Electroencephalography Signals Based Face Interaction System: Survey and Simulation

Shahad Hussain Alawi, Salih Mahdi Al-Qaraawi and Muayad Sadik Croock
Computer Engineering Department, University of Technology, Iraq

Abstract— **It is well known that the Electroencephalography (EEG) signals read from the human brain attract the interest of researchers in computer and control system engineering fields. Different applications have been produced to overcome real-life issues. This paper presents a comprehensive survey amongst the previous research works on the signals of human brain, i.e. EEG. This survey summarizes the recent researches in the EEG applications field and lists the advantages as well as the disadvantages. Motivated ideas that overcomes the problems of traditional systems are proposed. In addition, this paper simulates the human face interaction using Emotiv Control Panel simulator. This simulator represents the same face actions on the simulated face shape at the personal computer. Different case studies are considered to cover the ability of the simulator in representing the face actions.**

Index Terms— **EMOTIV, Electroencephalography, Face simulation.**

I. INTRODUCTION

Electroencephalography (EEG) signals are recorded in real-time from the scalp. These signals reflect brain's activities by measuring small electrical currents [1]. EEG signals were taken from dogs by Vladimir Pravdich-Neminsky in 1912. In 1922, Hans Berger measured EEG signals for humans [2]. EEG signals are composed of several frequency bands (Delta δ, Beta β, Theta θ, Alpha α and Gamma γ). Each band expresses as a frequency corresponding different brain activities [3]. The strength of these bands is frequently changed over the same day. In fact, the domination of different EEG bands is related to the brain activity and its degree of awakens [4].

EEG is measured by placing electrodes or poles on the scalp with conductive gel or paste. Some devices use caps or nets in which the electrodes are embedded [5].

The EEG signal is very important since it is used for research as in studying of cortical parts functions like understanding specific properties, such as attention, alertness, mental acuity. It is also used for diagnostic purposes, diagnosis of epilepsy and other brain traumas [6]. In this paper, we present a survey on a novel technology which can be employed in many applications that could be beneficial for many projects. Emotiv headset is an interesting tool that measures brain signals and maps them to the software -that is designed to work with it- to be read and translated to different actions.

II. SURVEY ON PREVIOUS WORKS

In [2], a research was proposed to examine the Emotiv system as a cost-effective gateway to non-invasive portable EEG measurements. The system that was built, used to control a robot with the power of the mind thinking. The researcher used the same thoughts to control a mouse on a computer screen and double blinking as a click.

Later, in [7], an Emotiv recognition and visualization system was presented to recognize the human emotions in real time. The data were collected and analyzed using the Emotiv Epoc headset to find the spatio-temporal emotion patterns. A dimension-based algorithm was realized for emotions recognition (fear, frustrated, sad, happy, pleasant and satisfied) from EEG signals in real time.

In [8], a system was implemented to recognize and visualize human's emotions in 3D virtual environments. The researchers proposed and implemented an EEG-enabled music therapy. They built a web-enabled EEG-based music player that plays music based on the user's emotion in the real time. The system helped in comforting the patients pain.

In [9], an article was written to explain the use of EMG-based HMI in controlling the movement of a farm tractor. They concluded that steering a tractor is possible with almost the same efficiency as with manual steering.

In [10], A machine learning approach was described to detect emotions from brain activity. An emotion annotated sounds was submitted to 6 healthy subjects, and data were collected during that using Emotiv Epoc headset. They found that it is possible to obtain data that have sufficient information to separate between emotional states.

In [11], a method was explored to find the appropriate location on the human scalp where EEG signals can be detected for attention training. They found that the best locations that could show the variations evidently in the relaxation/attention state for Alpha/Beta wave and have the reasonable power spectrum.

In [12], an EEG-based Brain Computer Interface (BCI) system was proposed in 2014 for automation home appliances without the use of any muscle. The system could be used by people who has physical disabilities to improve the quality of their life.

The system in [13] was developed to assess the driving of a participants in a different traffic situation. The participants were asked a few questions concerning their stress level. Meanwhile, EEG signals are acquired by Emotiv headset, visualized and recorded by Emotiv control panel. If the system discovers that the driver is mentally unstable, an alarm rings indicating that the driver is not capable of driving.

In [6], a method was introduced for controlling a servo motor. An Arduino micro-controller was connected to the servo motor to control its movement. When the servo motor receives a pulse from the Personal Computer (PC), it rotates at 90o movement, and 90o backward to its original position when it receives the second pulse. The research aimed to help people who lost their limbs due to an accident.

In [14], a BCI system was developed to control the movement of a quadcopter by identified brain concentration and eye blink. Emotiv Epoc was used to capture EEG data and sent to data processing computer to analyze it in real time. They found that the system uses less data and computational source as compared to the traditional BCI-controlled quadcopter systems.

