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# A Comprehensive Study on Behavioural Parameters-Based Drowsiness Detection Techniques

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***Abstract***— Drowsiness or fatigue is one of the major causes of road accidents. Numerous deadly mishaps can be forestalled if the drowsy drivers are cautioned in time. A variety of drowsiness detection techniques exist that monitor the state of the driver while driving and a warning alert is triggered if they do not concentrate on driving. In order to determine the state of the driver, various relevant features from facial expressions can be extracted such as yawning, eye closure, and head movements. This paper aims to study the existing techniques in order to enhance them or create a hybrid of them for a better result. The study highlights existing behavioural drowsiness detection techniques. Firstly, in this paper, we classify the existing techniques into three categories: behavioural, vehicular, and physiological parameters-based techniques. Our main focus is on the behavioural parameters. Secondly, implementation techniques for behavioural parameters used for drowsiness detection are reviewed in detail. In the end, the accuracy of each technique implemented is represented in a tabular format. The challenges faced along with the conclusion of the study may help researchers for finding further work in the relevant field.

***Keywords***—Driver drowsiness, fatigue detection, supervised learning, classification, support vector machine (SVM), yawning, eye closure.

## I. INTRODUCTION

Driver's Drowsiness is one of the major concerns that can lead to road accidents. Drowsiness or fatigue can be due to exhaustion, mental stress, and lack of proper sleep, boredom or alcohol consumption. These factors can also be fatal in certain scenarios. Various studies have shown that many road accidents are fatigue based. Due to technology and advancement, many techniques have come into existence which can be fruitful to detect the driver's state. Various safety measures are taken by people to safeguard themselves while driving like installation of reverse cameras in automobiles etc. Detecting Driver's Drowsiness is one of the measures to ensure road safety. There have been remarkable contributions by many researchers for fatigue detection. This paper recapitulates most of the existing techniques with the accuracy for the researchers to have a quick view.

Many android based applications have been invented to make the driver alert by looking at the parameters such as the face, eyes, head positioning, yawning. Steering wheel-based sensors, child lock, centre locking are the preventive measures for own safety.

People who work in night shifts and plan for long-distance travelling are more feasible to drowsiness. Therefore, lack of sleep can make the person's eyes blink, lead to distraction, and change the head position which could lead to serious casualties. Hence, the objective of this paper is to a detect driver's drowsiness by considering these parameters and make a technique which would make the driver alert and save his life.

### I.I Driver Drowsiness Techniques:

Techniques for Driver Drowsiness can be broadly classified into three classes [5]:

**I.II.I Behavioural parameter-based technique:** Behavioural parameters include eye detection, eye blinking, eye tracking, face expression, head tilting etc. Facial expressions can be recorded by the cameras installed or by the rear cameras of the Smartphone. Firstly, the face is detected by the appropriate algorithm. Then the region of interest is extracted and analyzed and further technique is implemented.

**I.II.II Vehicular parameter-based technique:** Vehicular parameters include a steering wheel and lane detection. Various algorithms can determine frequent lane changing and steering wheel angles which can further predict the level of drowsiness.

**I.II.III Physiological parameter-based technique:** Physiological parameters include EEG (Electroencephalogram), ECG (Electrocardiogram), pulse rates and many more. These parameters help in determining a driver's fatigue based on signals.

For better understanding, Figure 1 depicts the architecture for Driver Drowsiness Detection Technique:

 

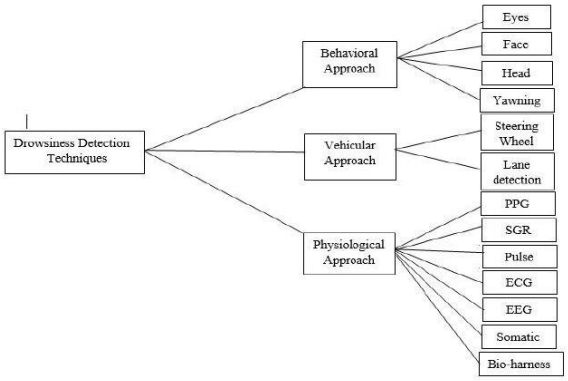


Figure 1. Architecture of Drowsiness Detection Techniques [5]

This paper is subdivided into four main sections. Section I contains the introduction of the paper which tells us about different approaches of drowsiness detection techniques.Section II describes the literature review. Section III describes the challenges faced during the implementation of the techniques and the purpose of the study. Section IV concludes the study of the paper with future direction to further enhancements in this field.

