | Face Status : Not moving  Right Eye : Closed  Left Eye : Closed  Drowsiness : No  Result : Not Accurate |
|  | **Person with big frame Spectacles** | Face status: moving  Right eye: closed  Left eye: closed  Drowsiness: Yes | Face status: moving  Right eye: closed  Left eye: closed  Drowsiness: Yes  Result : Accurate |
|  |  | Face status: moving  Right eye: closed  Left eye: closed  Drowsiness: No | Face status: Not moving  Right eye: closed  Left eye: closed  Drowsiness: No  Result: Accurate |

# **Result Analysis**

The program compiled and ran succesfully. It accurately detected face, eyes, face horizontal and vertical movement, left eye, right eye, closedness of left eye, closedness of right eye and inferred drowsiness state. Face movement was detected in all frames, including bright and dim lighting. Eye detection failed if the eyes are not fully visible in frame e.g in case of small frame spectacles.

If drowsiness is detected an audio alert is succesfully given to alert the driver.

In case the eyes or face are not properly detected, as a safety precaution we mark it as drowsiness detected because a false positive is tolerated but a false negative is fatal.

# **Conclusion**

We have introduced a drowsiness detection algorithm based on behavioral-based approach and image processing. It monitors and detects any head movements and classifies each eye as open or closed. We have used viola-jones algorithm for face detection and calculated a distance between positions of face in consecutive frames, if this distance is greater than a threshold value we infer that the face is moving. For eye monitoring, we utilised a pre-trained SVM classifier model to classify a cropped eye image as either closed or open. The status of both eyes along with a timestamp is inserted & displayed in the live frame. If any head movement is detected a warning message is displayed on the screen and a low volume audio alert is given. If both eyes are detected as closed, then a full volume audio alert is given to alert the driver. We implemented our algorithm in MATLAB software where we did our experimental study on live webcam video. We have analysed our results and concluded that our algorithm accurately detects face movement in all scenarios but it fails to detect the eye closedness if the eyes are not fully visible in the video footage. We plan to overcome this drawback in our future works by using point tracking analysis combined with MaxBidirectionalError.

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# **AUTHORS PROFILE**

**Dr. V. M. Manikandan** currently working as an Asst. Professor in Computer Science and Engineering at SRM University-AP, Andhra Pradesh, India. He did his Ph.D. in Computer Engineering from the Indian Institute of Information Technology Design and Manufacturing Kancheepuram, Chennai, Tamilnadu, India after his M.Tech in Software Engineering from Cochin University of Science and Technology, Kerala, India. He is an Associate Member of The Institution of Engineers (India). His research interests include reversible data hiding, digital watermarking, and digital image forensics.

**Mr****. Kandala Sree Rama Murthy** is currently doing his B.Tech in Computer Science and Engineering at SRM University-AP, Andhra Pradesh, India. His research interests include design and implementation of digital image processing algorithms and machine learning.

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**Mr. Vijay Kashyap Kompella** is currently pursuing B.Tech in Computer Science and Engineering at SRM University-AP, Andhra Pradesh, India. His reserch areas include Machine Learning and natural language processing.



**Mr. Boddupalli HemanthSriSai** is currently pursuing B.Tech in Computer Science and Engineering at SRM University-AP, Andhra Pradesh, India. His research areas are image processing and human activity analysis.



**Ms. Bhavana Siddineni** is currently pursuing B.Tech in Computer Science and Engineering at SRM University-AP, Andhra Pradesh, India. Her research interests include applying machine learning techniques in day-to-day life



**Ms. Kondaveeti Aashritha** is currently pursuing B.tech in Computer Science and Enginnering at SRM University-AP, Andhra Pradesh, India. Her research interests lie in Machine learning in computer vision.