WARNING SYSTEM FOR DRIVERS ACCORDING TO ATTENTION AND MEDITATION STATUS USING BRAIN COMPUTER INTERFACE

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Abstract— It is observed that the traffic accidents are mostly sourced from the drivers and its one of the main reasons is the lack of attention. Distracted drivers can't observe the traffic flow and traffic accidents occur as a result thereof. Brainwaves produce weak electrical signals that can be measured from the skull. Electroencephalography is a system that measures the activity of brainwaves using an electrical method. The Brain Computer Interface is a system that converts electrophysiological actions or metabolic rate to signals to be interpreted by a device. In the last decades, brain signals could be measured with systems requiring high costs, but nowadays, many EEG devices are available for personal use. These EEG devices and systems have their signal transformation methods. In this paper, a mobile system design that detects the distractions of drivers that are the major factor in traffic accidents via EEG signals is proposed. This system provides the necessary warnings to the driver. With the proposed system, it is aimed to measure and analyze the attention and meditation status via brain signals of the drivers. In case of the drivers' attention has been dispersed, it is aimed to provide the audio alerts to the drivers. It is proposed to use NeuroSkyMindwave Mobile as EEG device because of the wireless and easy to use options.

Keywords— Brain Computer Interface, Electroencephalography, Mobile Applications, Traffic, Drivers.

I. INTRODUCTION

Especially during long trips, attention of the drivers can be scattered, drivers can be encountered with sleep problems and the result of all of them can lead the traffic accidents. It is observed that the traffic accidents are mostly sourced from the drivers and according to the statistics, a rate of 25% to 50% of all traffic accidents are realized due to the distractions[1]. Distracted drivers cannot observe the traffic flow and traffic accidents occur as a result thereof. Also eating during the journey, talking on the phone and drowsiness condition raise the possibility of the traffic accidents. However, the stress also causes the traffic accidents.

Various security systems are developed for cars to prevent the traffic accidents. When the car safety monitoring systems are considered, drifting from the main road detection systems, detection the facial expressions of the driver and many image discrimination techniques are seen[2].While the image discrimination systems can be affected by external factors, Electroencephalography (EEG) systems are a new research area that can provide more accurate results on this issue.

Brain signals are one of the electrical signals produced by the body. Electroencephalography (EEG) is a method that enables measuring signals produced by the brain via electrodes or other electrical methods. Brain signals are converted through algorithms developed by the company and they are presented as a form that people can understand through their EEG devices and SDKs.

Measurement of brain activity, stimulation of the nerve tissue, advances in computer technology and robotic science allow interfacing between the human brain and artificial devices, these interfaces are called as Brain Computer Interface (BCI) [3].BCI is not a system used to transmit outputs and commands to the world with normal ways, it is a type of communication system that recognizes and analyzes the brain activity [4].BCI aims to produce the results of the signals that send via brain on computer systems rather than creating a reaction in the body.Mode of operation of BCI is shown in Figure 1.

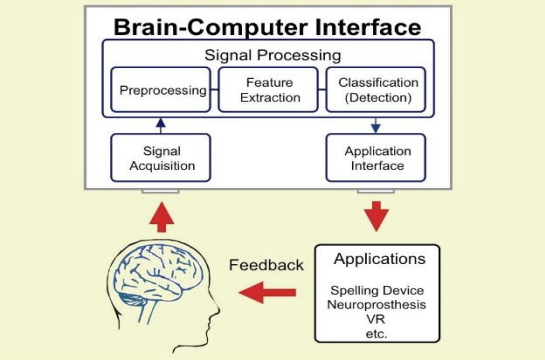

Figure 1. Brain ComputerInterface[5]

II. ELECTROENCEPHALOGRAPHY

Electrical biosignals in the body are produced as a result of the electrical activity of cells. The body produces many electrical signals and one of them is EEG signal that is the measurement the electrical activity occurring in the brain[3].