## II. RELATED WORK

A brief review of the related works is listed below:

**Anilkumar C.V, Mansoor Ahmed, Sahana R, Thejashwini R, Anisha P.S** proposed a safety system for the driver by detecting the face along with the heart rate. The main purpose of this system is to reduce the accidents which are caused by the driver's negligence. Frame difference algorithm was implemented to detect the head movement. Heartbeat rate was determined by the R-peak detection algorithm. After the detection, if any abnormality were detected in the driver's behaviour while driving, the alert would be triggered to the driver in the form of the buzzer. The entire process was simulated using MATLAB [1].

**Ashish Kumar and Rusha Patra** designed a method that was lowcost real-time drowsiness detection with increased accuracy. In the method implemented, a webcam was firstly used to record and the face was detected from the recorded video from each frame using the image processing techniques. Eye aspect ratio, nose length ratio and mouth opening ratio was computed from the landmarks on the detected face. Machine learning algorithms have been implemented in the method along with the SVM classifier. Their method outperformed the value of the accuracy that would have been calculated from the Bayesian technique. They both calculated the sensitivity and overall accuracy [2].

**Bappaditya Mandal, Liyuan Li, Gang Sam Wang, and Jie Lin** proposed a vision-based fatigue detection method for heavy vehicles such as buses and trucks and not for the cars. A measure percentage of eyelid closure (PERCLOS) is implemented which checks for the eye's openness and closure. A systematic analysis of the algorithm proposed was experimented in which the analysis of the continuous level of open eyes is made and a fusion algorithm is implemented to check the status of both eyes. The proposed robust method is performed for an oblique angle as well which could be a challenging factor. The experimental results showed that the method distinguished the sleepy state from the normal state [3].

**Belhassen Akrout and Walid Mahd** proposed a method for yawning detection of the driver while driving. Their approach was based on the spatial-temporal descriptors of non-stationary and non-linear signals. Also, it was based on locating the lips. The signals were detected by the method of the "Zero-Crossing". To further enhance their approach, they would also consider the state of the eyes and the 3D pose estimation [4].

**Feng You, Xiaolong Li, Yunbo Gong, Haiwei Wang, Hongyi Li** proposed a method for drowsiness detection based on individual differences in drivers. A deep convolutional neural network was used to determine the face in real-time. Various landmarks of the face detected by the Dlib Toolkit, were considered whose further analysis introduced a new landmark i.e. Eyes Aspect Ratio. There were two modules i.e. offline training and online monitoring which depends on the differences on the driver's eye. In the offline training module, Support Vector Machine was used which took the Eyes Aspect ratio and the latter one a trained classifier was used to simply monitor the driver. The experiments carried out demonstrated that the proposed method outperforms the existing drowsiness detection technique in terms of both accuracy and speed [5].

**Jang Woon Baek, Byung-Gil Han, Kwang-Ju Kim, Yun-Su Chung, Soo-In Lee** proposed a novel drowsiness detection technique by acquiring the image of the driver and then estimated the landmarks on the face region. The algorithm used the Adaboost Classifier method. The eye state (open/close) was determined by the Eye Aspect Ratio.

 

The proposed algorithm provided a real-time performance that could be used on any system [6].

**Jun-Juh Yan, Hang-Hong Kuo, Ying-Fan Lin, Teh-Lu Liao** developed a drowsiness detection using the PERCLOS and the grayscale image processing. Their methodology consisted of three parts. Firstly, it calculates the position of the driver in grayscale image and the eye positions are analyzed with and without glasses. Secondly, the data is extracted and a fatigue model is established. As soon as the model is examined by continuously monitoring the driver's state, the alert system triggers the warning to the driver [7].

**Kangning Li, Shangshang Wang, Chang Du, Yuxin Huang, Xin Feng, Fengfeng Zhou** integrated morphological features such as mouth as eyes and further investigated each of those aspects based on their numbers. Their proposed algorithm called Recognizing the Deep Expression (REDE) received 10-fold cross-validation accuracy. This method outperforms the existing methods for the run time which is a challenging factor. Firstly, A LBP algorithm was implemented and then the SVM model was trained to do the classification. The REDE algorithm runs faster and outperforms other proposed methods [8].

**Lei Zhao, Zenkai Wang, Xiaojin Wang, Qing Liu** implemented a method for drowsiness detection by using facial dynamic fusion information and Deep Belief Network. They first extracted the landmarks and textures of facial expression from the video captured by a high definition camera. A Deep Belief network was developed to further classify facial expressions. Experiments were carried out independent of gender and other illuminations and it was validated to give highly accurate results [9].

