NEUROPHONE: BRAIN MOBILE PHONE USING A WIRELESS EEG HEADSET

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DECLARATION

‘‘I hereby declare that this report entitle Brain Mobile Phone Interface Using A Wireless EEG Headset is the result of my own work and that, to the best of my knowledge and believe. It contains no material previously published or written by another person except for quotes as cited in the references and also no material which to a substantial has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.’’

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Date : 6 June 2014

SUPERVISOR DECLARATION

"We hereby declare that We have read through this report entitle Brain Mobile Phone Interface Using A Wireless EEG Headset and found that it is sufficient to a comply the partial fulfillment for awarding the degree of Bachelor of Electronics Engineering (Telecommunication Engineering) with Honours"

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Special to my beloved mother and father who always standby my side in giving supports morally and physically

ABSTRACT

Neurophone is a device that acquires and analyzes neural signals with the goals of creating a communication channel directly between the brain and mobile phone. Currently, neurophone uses neural signal to control mobile phone for hands-free, silent and effortless human-mobile interaction using a wireless EEG headset. However, devices for detecting neural signal have been costly, bulky and fragile. Therefore, in this project a neural signal is proposed due to fact that neural signals are everywhere just like mobile phones which uses the Emotiv EPOC headset with Samsung mobile phone. The scope of this project is limited to certain applications for the smart phone such as smile at the photo in the user's contact address and dial up. When the phone flashes a selection of photos of contacts from the address book, the user uses his facial expression to smile at those photos and dial up to the person that he/she wishes to call. The signals from the EEG headset are transmitted wirelessly to smart phone which natively runs a lightweight classifier to discriminate neural signals from noises. When a person's contact-photo matches with facial expression signals, his/her phone number is automatically dialed. Neurophone breaks new ground as a brain-mobile phone interface for ubiquitous pervasive computing. A neurophone is expected to be developed.

ABSTRAK

Neurophone adalah alat yang mengambilalih dan analisis isyarat saraf dengan matlamat mewujudkan satu saluran komunikasi secara langsung antara otak dan telefon bimbit. Pada masa ini, neurophone menggunakan isyarat saraf untuk mengawal telefon bimbit tanpa menggunakan tangan, senyap dan tanpa tenaga manusia berinteraksi antara mudah alih dengan menggunakan alat dengar EEG wayarles. Walau bagaimanapun, peranti untuk mengesan isyarat neural adalah mahal, besar dan rapuh. Oleh itu, dalam projek ini isyarat neural adalah dicadangkan kerana hakikat bahawa isyarat saraf di mana-mana sahaja seperti telefon bimbit yang menggunakan alat Emotiv EPOC dengan telefon bimbit Samsung. Rangkaian projek ini adalah terhad kepada sesetengah aplikasi untuk telefon pintar seperti senyum pada gambar di dalam alamat kenalan pengguna dan akan mendailkan nombor tersebut. Apabila pengguna mempamerkan pilihan gambar kenalan dari buku telefon, pengguna menggunakan ekspresi muka untuk senyum pada gambar tersebut dan dail kepada orang yang dia ingin panggil. Isyarat dari alat dengar EEG dihantar secara wayarles kepada telefon pintar dengan secara asalnya menjalankan pengelas ringan untuk mendiskriminasi isyarat saraf daripada bunyi. Apabila gambar seseorang setanding dengan isyarat ungkapan muka, nombor telefon beliau akan didail secara automatik. Neurophone merupakan teknologi dan pengalaman yang terbaru bagi pengguna telefon pintar. Neurophone dijangka akan dimajukan dalam masa akan datang.

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CHAPTER I

INTRODUCTION

1.1 Project Background

Recently, humankind has seen a revolution in the smart phone industry and emerging growth in the usage of mobile applications that range from entertainment and educational apps to simple games, health care apps and more. However, the development of technology broke the science fiction and brought the reality into play when reading human minds was just as science fiction.

With the increasing cost and demands made of the mobile phones applications and services, there is significant interest in the development of technology that can help to make a communication between our brains and mobile phones. In particular, there is growing interest in the development of wearable systems for acquiring and analyzing various neural signals. A commonly used device for the implementation of such systems is called electroencephalography (EEG) wireless headset. By using this device, neural signals are acquired from the brain based on the brain activity interact with influence or change of the environment.

Brain-mobile phone aims to provide a communication channel from human's brain to a mobile phones and it is a system which directly translates brain activity

into a sequences of control commands. It also decodes real time digital signals from electrical activities of the brain and it does not depend on the cessation of physical movements, hence it is capable of providing superior communication and control. Brain-Mobile Phone Interface allows people to send massages or commands from human's brain activities to the outside world without peripheral nerves and muscles activities. However, these activities can be detected and recorded by EEG wireless headset [1].

This headset is wirelessly connected with a smart phone where this phone is directly interfaced with human brain. In this project, we will discuss the Brain-Mobile phone interface design and build a mobile real-time platform for stimulus delivery, data acquisition, and processing with focus on real-time of brain activity. The implementation and evaluation will be discussed as well for the neurophone system.

