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Neural Network Based Drowsiness Detection System Using Physiological Parameters

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Abstract— ***In recent years, driver drowsiness has been one of the major causes of road accidents and can lead to severe physical injuries, deaths and significant economic losses. Statistics indicate the need of a reliable driver drowsiness detection system which could alert the driver before a mishap happens. Researchers have attempted to determine driver drowsiness using the following measures: (1) vehicle-based measures; (2) behavioural measures and (3) physiological measures. EEG signals acts as an indicator for the state of brain, and when the driver gets drowsy, α and θ waves become predominant. The main issue in such a technique is to extract a set of features that can highly differentiate between the different drowsiness levels. In this work, a new system for driver's drowsiness detection based on EEG using Neural network is proposed. This uses physiological data of drivers to detect drowsiness. These include the measurement of EEG and feature extraction in time and frequency domain. The proposed method was tested and validated on known set of standard data.***
Keywords— driver, drowsiness, eeg, spectral, neural network

I. INTRODUCTION

Many traffic accidents are caused by drivers falling asleep while driving. So it would be beneficial to develop a way to detect the drowsiness before it occurrence and to be able to warn the drive-in time. Many systems have already been developed which are based on the vehicle behavior like steering wheel movements, focusing on the driver physical behavior i.e. based on recording of head movements, eye closure, heart rate variability or grip strength. System uses a video camera for the tracking of eye movements have also been developed. Till now no system has proved to be sufficiently reliable.

II. DROWSINESS

Drowsiness is the transition state between awakening and sleep during which a decrease of vigilance that is the capacity of keeping oneself attention on a task is generally observed. It is the state where a person is almost asleep or very lightly asleep. During drowsiness Reaction time is slower, vigilance is reduced and information processing is less efficient, which can generate abnormal driving. Moreover, as drowsiness is the transition between awakening and sleep, it induces an increase of the number and the duration of blinks and yawns as per the study [1], [2]. Fatigue which means an extreme tiredness that result from physical or mental activity and the amount of sleep during night is the most common factors of drowsiness. Other factors contributing are the amount of light, sound, temperature and oxygen contents.

Most of the automated drowsiness detection are vehicular based detecting the abnormal behaviour, but this will depend on the type of vehicle [3,4]. The driver assistive systems already in place use the deviation of the steering angle, deviation from the lane, and tracking eye blinking using IR using physiological behaviour is based on EEG but very few online systems exist [5]. The driver monitoring system where the data is analysed for statistical parameters to determine the drowsiness were the frequency lateral position, the number of times the lane is missed [6]

A. Detection of Drowsiness

Drowsiness has an effect on many physiological parameters, such as EEG rhythms, heart rate variability and EOG signals. For drowsiness detection in drivers, the best base for detection is the use of EEG signals [7]. Many researchers have used EOG for drowsiness detection and [8] uses artefacts of EOG present in EEG as baseline for detection. The classification of EEG signal depends upon the frequency range of each band. i.e., *delta, alpha, beta and theta.* Tiny electrical signals are produced by brain cells when they pass message to each other. Electrodes which are placed on brain scalp of subject will pick up these signals and send them to machine called as Electroencephalograph (EEG). This pattern of electric activity produced on EEG can be used for various applications like sleep detection, drowsiness detection, and sleep disorders like insomnia. This project discuss about how EEG can be used to implement drowsiness detection in intelligent transportation system for example, cars, airplanes, helicopters etc. to monitor drowsiness status of the driver /pilot and alert them being drowsy.

B. Electroencephaloagram (EEG)

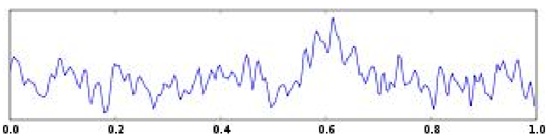

Fig.1 EEG Signal

Electroencephalography measures the electrical activity of the brain from electrodes placed over the scalp. Electroencephalography is a method for measuring the electrical activity generated by the nerve cells of the brain, mainly the cortical activity. The EEG activity is present all the time and recording show both random and periodic behavior. The main origin of the EEG is the neuronal activity in the cerebral cortex, but some activity also originates from the thalamus and from sub-cortical parts of the brain. The rhythmic activity is due to the synchronous activation of the nerve cells. The signal is classified on the basis of its amplitude and frequency range. The recorded pattern differs during the different sleep stages, but also when performing cognitive tasks, focusing attention, preparing manual tasks or by brain diseases, for example epilepsy or tumors. Different study are based on the EEG signals and extraction of control signals to activate alarm or warning system to alert a fatigued driver such as in [9] [10]. Wireless sensors and embedded systems can also be developed for these application as in [10]. Classification of delta, theta and alpha band is done by implementing different classification algorithms like neural network and ICA[11] by identifying different features [12]

III. DIFFERENT STAGES OF SLEEPING

Analysis of EEG done to classify different stages of sleep depends upon the percentage power in each band. Different stages of sleep are:

- Alert, wide awake person displays the unsynchronized high frequency.
- Alert person, one whose eyes are closed, it produces large amount regularly activity in the range 8 to 13 Hz
- The person begins to fall sleep then the amplitude and frequency of the wave form decrease
- Light sleep, it is large amplitude and low frequency of the wave form emerges

When the person is relaxed the synchronised alpha pattern appears and when he begins focussing the synchronising is replaced with a desynchronised pattern beta. At certain times a person still sound asleep, then breaks into unsynchronized high frequency EEG pattern for a time and then return to the frequency sleep pattern. The period of high frequency EEG is the paradoxical sleep representing alertness of who is asleep. Then there is rapid eye movement (REM) sleep, because high frequency EEG is a long amount rapid eye movement beneath the closed eyelids. Itcalled dreaming.