Without expensive and impractical EEG devices, brainwaves can be measured and analyzed by using a non-invasive EEG with a dry electrode on the forehead [6]. Today, easy to use, affordable, wireless EEG devices are available for users.

EEG signal has a wide frequency band (0.5-H 11/1) although clinical and physiological interest concentrated between 0.5 and 30 Hz. This frequency range is divided into 4 frequency bands. These are [4][7][8];

1) Delta *(δ)* Waves: Frequencies range from 0.5-4 Hz, amplitudes μv 20-400. It is encountered in cases where the brain shows very low activity.

2) Theta (θ) Waves: Frequencies range from 4-8 Hz; μv amplitudes vary from 5-100. In normal individuals, it is encountered in the condition which the brain has lower activity such as dreaming sleep, medium depth of anesthesia and stress.

3) Alpha (α) Waves: Frequencies range from 8-13 Hz; amplitudes vary between 2-10 μv. They appear in the state of the absence of external stimulus, physical and mental rest state, closed eyes of individuals in the awake state.

4) Beta (β) Waves: Frequencies are more than 13 Hz. Amplitudes vary between 1-5 μv. It is encountered in the phase of rapid eye movement when sleeping, in case of focused attention, mental work, sensory information processing, tension. Beta waves correspond to the highest activity levels of the brain.

III. LITERATUREREVİEW

Liu et al[2] developed a drowsiness detection system using EEG. It uses wireless EEG device and collects EEG data from the driver. This system proposes a personalized music recommendation system because it is known that the music effects the state of mind. Artificial Neural Network (ANN), Support Vector Machine (SVM) and k Nearest Neighbor Classifier (kNN) are used for EEG signal classification to indicate drowsiness. This system uses the car's stereo system and when the brainwaves changes and the drowsiness is detected, refreshing music plays as spontaneously.

In the study ofSchier[9], 'Need for Speed' simulation device is used. During the driving experience with this device, EEG recording has been made from 4 channels (P3, P4, F3, F4). Power spectra were computed to produce values of relative alpha activity for each channel. EEG changes and changes and reductions in attention were examined.

InLin et al study [10], electroencephalogram (EEG) power spectra estimation and independent component analysis and fuzzy neural network models combination have been proposed to estimate drivers' cognitive state. Virtual reality based driving environment is used. The results show that the EEG signals can be used for accurately and successfully estimating the driving performance.

In the study of Lim et al[11], eye activity detection algorithm is studied for a safer driving. So that NeuroSkyMindWave headset that entailed a single-electrode has been used for detecting driver's eye-states. The system keep drivers awake by alarm notifications with adaptive percentage threshold algorithm for alarm-triggering. As the result, the EEG eye-states system has detection rate 31% per second, false alarm rate of 0.5%.

In the other study [12], an application has been developed that detects the drowsiness of workers and gives warning to them. For this research 5 subjects had used NeuroskyMindwave Mobile for 3 hours. As the result of this research, drowsiness detection application has been successful with approximately 87.40% accuracy.

IV. DRIVER WARNINGSYSTEM

In this section, the aim of the proposed EEG-based driver warning system for drivers, software and hardware environments and the design stage of the system will be discussed.

A. Aim of theSystem

The main objective of the system is to determine the distractibility of the drivers that is the major factor for the traffic accidents using EEG signals and to warn the drivers with the alerts.The aim of the proposed system is to allow drivers to control distraction, stress and sleep situations while driving utilizing EEG and Brain Computer Interface environment via mobile devices. The driver warning system will measure and evaluate attention and stress status of drivers using EEG frequency waves; beta waves for attention and alpha waves for stress. Also it is aimed to determine the driver's sleeping situation depending on the blink frequency. A driver who wears NeuroSkyMindwave mobile is seen on the Figure 2.

Figure 2. A driver who wears NeuroSkyMindwave mobile

Also with the proposed system, the statistical information of the attention and stress can be shown for the desired time interval and the statistical information can be used for driving performance analysis or the other relations.