The system in [15], implemented a Brain Computer Musical Interface (BCMI). They used Emotiv Insight headset as an input and signal processing device. Data collected via Bluetooth was then routed over the network formatted for OSC protocol. They concluded that the Emotiv Insight headset is an existing choice for a BCIM because of its low price and ease.

III. EMOTIV CONTROL PANEL

Emotiv insight headset, shown in Fig. 1, is a lightweight, elegant, low cost brain computer interface used to measure human EEG signals. It has five sensors in addition to two reference sensors, providing full coverage to the brain cortex. It does not require a sicky gel to be put on the human scalp [16].

Fig. 1. Emotiv insight headset [16].

The headset works with many software environments, such as the Emotiv Control Panel. The Emotiv Control panel is a toolset used to visualize and record and map EEG signals to three different classes of detection algorithms, which are facial expressions, mental commands and performance metrics.

A. Mental Commands

The mental commands detection suite distinguishes the user's mindful intent to do different physical activities on a real or virtual object. This is done by measuring user's real time brainwaves. This suit is implemented to work with ten distinct actions: (push, pull, left, right, up, down, clockwise, counter-clockwise, forward and backward) as shown in Fig. 2.

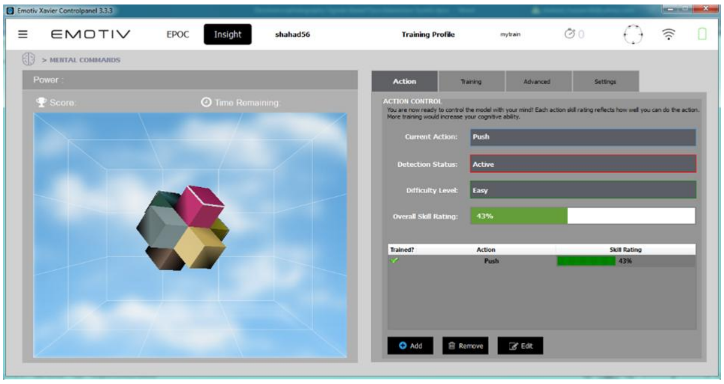

Fig. 2. Mental commands detection suit

B. Performance Metrics

The performance metrics detection suite shows real time fluctuations in the user's emotions. Emotiv currently offers six performance metrics detections: Interest, Engagement, Stress, Relaxation, Excitement and Focus. Data are collected while the performance metrics run for each individual user. This data are saved and used to enhance the detection accuracy. The recorded performance metrics are represented as signals with different colors as shown in Fig. 3 [18].

Fig. 3. Performance metrics detection suit

C. Facial Expressions

As mentioned earlier, Emotiv insight headset has five sensors that are located in the frontal and prefrontal lobs. These sensors record the signals that are come from facial muscles and the eyes. A classifier was developed to detect many facial expressions, such as blink, left wink, right wink, surprise, frown, smile and clenched teeth as expressed in Fig. 4 [19].

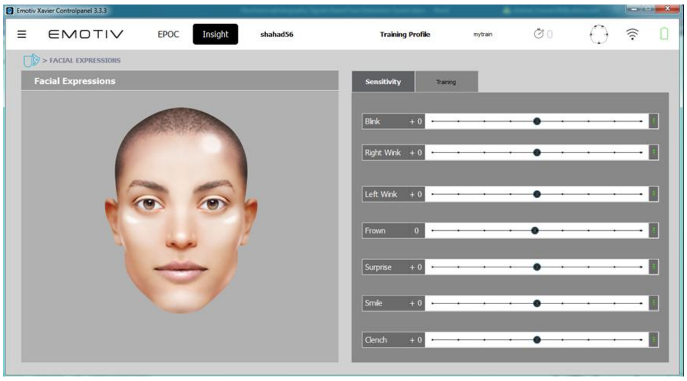

Fig. 4. Facial expression detection suit.

IV. Simulation of the Face Direction

The Emotiv control panel comes with many fascinating features. One of these is the facial expression detection suit. This feature simulates the face's actions of the person wearing the headset and displays the expressions in real time on an avatar that represents the human face as shown in Fig. 5. Most EEG devices ignore the signals that are picked up from facial muscles and the eyes and consider them as noise. The Emotiv headset dose not only filter these signals before inferring the brain signals, but also classifies them to identify which muscle group are causing them [19].