IV.METHODOLOGY

In this paper we have proposed a neural network for training and detecting drowsiness. The EEG data is filtered using a low pass filter for rejecting high frequency artefacts and power line frequency. The spectrum of an EEG signal is limited to 32 HZ. The filtered EEG signal is analysed for detecting drowsy and alert signal. The acquired signal becomes more synchronised and low frequency components of theta and delta waves begin to dominate. The sampled signal is analysed over definite intervals to locate these synchronised signals.

A. System Overview

The fig. 2 describes the block diagram approach to the proposed work. The EEG signal is filtered using band pass filter The filtered signal is passed to the feature extraction algorithm. Feature extracted is used for training the neural network. All the computations were carried out using MATLAB.

B. Feature Extraction

The features are extracted from this filtered EEG signal in time domain as well as in Frequency domain. The time domain features like mean, standard deviation, variance, the maximum and minimum over a set of N values were analysed. Since the EEG signals are varying in nature, the time domain signals were repeatedly taken over different time intervals and the mean of these is considered. The spectral components were derived from the power spectrum over the same duration. The features were extracted from both alert and drowsy signals.

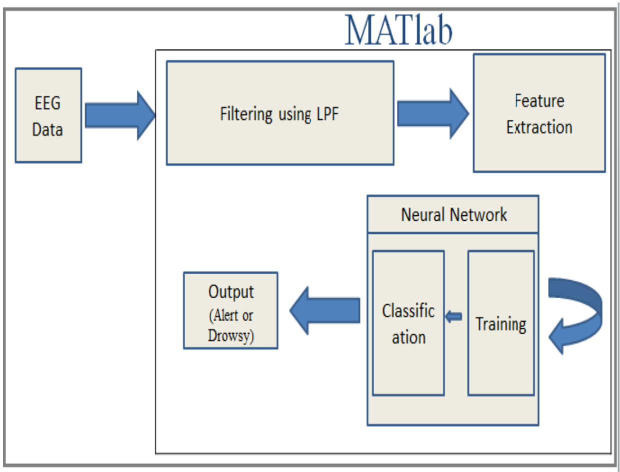

Fig. 2 System Overview

V.EXPERIMENT AND RESULT

The experiment was carried out on the data acquired from the system called as POWER LAB from AD INSTRUMENTS. EEG electrodes are a set of five gold plated, cup shaped disk recording electrodes. The gel was applied through the hole in the top. The gel is also applied on the scalp of the specimen. The alpha waves were recorded from the front parietal and occipital electrodes. The theta waves are also maximal in the frontal regions.

The acquired data over finite time intervals were saved and exported to MATLAB. All computations were carried out in MATLAB. Neural network is used as classifier. The standard commands from MATLAB NN Tool Box for training and simulation were made use. The network was trained on standard known data sets, extracting the features to classify a drowsy signal and an alert signal. The same data were used for validating while checking the simulations. The network performed with 100 % accuracy. Later the data acquired from AD Instruments Power Pack were given as test data and the network classified accurately. An existing pictorial representation indicated the alert and drowsy signal. Drowsy data was acquired after making the subject relax in an isolated room after the long working hours. In certain cases the data was acquired by making the subject stare at a particular object for long hours after a tiring day [7]

The table 1 shows the features of the alert and drowsy signal in time domain and frequency domain.

VI. CONCLUSIONS

The proposed work can be improved by going for a larger multichannel EEG acquisition system. The product can be developed into embedded system using DSP processor as a wearable gadget and a warning system to alert the driver.

Table 1. Features of Alert and Drowsy Signal

Alert Signal						Drowsy Signal				
Feature	A1	A2	A3	A4	A5	D1	D2	D3	D4	D5
Mean	12.31	-16.45	-3.75	-0.88	-18.83	-3.99	8.35	-2.03	-49.59	-1.61
Variance	1077 12.3	26678 1.1	143281 .7	224998 .6	338456 .9	3687. 93	3793. 98	2669. 47	11185. 24	3501. 79
Maximum	551	1333	1567	1210	1405	180	176	213	251	167
Minimum	-1018	-1885	-624	-789	-1523	-211	-214	-178	-346	-229
Standard Deviation	328.2	516.5	378.53	474.34	581.77	60.73	61.6	51.67	105.76	59.18
Delta	51.94	53.32	48.71	50.75	49.9	41.86	42.62	39.35	42.22	45
Alpha	61.77	58.15	59.94	61.76	62.38	37.26	38.53	38.9	40.95	40.27

Fig. 3 EEG Electrodes

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