EMERGING NEUROSKY MIND-WAVE BCI SYSTEM TO PERCEIVE DROWSINESS

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Abstract- Drowsiness is becoming a stern dispute in case of traffic accident. Along with physical activities such as eye blink, yawning, gripping of the human, people will mentally sleep with eyes open for few seconds. This will be accountable for severe accidents. The main objective of this research is 1) introducing a brain wave sensor which would be at ease in operational conditions to record EEG signals 2) providing self-controlled operation of vehicle once the alert is received. The emerging brain wave sensor consists of a single electrode which is to be placed at FP1 and it delivers real-time assessment of brain wave signals consistent with changes in neuron pattern of the brain. The received signals are further acquaint with BCI system. The system compares the received and predefined vigilance level and gives the alert accordingly. This can protect loads of lives in road transportation.

Index Terms- EEG, Drowsiness, Mindwave mobile, Alpha, Beta, eSense meter, TGAM, TGAT, RT.

I. INTRODUCTION

EEG is the technique to record electrical impulses from the nerves in the head. “Electro” refers to the electrical impulses sent from one cell to another. “Encephalo” refers to the head, and “gram” refers to the printed record. High quality EEG signals can be collected from brain with high scalp impedance (>>40kW) without scalp abrasion using modern engineering principles [1]. Brain-Computer Interface (BCI) systems establish a direct communication channel from the brain to an output device to control variety of applications [2]. The interfacing of brain and external devices such as computers, wheelchairs or any virtual environments would help people to overcome their disabilities [3]. To examine the brain activity recently a four channel based EEG device [4] with electric foams to contact forehead area have been developed.

BCI systems help to analyze a quantative analysis for assessing driver’s intellectual responses by examining the neurobiological data underlying EEG brain dynamics in a virtual-reality (VR) dynamic driving environment [5]. Further, the driver’s drowsy level is estimated using a prediction system with a JAVA-based graphical user interface (GUI) for online analysis and Mindo4 brain wave sensor [6]. The main goal of this research is to develop a single electrode brain wave sensor which will provide real-time vigilance monitoring of driver’s drowsy level and provide self-controlled operation of vehicle and give some criticism to the factual applications.

II. EMERGING NEUROSKY MINDWAVE MOBILE AND WIRELESS EEG SYSTEM

The NeuroSky Mindwave Mobile, a mobile and wireless EEG system has been developed which constitutes of a headset, an ear-clip and a sensor arm as shown in Figure 1. The EEG electrode is on the sensor arm resting on the forehead above the eye (FP1 position) as shown in Figure 2(A) and headset’s reference and ground electrodes are on the ear clip as shown in Figure 2(B). The reference electrode on ear clip will be beneficial to remove the ambient noises. The Mindwave mobile safely measures and outputs the EEG power spectrums (alpha waves, beta waves etc.), NeuroSky eSense meters (attention and meditation) and eye blinks. It can perceive multiple mental states simultaneously. It exceeds the conventional wet electrodes with the conduction gel for long term EEG measurement [7].

The Mindwave mobile requires a single AAA battery that provides 8 hours of runtime. Bluetooth 2.1 is used with 1.0V minimum required voltage, 10mA power consumption (when connected and transmitting), 10m range and 57,600 UART Baudrate.

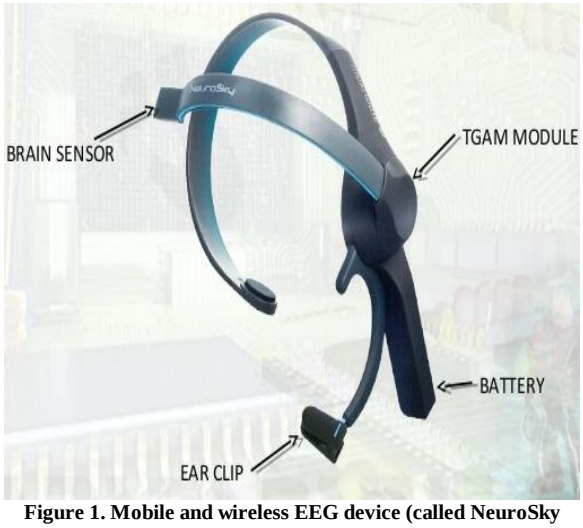

Figure 1. Mobile and wireless EEG device (called NeuroSky Mind-wave)

