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Article

A Study on Driver Sleepiness Alert System

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A B S T R A C T

Expertise advancement has always been a great boon to human life that helps to develop many systems which adds comfort, safety, advancement, and so on, in every field right from agriculture to industries. One of such area is to have an automatic system for detecting driver sleepiness condition that will alarm the driver to stop driving. Many systems are available in this area for warning the driver of his drowsiness for safety of drivers. This paper is survey of driver sleepiness classification that will help us understand different techniques that can be employed to make this alert system more accurate thereby increasing the rate at which drowsiness detection can be done. This paper also introduces how modern technology like Machine learning and IoT can also be used to enhance the performance of driver sleepiness detection which will avoid accidents and ensure read safety.

General Terms

Classification, Pattern Recognition, Security, Algorithms

Keywords: Neural Network, Machine learning, Driver Drowsiness, Driver Sleepiness, Accident Detection System

Introduction

Conferring to the survey of world health organization, every year about 1.25 million people are killed in road accidents and most of these people are from age set 15-29. The percentage of crashes caused due to drowsiness is about 10-20%In many cases drivers are aware of sleepiness but still they continue to drive.[9] To stop drivers from driving in the sleepyconditions many smart sleepiness warning systems has been designed and some of them are already inmarket, unfortunately quantification of sleepiness is still an issue and the exact measure of drowsiness has yet to found. Now-a-days, many schemes are available in market like navigation systems, warning alarm systems etc. to make driver'swork easy. But still Driver sleepiness is one of the major reasons of traffic accidents. Drowsiness reasons more roadaccidents than drink-driving. It is a serious highway safety problem which leads to health injuries, deaths and economicallosses. Ifdrivers could be signaled before they became too sleepy to drive safely, some of the crashes could beavoided. Drowsiness detection systems is yet not that effective due to `not considering the individual differences. Based on the kind of data used, sleepiness detection systems can be differentiated as of invasiveand non-intrusive methods. Different parameters for Sleepiness detection systems are - vehicle groundedevents, behavioral measures and physiological measures.[7] Vehicle based information like steering position and deviation of lane positioning can be used for sleepiness detectionand are already present in modern vehicles but warning generated are often inaccurate and unreliable. Behavioral information like eye closure,eye blink, yawning and head postures can also be used but recognition of headpositioning or eye blinks or other features extraction using camera is still hard and clumsy especially due to changing lightconditions. Physiological signals like ECG, EEG, and EOG also can be helpful and accurate for sleepiness detection but again is clumsy and difficult.[5] We can use hybrid measures like

machine learning and neural networks to build drowsiness detection systems and these various drowsiness detection techniques researched have been discussed in this paper which are then further classified and compared with the help of their features. Different Drowsiness Detection Techniques.

Numerous techniques that have been utilized by investigator to spot sleepiness are vehicle based procedures, Behavioral measure, Physiological based measures and combination of measures i. e. Hybrid approach are shown the following figure7,

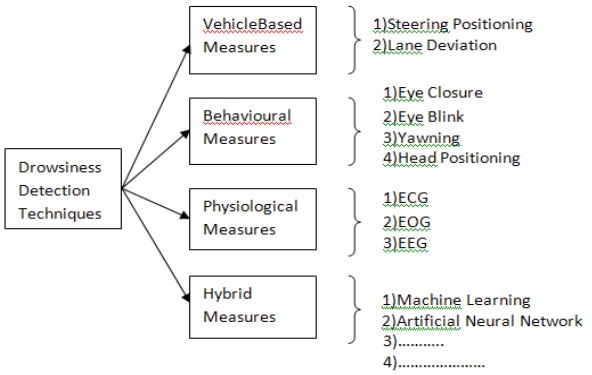

Figure 1.Various Drowsiness Detection Systems

Drowsiness is a synonym to sleepiness. Sense of sleepiness or exhaustedthrough day is drowsiness. This further leads to symptoms like forgetfulness or falling asleep at odd timings. There are many reasons for drowsiness ranging from mental states or régime choices to serious medical conditions. Nearlyroutineselections may chief to drowsiness, because working for very long hours or night shift. Medications also list drowsiness as a possible side effect. These medications carry a label that warns against driving or operating heavy machines while consuming drugs.