B. Hardware and Software

It is proposed to develop the BCI based mobile driver warning application in the Eclipse platform using the Java Programming Language. It is practical to use mobile devices because of accessing in anywhere and it is proposed to be developed this system for Android operating system. Because the demand for the devices and the brands running the Android operating system is majority with 82%[13]and Bluetooth access for Android devices and Bluetooth permit procedures for applications are easier. Also an Android mobile device is needed to upload the mobile driver warning application.

NeuroSky EEG device that is for personal use will be used for the proposed system. NeuroSky is a company that has founded in Silicon Valley to produce EEG devices for personal use. For NeuroSkyMindwave device, its software development kits are available for the developers. NeuroSkyMindwave Mobile is used as EEG device. Brain-controlled games, applications are being developed Using NeuroSky technology. ThinkGear is the name of a single dry sensor technology that makes the measurement, filtering and analysis of EEG signals and brain waves and converts the user's brain signals to the shape information for applications using proprietary eSense algorithms of NeuroSky[14].NeuroSky has mobility and effortless fitting procedures, so it's proper for the driver safety systems [11].

NeuroSkyMindWave Mobile uses the TGAM1 module, and have Automatic wireless pairing, single AAA battery, Bluetooth v2.1 Class 2 (10 meters range), static headset ID (headsets have a unique ID for pairing purposes) [15]. TGAM is the first brain wave sensor developed for personal applications by NeuroSky and gives raw brain waves, inputs and outputs of the EEG power spectrum and states such as meditation and attention, measures EEG / ECG signal quality and detects the blink [16].

C. Progress of the Driver WarningSystem

For the driver warning application, an android mobile device that will be installed the application and NeuroSkyMindwave Mobile EEG device are needed. The drivers are required to wear the EEG device. NeuroSkyMindwave mobile device is a device that is worn as an electrode on the forehead, other electrode on hair and the other electrodes clipped to the earlobe. When the mobile device that the application installed on has been opened, it connects to the EEG device via bluetooth. Once the connection is established, attention and stress status of the drivers will be measured. Attention and stress status will be shown as progress bar on the application. In case of the attention status of the drivers remain below 20% level that is the critical point, necessary warnings that is proposed by the psychologists and the experts will be given to the driver by audio. In case of increasing the frequency and intensity of blink, music will be given to the drivers as stimulus because of the risk of sleep. Experimental studies shows that listening louder music activates the autonomic nerve system of drivers [6].

If the stress status continue as 80 and over for the percentile scale, the driver will be alerted with the voice. In this case, the rest of the drivers will be recommended. Also in this case appropriate warnings and recommendations will be presented to the driver.

EEG recordings will be kept and the statistical information of attention and stress information can be shown for the desired time interval to the user. Thus, the average of stress and attention information that is obtained by recorded data will be presented to the user.

D. Development of the Driver WarningApplication

- Java is selected as the programming language and JDK and Eclipse IDE has to be installed.
- The Android SDK will bedownloaded and the installation for Android SDK for Eclipse will becompleted.
- Related classes are created and coding phase is begun.
- ThinkGearBase. jar and ThinkGearPackX. jar libraries that are NeuroSky's library for Android will be added to the project[17].
- Bluetooth permission and other permissions will be added to Android Manifest file.

The progress of the application is as follows;

- The user wears NeuroSkyMindwave Mobile device and the application that installed on the device performs a Bluetooth connection.
- When the application is opened, if the Bluetooth device is not available, "Bluetooth is not available" message will be displayed to the user with a toast.
- Measurements of stress and attention level representation visualized with a progress bar as in Figure 3.

Figure 3.Attention and Stress Levels

- MySQL database is used to store attention and stress percentage data. The connection will be performed with JSON object to MySQL database.
- Date, time, stress percentage and attention percentage data will be stored in MySQL database. When the application opens, data record starts automatically.