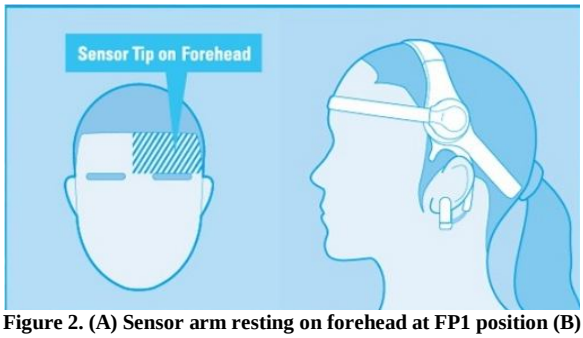

Figure 2. (A) Sensor arm resting on forehead at FP1 position (B) Ear clip position with headset's reference and ground electrodes.

III. THINKGEAR ASIC MODULE (TGAM) AND ESENSE

Mind-wave mobile sensor is based on TGAM module which is primary brain wave sensor ASIC module containing TGAT, a chip that revolutionized the world of brain computer interface. TGAM module 1) unswervingly connects to the dry electrode 2) provides advanced filtering with high noise immunity 3) consumes low power for portable battery driven applications (maximum power consumption of 15 mA at 3.3 V) 4) produces raw EEG data at 512 bps. TGAM module is based TGSP (ThinkGear Socket Protocol) for the transmission and reception of ThinkGear brainwave data between a client and a server. For characterizing the mental states Mind-wave uses a proprietary algorithm termed as eSense. To calculate eSense, the NeuroSky ThinkGear technology amplifies the raw brainwave signal and removes the ambient noise and muscle movement. The eSense algorithm is then applied to the remaining signal, resulting in the interpreted eSense meter values.

IV. ESENSE ALGORITHM

eSense is a NeuroSky's proprietary algorithm for characterizing mental states. To calculate eSense, the NeuroSky ThinkGear technology amplifies the raw brainwave signal and removes the ambient noise and muscle movement. The eSense algorithm is then applied to the remaining signal, resulting in the interpreted eSense meter values.

A. eSense Meter

For each different type of eSense (i.e. Attention, Meditation), the meter value is reported on a relative eSense scale of 1 to 100. On this scale, a value between 40 and 60 at any given moment in time is considered "neutral" and is similar in notion to "baselines" that are established in conventional brainwave measurement techniques. A value from 60 to 80 is considered "slightly elevated", and may be interpreted as levels tending to be higher than normal (levels of Attention or Meditation that may be higher than normal for a given person). Values from 80 to 100 are considered "elevated", meaning they are strongly indicative of heightened levels of that eSense. Similarly, on the other end of the scale, a value between 20 and 40 indicates "reduced" levels of the eSense, while a value from 1 to 20 indicates "strongly lowered" levels of the eSense. These levels may indicate states of distraction, agitation, or abnormality, according to the opposite of each eSense.

V. APPROACH TOWARDS DROWSY LEVEL DETECTION

A persistent attention driving task is organized for some intended adults after 1.5 hours of their lunch approximately. This time period is more prone to let the subject fall asleep and encourage their drowsy level in the research. NeuroSky Mind-wave mobile EEG device is worn by each subject driving the vehicle. 360-degree surrounding vision pretending the highway road scene at nighttime formulates the virtual-reality driving environment. The executed task, event-related lane-departure pattern [8], arbitrarily makes the car drift away from the original cruising lane and toward the left or the right side. The instant at which deviation event is detected, subjects are instructed to reimburse the trajectory error. Subject's fatigue level is determined by evaluating the response time (RT), the duration time taken by the subject to response to the deviation event. The decreasing RT is correlated with alert and increasing RT with fatigue status during driving.