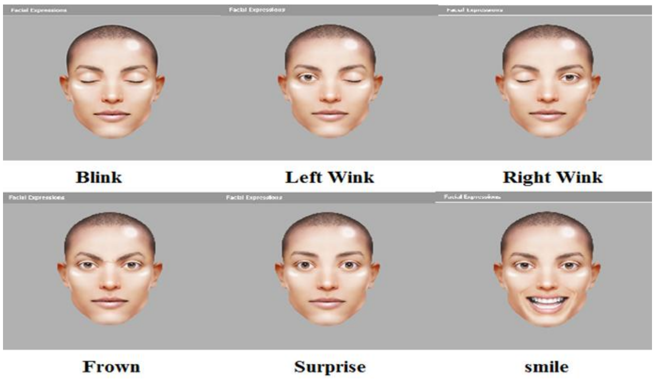

Fig. 5. Facial expressions.

While experimenting the facial expressions and what is their impact on the brain waves, each face's expression draws different shapes of brain waves. In Fig. 6 shows the brain waves that was drawn during blinking. It caused the stress and engagement waves to raise while the others are remained stable.

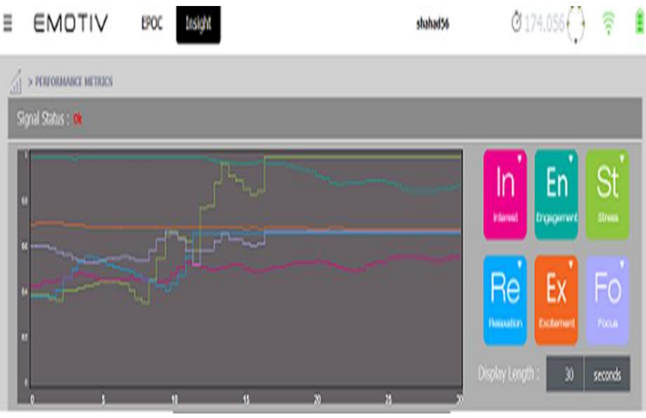

Fig. 6. Blink brain waves

Fig. 7 shows the waves while the user does "left wink". We notice that most of the waves are remained stable with no noted changes.

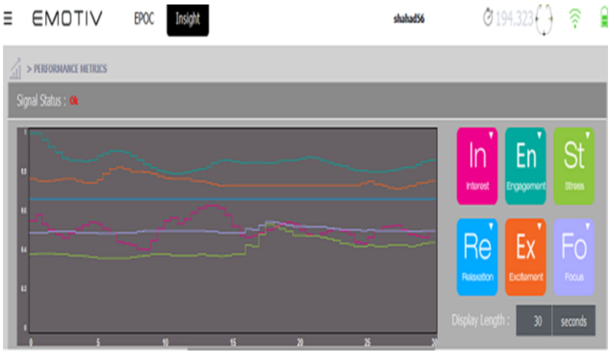

Fig. 7. Left Wink brain waves.

As the previous state, brain waves are showed no further change when the user does right wink, as exposed in Fig. 8.

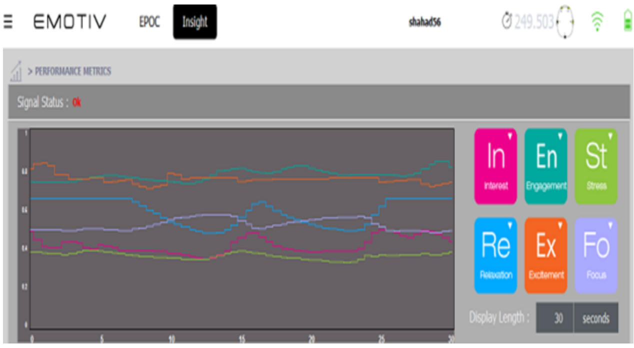

Fig. 8. Right Wink brain waves.

Fig. 9 demonstrates the brain waves in the state of doing surprise (raise brows) expression. We mark a perceptible raise in the stress wave, while the others managed to remain stable.

Fig. 9. Surprise brain waves.

Finally, Fig. 10 displays the brain waves, which are caused by the user muscle doing frown (furrow brows). It is clear from this figure that the engagement and focus brain waves gone below there's steady states.

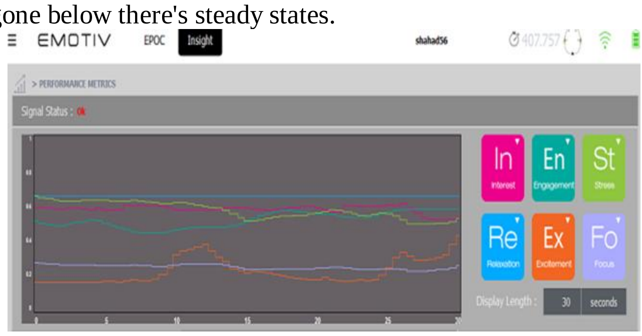

Fig. 10. Frown brain waves.