**Marchel T. Tombeng, Hence Kandow, Stenly I. Adam, ArghaSilitonga, JuveKorompis**designed a technique for drowsiness detection that works for the Android Operating System. In order to avoid road accidents due to fatigue, the authors used the OpenCV library for digital image processing. OpenCV library uses a Haar Cascade Classifier for detection of the eyes and face. They further concluded that the camera which captured the images of the driver can be connected to the android system with wireless technology [10].

**Melissa Yauri-Machaca, Brian Meneses-Claudio, Natalia Vargas-Cuentas, Avid Roman-Gonzalez** had major objectives while detecting the driver's drowsiness. They focused on the factors that made a driver fall asleep by stating that the quality of the sleep depends on the number of the hours. Also, they mentioned that the most notable characteristics in determining the drowsiness is the frequency of blinking of the eyes, closure and the opening of the eyes. They acquired the image of the driver sleeping and further processed it in the MATLAB [11].

**Menchie Miranda Alonica Villanueva, Mark JomarBuo, ReynaldMerabite, Sergio Paulo Perez, and John Michael Rodriguez** proposed a system for the driver's safety that was based on the scanning of the eyelid movement. The report was sent to the driver automatically from the web application through the internet of things. The technology uses the internet of things so that the owner of the vehicle would be aware of the driver's actions. They conducted many types of tests, for instance, normal status with regular eyes, normal status with small eyes and so on. Their algorithm was built with dlib, OpenCV, Python installed in Raspberry Pi 3. Their experiments achieved a high rate of accuracy [12].

**Muhammad Tayab Khan,Hafeez Anwar et al.** proposed a method for real-time video by determining a person's eye whether opened or closed. The method included a four-step procedure. Firstly, the determination of the face from the entire region including the background. Secondly, the extraction of the face from the videos. The methodology only considered the Region of Interest i.e. eyes. It further removed noise such as eyebrows and focused only on the curvature of the eyes. Based upon the curvature of the eyes, it was classified as opened or closed and it will trigger the alarm system invented to make the driver alert [13].

**Omar Rigane, Karim Abbes, ChokriAbdelmoula and Mohamed Masmoudi** developed a novel approach using the visual behaviour of the driver while driving. They used a fuzzy logic controller for combining the facial as well as eye parameters. The results of the experiments proved to be more reliable and robust. They implemented the experiments using the SVM and NN classifiers [14].

**Omar Wathiq and Bhavna D. Ambudkar**designed a novel method to improve the efficiency of the driver's safety. Firstly, they reviewed the approaches that were used to implement the drowsiness detection and based on the limitations of the discussed approaches they developed their new method. Their method had the objective to primarily

 

improve the safety technique. Their technique is based on optimized face detectors and feature extraction with SVM classifier [15].

**Rateb Jabbar, Khalifa Al-Khalifa, Mohamed Kharbeche, Wael Alhajyaseen, Mohsen Jafari, Shan Jiang** proposed a novel approach for real-time fatigue detection. The proposed method was implemented on the android application. The approach used the deep neural network technique ie. Multilayer's perceptron classifier which took the facial images as an input. Their work compressed a heavy baseline model to a lightweight model i.e. it can be used for compact android devices. Also, a structure was further invented which primarily focused on the facial landmarks key point detection to check whether the driver is sleepy or not [16].

**Samra Naz, Aneeqa Ahmed, Qurat ul ain Mubarak, Irum Noshin** focused primarily on the features that should be taken into consideration while detecting drowsiness. Their proposed method suggested that based on one feature the detection of the fatigue would not be accurate. So, they combined the features extracted from facial expressions such as yawning, head movement and eye closure simultaneously. They considered three parameters for the detection of drowsiness (high/medium/low) and generated a signal based on these levels [17].

**Umit Budak, Varun Bajaj, Yaman Akbulut, Orhan Atilla, Abdulkadir Sengur** developed an efficient hybrid approach for drowsiness detection based on EEG. EEG signals that depend on the brain were used to detect the drowsiness of the driver. The work was divided into three different blocks. Firstly, energy distribution and zero-crossing distribution was collected from the raw EEG or the EEG spectrogram images. Secondly, a method of deep feature extraction was implemented on the EEG spectrogram images. In the last building block, a Q-factor wavelet transform was used on those images to divide them into sub-bands. The features from all the building blocks were fed into the long short-term memory. Their experimentation was based on Wavelet Transform and Artificial Neural Network and a comparison was made from each building block which received a high accuracy rate for determination of drowsiness [18].