VI. DROWSINESS DETECTION SYSTEM

The drowsiness detection system founds BCI unit, Data processing unit and Vehicle unit.

A.BCI Unit

This unit formulates the subsystem of proposed system and plays major rule in the system. Brain wave sensor accompanying human brain comprises Dry electrode unit, Reference ground section and EEG power spectrum processing unit. Sensor detects the raw brain wave signal which can be worn by the subject in an operational environment. EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain. The brain wave sensor also transfigures the signal into packets which are transmitted via Bluetooth.

B.Data Processing Unit

Bluetooth transmission culminations at Level Splitter Section (LSS) which analyses the acknowledged data. LSS is also associated with serial data transmission and a level defining drowsiness is introduced in it.

C. Vehicle Unit

The serial data sent by LSS is destined in this unit. The acknowledged record is in the form of packets which is

interfaced with Universal Asynchronous Receiver/Transmitter (UART). UART is contained within the subunit which also institutes ARM processor, General Purpose Input/output device (GPIO), Pulse Width Modulation (PWM). The drowsiness alert is recognized by this section and alert message is displayed.

ARM lpc2148, UART, RS232 and DC motor are comprised in the hardware part. High-level language called Embedded C is used for ARM lpc2148 development. Keil software offers development tools for ARM. Orcad capture provides the tools needed to enter, modify, and verify the PCB design. Matlab is used to characterize the result graphically.

VII. EXPERIMENTAL RESULTS

The moment subject feels drowsy, neuron pattern in the brain changes which is detected by brain wave sensor and simultaneously it converts the signal into electrical form to be processed further. The drowsiness detected is displayed as shown in Figure 3.

The eSense algorithm helps to detect attention and eye blink levels which are plotted as shown in Figure 4. Along with detection of drowsiness, self-controlled operation of vehicle is induced so that vehicle could stop by itself and accidents are avoided.

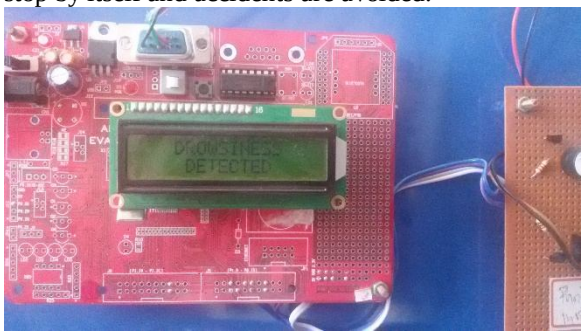

Figure 3. Display showing drowsiness detected

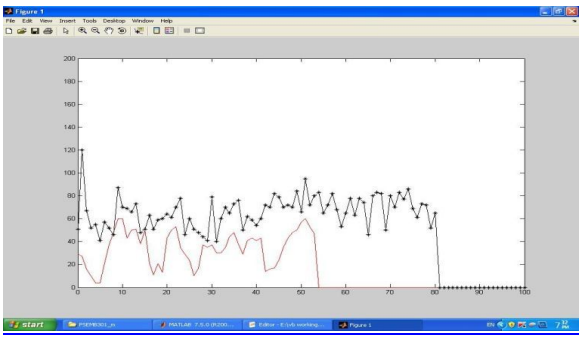

Figure 4. Graph representing attention and eye blink levels

CONCLUSION

In this research, a system is forecasted to perceive drowsiness with the wireless and wearable EEG device, NeuroSky Mind-wave sensor, which is comfortable to be worn in operational environment, as they do not require skin preparation and gel and the results are graphically represented using Matlab. Real-time meaningful information is extracted from drivers by implementing simple signal processing techniques. The vehicle will perform self-controlled operation until awaken state of the subject. It proves to be an efficient system to perceive drowsiness and save lives during accident.

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