According to a survey these are some common measures of drowsiness detection.

Vehicle Based Measures

Vehicle based trials can be utilized to grip driver drowsiness. The two extensively used measures are Steering Wheel Movement and Deviation of Lane Positioning.

Steering Wheel Movement (SWM)

It is restrained with the assistance of steering angle sensor and iscommonly used to sense the level of drowsiness in drivers. The driver's steering behavior is observed and measured by insertion an angle sensor on the steering column. When the amount of micro-corrections on the steering wheel seems to reduce as compared to normal driving it seems drowsy, Most of the vehicle industries like Nissan and Renault, have adopted SWMs but it works in very limited situations.[8]

Standard Deviation of Lane Position (SDLP)

It is one more measure using which the level ofdriver sleepiness can be outlined. In field experimentations the position of lane is followed with the assistance of an exterior camera. In swift, many studies have concluded that vehicle-based measures are not specific to drowsiness because deviation of lane can be caused by any type of impaired driving, including driving under the influence of alcohol or other drugs, especially depressants.[8]

Behavioral Measures

A sleepy person displays numeral of face movements, containing rapid and constant blinking, nodding or swinging their head, and even yawning. Behaviormethods are widely used for investigative the drowsiness level of drivers by calculating their abnormal behaviors.

Eye-closure

Locating the exact position of eye is hard because of many factors like lighting effect, facial expression, facial shadowing. By making use eye features, various measures can be calculated with percentage of eyelid closure, maximum closure duration, blink frequency, average opening level of the eyes, opening velocity,closing velocity of eye and a effective driver sleepiness detection model can be designed which can work under varying unconstraint and luminance atmosphere. If the position of face gets obtained, locating the eye can be done with more accuracy. We can use the method to detecting eyes using L*a*b color space [6]which easilydiffers the face and non-face portions. This method is not robust to pose variation. But we can use this disability as an advantage in distraction detection system. If eye portion is not found we can assume that the driver is not looking at forward and this can be categorized in distraction state and must warns the driver.

Face Tracking

Face tracking system must be accurate to head movement, head rotating movements, posing variety and illuminating changes. To achieve this goal many methods are present. We can use face detection and object tracking systems simultaneously and their combination may give the opportunity to take benefits of both utilities together. Other method currently in use is the Head Position Detection. It simply determines the head tilt angles and when head angle crosses a certain angle, an audio alarm is sent in the driver's ear.[5]

Yawning Based Technique

It consists of several steps like the actualtime detection and tracking of driver's face, detection andtracking of the mouth contour and the detection. An automotive smart camera platform APEXTM is developed by Connive Corp. In this system the video camera which is fitted under the

front mirror of car is continuously captures the driver's face. Next,discovery of drowsinesshas two chief steps to correctlyamount changes in facial gestures that show drowsiness on driver's face. Primary, it detects the driver's face and tracked it in the seriesof frame shots taken by the camera. After locating theface, the next step is to detect and keep track the locationof the mouth on face. The system first chooses to detect and track theface before to tracking the mouth which makes the mouth-tracking procedure easier and simpler against error prone detections. After that the yawning state is detectedbased on measuring the rate of changes in the area of themouth contour and the aspect ratio of mouth area.[5]

Eye Blinking Based Technique

Eye blinking rate and eye closure duration is measured to detect driver's drowsiness. The aim behind this is, when driver felt sleepy his/her eye blinking and gaze between eyelids are dissimilar from normal situations so they effortlesslynotice drowsiness. In this eye blinking based drowsiness detection, the position of irises and eye states are monitored or checked through time to estimate eye blinking frequency and eye close duration. System uses a at all placed camera to apprehension video and then to locate the face, eyes and eyelids position system uses computer vision approaches to measure ratio of closure. Using these values one can easily detect drowsiness of driver.[5]