V. CONCLUSION

In this paper, a survey on previous research works in the field of human EEG signal description as well as human EEG based control systems was presented. This survey expressed the use of EEG signals in controlling different types of systems and devices that can be used to assist same people in this life. In addition, an Emotiv headset based simulation to the human face actions was introduced. The Emotiv headset as a novel, interesting and easy to use Brain Computer Interface (BCI) was adopted to offer various capabilities. It detected facial expressions by picking up signals from face muscles. These face expressions were mapped to a head model that simulates the face movement. Different expressions exhibited different brain waves. These waves represented the facial expressions were sent as signals to related brain lobes. Each signal was picked up from one or more lobe to generate the variation in brain waves for each expression.

REFRENCES

[1] F. Lotte, L. Bougrain, and M. Clerc, "Electroencephalography (EEG)-Based Brain–Computer Interfaces", Wiley Encyclopedia of Electrical and Electronics Engineering, 2015.
[2] D. Szafir, "Non-Invasive BCI Through EEG", Undergraduate Honors Thesis in Computer Science, Boston College, 2010.
[3] G. Placidi, D. Avola, A. Petracca, F. Sgallari, and M. Spezialetti, "Basis for the Implementation of an EEG-Based Single-Trial Binary Brain Computer Interface Through The Disgust Produced by Remembering Unpleasant Odors", Neurocomputing, Vol 160, P.P. 308-318, 2015.
[4] K. Jerbi, E. Combrisson, S. Dalal, J. Vidal, C. Hamame, O. Bertrand, A. Berthoz, P. Kahane, and J.P. Lachaux, "Decoding Cognitive States and Motor Intentions from Intracranial EEG: How Promising is High-Frequency Brain Activity for Brain-Machine Interfaces", Epilepsy and Behavior,. Vol 28, No 2, P.P. 283-302, 2013.
[5] Y. Popat, S. Sharma, and Gupta, "Generation of Brain Waves in Different Psychological Conditions", Interbation Journal of Engineering Research & Technology, Vol 2, No 4, P.P. 5, 2013.
[6] S.M. Nacy, S.N. Kbah, H.A. Jafer, and I. Al-Shaalan, "Controlling a Servo Motor Using EEG Signals from the Primary Motor Cortex", American Journal of Biomedical Engineering,. Vol 6, No 5, P.P. 139-146, 2016.
[7] Y. Liu, O. Sourina, and M.K. Nguyen, "Real-Time EEG-Based Human Emotion Recognition and Visualization". IEEE International Conference on in Cyberworlds (CW), 2010..
[8] Y. Liu, O. Sourina, and M.K. Nguyen, "Real-time EEG-Based Emotion Recognition and Its Applications", Springer Transactions on computational science XII, P.P. 256-277, 2011.
[9] G.Gil, "Steering a Tractor by Means of an EMG-Based Human-Machine Interface Sensors", Vol 11, No 7, P.P. 7110-7126, 2011.
[10] R. Ramirez, and Z. Vamvakousis, "Detecting Emotion from EEG Signals using the Emotive Epoc Device", Springer International Conference on Brain Informatics. 2012.

[11] K. Yaomanee, S. Pan-ngum, and P.I.N, "Ayuthaya Brain Signal Detection Methodology for Attention Training Using Minimal EEG Channels", 10th IEEE International Conference on ICT and Knowledge Engineering, 2012.
[12] A.I.N Alshbatat,, "EEG-Based Brain-Computer Interface for Automating Home Appliances", 2014.
[13] R.K. Tiwari, and S. Giripunje, "Design approach for EEG-Based Human Computer Interaction Driver Monitoring System", IJLTET, Vol 3, No 4, P.P. 250-255, 2014.
[14] X. Song, "A Quadcopter Controlled by Brain Concentration and Eye Blink", IEEE Signal Processing in Medicine and Biology Symposium (SPMB), 2016.
[15] C. Levicán, "Insight2OSC: Using the Brain and the Body as a Musical Instrument with the Emotiv Insight".
[16] "Insight Features", https://www.emotiv.com/insight/, 10:15PM, 28/2/2018
[17] " Mental Commands Introduction", https://emotiv.zendesk.com/hc/en-us/articles/201483705-Understanding-the-Mental-Commands-Detection-Suite, 3:20AM, 27/2/2018
[18] ”Performance Metrics Introduction", https://emotiv.zendesk.com/hc/en-us/articles/201444095-Understanding-the-Performance-Metrics-Detection-Suite, 7:19, 3/3/2018
[19] " Facial Expression Detections", https://emotiv.zendesk.com/hc/en-us/articles/201216295-Facial-Expression-Detections, 4:45, 1/3/2018