- e-SENSE measurement has been developed for NeuroSky devices specially and is based on the conventional EEG measurements[17]. Attention and Meditation values were scaled between 1 to 100 and evaluation of the rating scale is as follows [18]:
- Measurements between 40 and 60 are considered as "neutral ".
  - It is accepted as a little high between 60-80.
  - It is accepted as high between 80-100.
  - Values between 20 -40 are considered as low.
  - Values between 1-20 are shown to be very low
- Users can see the attention and stress percentage. They can reach the attention and stress statistics from the main screen as seen on Figure 4.
- All attention and stress data can be cleared with “Clear all attention and stress data” button as seen on Figure 4.

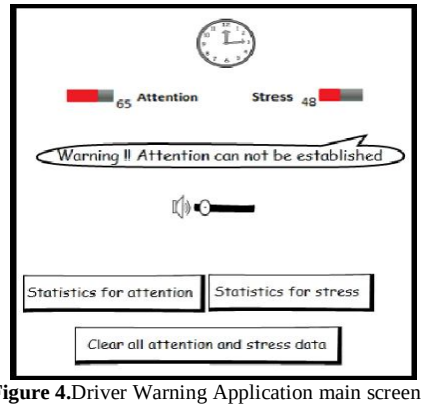

Figure 4. Driver Warning Application main screen

- Users can reach the attention and stress statistics. When the user clicks the “Statistics for attention” button, user reaches the statistics page as shown in Figure 5. The user selects the time interval for the average percentage information of the attention. The user clicks the “Show information for the average attention” button and the average attention information is obtained from the stored data.

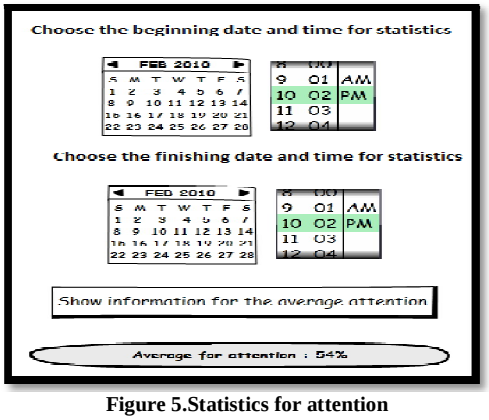

Figure 5.Statistics for attention

E. SampleCodesforthe Application

TG device communicates with application by messages sent to a Handler object and these messages are transmitted within the msg.what object. The codes about Bluetooth connection and the connection of the device as shown in Figure 6[17].

```
BluetoothAdapter                                    =
BluetoothAdapter.getDefaultAdapter();

if( bluetoothAdapter == null ) {
        for (int i=0;i<5;i++)
        {

        Toast.makeText( this, "Bluetooth is not
available", Toast.LENGTH_LONG ).show();

        return;}

    } else{
            // TG Device was created
        device  = new  TGDevice(bluetoothAdapter,
handler);

    }

if( device.getState() != TGDevice.STATE_CONNECTING
&& device.getState() != TGDevice.STATE_CONNECTED )
{

        device.connect( rawEnabled );
        ;
```

Figure 6.Bluetooth and TG device connection codes

CONCLUSIONS AND RECOMMENDATIONS

Inthisarticle, a driver warning system design using EEG data so attention and stress status of the driver is discussed. The aim, benefits and the proposed design of the system are focused on. In addition to these results, the following can be said astheconclusionandtherecommendation;

- This system can be used by car manufacturers because that system can provide the required statistical information.
- When they drive, drive difficulties can be observed and attention and meditation levels at critical moments can be examined.
- Statistical institutions can use the system to obtain information about the attention and stress situations of drivers.
- The system can easily be adapted to other areas. In the field of education, in case of distractions of the students when they are studying, the system can be transform to the system that reminds to interrupt the training or to do the exercises to recover attention.

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