Physiological Measures

Numerous researchers have made use of the physiological signals to detect sleepiness like Electrocardiograph (ECG), Electroencephalograph (EEG) and Electrooculography (EOG). The value of Heart Rate (HR) varies in different stages of drowsiness, so we can detect the driver's sleepiness using Heart Rate (HR) as alert or sleepy. This heart rate can be determined by ECG signals which then we can use for drowsiness detection. The physiological signal EEG has frequency bands as delta band (0.5-4 Hz) implies sleep activity, theta band (4-8 Hz) implies drowsiness, alpha band (8-13 Hz) implies relaxation and creativity and beta band (13-25 Hz) implies alertness. The success rate of detecting drowsiness using combination of ECG and EEG is higher than using either signal alone. Some investigators have used EOG signals to detect sleepiness finished eye movements, the electric potential difference within cornea and retina makes electric field which reflects orientation of eye and the generated electric field is the measured EOG signal. Horizontal eye movement can be got by placing a disposable Ag-Cl electrode on outer corner of each eye and a third electrode at the center of forehead for reference. From this we get parameters like rapid eye movement (REM) occurs when subject is awake and slow eye movement (SEM) occurs when subject is drowsy.[9]

Hybrid Measures

Artificial Neural Network Based Technique

In this technique they make use of neurons to notice driver's drowsiness. People in fatigue if possessing some visual behaviors which are easily noticeable from changes in facial features such as eyes, head, and face. Visual behaviors that typically reflect a person's level of fatigue include eyelid movement, gaze, head movement, and facial expression. To make use of these visual cues, they made artificial neural network to notice drowsiness. This diagram describes the flow how ANN system can detect drowsiness.[9]

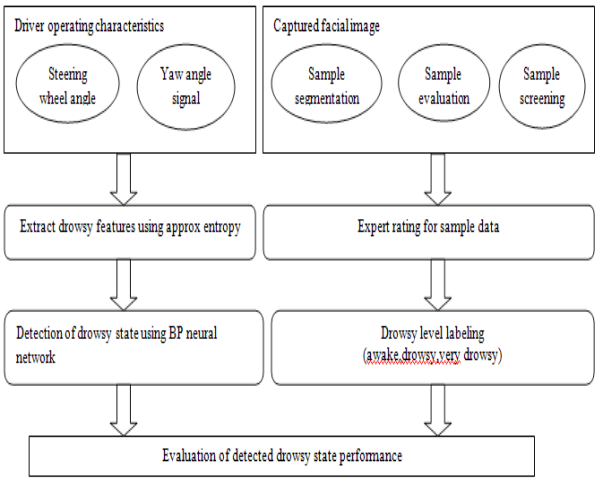

Figure 2.Framework of Fatigue Detection System

For this reason, the technique is given which is based on the Steering Wheel Angles (SWA) and Yaw Angles (YA) information in real time driving conditions to capture drivers' fatigue levels. It analyzes the operating features of SWA and YA in several fatigue statuses, and then calculates the estimatedentropy (ApEn) features of a short sliding window on time series. It makes use of a "2-6-6-3" multi-level Back Propagation (BP) Neural Networks classifier to get the fatigue detection. The data recovered are segmented and labeled with three fatigue stages after concluding expert assessment, as "awake", "drowsy" and "very drowsy". The total accuracy of 88. 02% is achieved in this method.[9]

ANN delivers high precision and efficacy in credentials, which justifies its claim in driver fatigue identification. ANN is mathematical model that depicts human brain or behaviors, is a non-algorithmic, non-linearand self-adaptive system, which consistsof number of computation processing units properly connected.

One unit of Neuron can be expressed as:

$A = f(WP + B)$

where W = weight vector of ANN, B = threshold value vector of network, P = input vector,f = transmission function.