**Wanghua Deng and Ruoxue WU** invented a system called DriCare which focused primarily on the extraction of facial features such as eye blinking, yawning, duration from which the eye was closed etc. without equipping any device on the body. They also considered the prevailing problems with fatigue detection and introduced a new face tracking based on 68 key points for a face. The method evaluated the status of the driver to enhance the detection of driver's fatigue [19].

**ZhuoniJie, Marwa Mahmoud, Quentin Stafford-Fraser, Peter Robinson, Eduardo Dias and Lee Skrypchuk** developed a method that would analyze the yawning in a spontaneous expression of the drowsy driver. They also included face touches as a novel cue in automated driver drowsiness detection. Their method detected both covered and uncovered yawns. It also included geometric and appearance features of both mouth and eye region. However, their technique would be best implemented by combining their results in a hybrid approach [20].

Table 1: Summary of behavioural based parameters with accuracy

| Reference No: | Parameters | Techniques Used | Accuracy |
|---|---|---|---|
| 1 | Head Movements and Heart Beat rate | Frame Difference Algorithm, R-peak Detection Algorithm, MATLAB | NIL |
| 2 | Eyes, Head and Mouth | HOG, SVM, Eyes Aspect Ratio ,Mouth Aspect Ratio, Nose | 95.8% |
| 3 | Head Shoulder, Face Detection, Eye Openness | PERCLOS | NIL |
| 4 | Yawn Detection | Detection of lip contours, Zero-Crossing Method | 85% |
| 5 | Eyes | CNN, SVM, Eyes Aspect Ratio | 94.80% |
| 6 | Eyes | AdaBoost Classifier, Eye Aspect Ratio | NIL |
| 7 | Eyes | Gray Scale simulation, Sobel Operators | 94.36% |
| 8 | Eye and mouth regions | REDE algorithm | 96.07% |
| 9 | Eye and Mouth changes | Deep Belief Network | 96.7% |
| 10 | Eyes | OpenCV library, HAAR cascade classifier | NIL |
| 11 | Eyes opening and closing | MATLAB | NIL |
| 12 | Eyelid Movement | dlib, OpenCV, and Python, Raspberry Pi3 | 95% |
| 13 | Eyes | Viola- Jones algorithm, Sobel Operator | 93.79% |
| 14 | Eyes | HOG descriptor, Neural Network Classifier, Fuzzy Logic | About 94% |
| 15 | Face Detection, Eyes Detection, Yawning | Viola-Jones Algorithm, SVM classifier | NIL |
| 16 | Facial landmark position | Deep Neural Network Technique | 80% |

 

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|---|---|---|---|
| **17** | Eye Closure, head moment and yawning | Gray Scale Conversion, Frame differences | NIL |
| **18** | EEG signals | Signal Processing, LSTM network, Deep Feature Extraction | 94.31% |
| **19** | Yawning, Blinking of Eyes, Duration of Eye Closure | DriCare Method | 92% |
| **20** | Hand over face touches and Yawning | HOG, LBP, SVM classifier | 95% |

## III. RESEARCH GAP & NEED OF STUDY

The following points have been analyzed based on which there is a need to elaborate on the existing work:

III.I Focuses primarily on eyes detection only [6] [2].

III.II More complex images where the mouth is covered with hands while yawning and other behavioural features should be involved are not considered.

III.III Most of the proposed methods are applicable only during the day time.

III.IV Eyes detection methodology can pose a problem if the driver is wearing glasses.

The main purpose of this study includes designing an enhanced drowsiness detection technique to improve the overall accuracy. In order to determine the accuracy, we need to compare the proposed technique with the existing technique based on various parameters.

## IV. CONCLUSION & FUTURE SCOPE

Driver's drowsiness is one of the main factors that can prove to be fatal at times. Countermeasures need to be taken to make the driver alert. Drowsiness techniques can be broadly classified into three categories i.e. behavioural, vehicular and physiological.Various techniques have been implemented to improve the accuracy of the experimental results. The central idea of this systematic review is to study various techniques implemented in the behavioural parameters-based drowsiness detection system along with accuracy. There are many limitations as highlighted in Section III. Future work can be done by making ahybrid of techniques to overcome the issues associated with them and hence results can also be improved. Consider yawning and more complex images like eye and sunglasses etc. to improve efficiency.

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