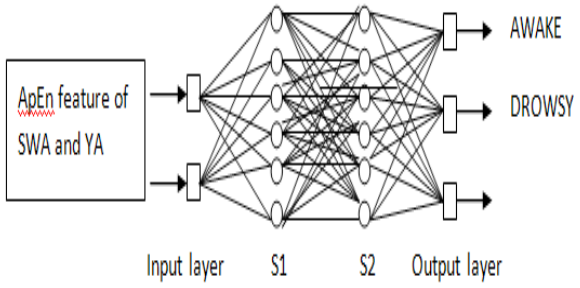

Figure 3.BP Network Architecture

It makes use of multi-layer perception neural network for organization and identification of sleepiness. It has one input layer, one or more hidden layers and one output layer. Inputs are ApEn features like SWA, YA while sleepiness levels like awake,drowsy,and very drowsy are outputs.[9]

Signal Analysis and Machine Learning

Signal analysis along with Machine Learning is used to achieve an accurate classifying sleepiness system. Bio-mathematical model has been proposed in this paper where machine learning framework has been used for feature extraction, Classifier selection and evaluation.

Input dataset consist of physiological info like EEG, ECG and EOG signals, from experiments carried out on real road vehicle-based information like lane position, steering, etc. All these different signals are then pre-processed to filter out unfavorable outliers (signals) using zero-phase forward and reverse digital IIR filter. KSS values are used as target values to train the system.

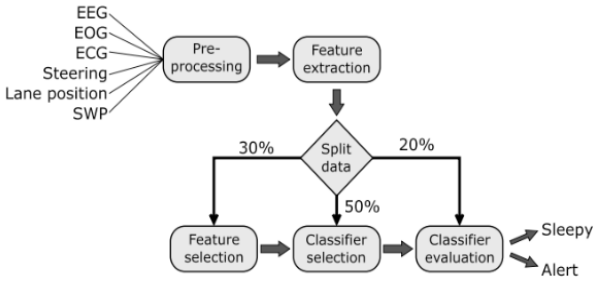

Figure 4.The Machine Learning Pipeline, Going From Raw Data, Via Classifier Design to Decision

Filtered signals are passed in length of 2. 5-minute segment to Feature extraction stage, as 2. 5-minute segment is adequately large enough to calculate feature. As KSS ratings are provided every fifth minute, two features are obtained per KSS ratings. For this sample entropy and Higuchi fractal dimensions are calculated for extracting features from EEG, ECG and EOG signals. SWP, a sleep/ wake predictor is also included as one of its feature.[3]

Feature selection is done using SFFS (Sequential Forward Floating Feature Selection) based on decision tree cataloguing to decrease the feature set by dimensionality reduction. Feature selection is done on 30% of dataset and highest optimization score of the candidate set is included in the final feature set. SFFS works on feature set with and without SWP, use of SWP as feature is exposed to improve the results when used to classify the drowsiness based on features from driving performance.[2] There are total 54 dissimilar features selected in the final feature set.

Classification of the data is carried on 6330 observations and 54 features using 5 different classifiers - KNN, linear SVM, Gaussian SVM, Gadabouts and random forest. All these classifiers are trained on 50% of training data, using 10-fold cross validation. It is found that 5232 cases were in alert class and 1098 in sleepy class. Selection of classifier is based on best sensitivity results and stable behavior across parameter values.[7]

Evaluation of final classifier is carried out purely on the test dataset (20%) for accuracy, sensitivity and specificity. In addition, evaluation is carried out on all the participant from test dataset as training data except one participant and this was repeated for all participants to get mean accuracy, specificity and sensitivity across all participants. Random forest classifier was found to give good classification accuracy for data from real roads in real traffic. Results were calculated on feature sets with and without SWP. Also, this classifier was trained on entire dataset instead of partial. This method does feature extraction from the input dataset to classify the data as awake, alert, sleepy, sufficiently alert or neither alert nor sleep. Dimensionality reduction is carried out on this feature set using SFFS (Sequential Forward Floating Feature Selection) technique.[9]

Conclusion

Various methods for driver drowsiness are discussed in this paper like vehicle-based measure, behavioral measure and physiological measures. Combination of all these methods, a hybrid model, helps to enhance the accuracy of driver sleepiness detection. In addition, adding blink related information or heart rate to steering wheel or seat would greatly improvise the system's performance.[8]

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