1.2 Motivation

Mobile phones and neural signals are present in everywhere and accessible to many people. For this reason, the development in low-cost EEG headsets is led to the advanced technology. In order to run sophisticated machines learning algorithms, the smart phones are now powerful enough to do that. Thus, this helps to interface the neural signals with the mobile phones.

Affordable wireless EEG headsets that capture the impulse electric potentials of the neuron in the brain by electrodes resting on the headset have become available. It is originally designed for games interfaces and it is also used some applications like controlling wheelchair [2], interfacing brain machine to directly manipulate robotic arms [3], driving a car[4], or selecting mentally the images using the P300 oddball paradigm to call contacts by also selecting their image from the phonebook contact of an iPhone [1].

However, there is an obvious question whether the quality of consumer priced EEG sets and the limited number of electrodes make it feasible to capture brain signal data in noisy environments. Therefore, combining a wireless EEG headset with a Smartphone to interface these signals and measure the emotional responses by capturing the EEG data of brain activity on the device.

1.3 Problem statement

Neurophone is a device uses the neural signal for driving mobile phone applications. Currently neurophone for brain mobile phone appliances uses a wireless EEG headset to interface the neural signal to a smart phone. However, not all the people enjoy the privilege of using new technology such as smart phones. The paralyzed people who cannot utilize the basic motor functions of their body, people with locomotive defects. They are limited to the usage of smart phones that often required optical and hand coordination. They are also facing some difficulties to communicate with other people by using the new technologies due to hearing problems or they cannot use mobile phones by their hands. Neruophone has to be developed in order to achieve communication between brain and mobile phone.

1.4 Objectives of the Project

The main purpose of this project is to develop the Brain-mobile phone interface using a wireless EEG headset. Therefore, the objectives as below should be achieved:

- to interface the neural signal for controlling mobile phone.
- to develop and implement algorithm in order to poll a real time data using EEG headset.
- to apply knowledge with advanced technology for creating new device in communication field.

1.5 Project Scope

The goal of this project is to interface the neural signal to mobile phone based on the Emotive EPOC headset. This includes the evaluation of current neurophone technology and demand to bring together the neural signals and phones. This project limits to certain applications on mobile phone which allows neural signal to drive mobile phone. The neurophone system uses the Smartphone to display pictures of contacts in the user's contact address. Those pictures are displayed and selected randomly. The user focuses on the picture that he wants to call then the EEG headset record the smiling mode's signals and transmit them to the Windows PC wirelessly. Then, these data will be sent to Android Smartphone using Wi-Fi transmission. Neurophone recognizes these signals and determines which person the user smiles on and calls him/her.

The EEG headset acts as transmitter and mobile phone as a receiver in this case. On the other hands, the Expressiv Suite will be used in order to detect the facial expression. The accurate detection result depends on a good sensor contact and EEG signal quality. However, the graph of the signal in the Expressiv Suite will be increased and decreased according to the level of the expression detection. There will be no detected expression if the facial expression is at low level. Nevertheless, if it is at high level, the maximum level of expression will be detected.

1.6 Thesis Structure

This thesis consists of five chapters which are categorized as below:

Chapter 1: **Introduction**-This chapter introduces and explains the purpose of this project, presents the problem formulations, thorough and as well as detail information about the neurophone system will be discussed.

Chapter 2: **Literature Survey-** This chapter provides a detailed background of the Brain-mobile Interface and taking in the consideration the fundamental concepts of neurophone system. It also provides information about the real concept of EEG, Wireless EEG headset, Smart phones and brain-mobile controlled.

Chapter 3: **Methodology-** This chapter describes the methods and procedures used to design this project in details as well as flow charts, provide specifications and discuss the data acquisition and processing techniques.

Chapter 4: **Result and discussion**- This chapter illustrates and analyzes the result of this project and discusses the possible further improvements of the developed system.

Chapter 5: **Conclusion and recommendation-** This chapter presents the conclusion of the project. The strengths and limitation of the project will be highlighted as well. Furthermore, some recommendations for future works will be provided.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Previous study by Matthew K. Mukerjee, indicates many mobile applications can be reinvented, for instance; instead of hand dialing up, it can be simply wink or think to the particular person that appear while the phone displays the pictures of contents in the user's address book. The neurophone system uses the iPhone to display those pictures. Once the user concentrates on the picture of the person that user wishes to call in case of the think mode of application called "Dial Tim." Neruophone recognizes the person that user is concentrated on and calls him [1]

Another study by Anthony M. Garcia, demonstrates the brain activity recording is considered as the beginning of the development of future brain computer interaction software by using commercial EEG devices. And some systems have been developed in order to use neural signals from a commercial EEG headset to control mobile phone. Neurophone system combines the emerging EEG hardware with the interface of smart phones. The final product is an application which sets up a platform for the mobile collection and analysis of EEG data. In this study, the applications were not indicated to intend it as a product for entertainment or to

provide BCI functionality. It is only a research tool to facilitate the development of the EEG pattern recognition techniques with the help of the average user [5].

In another work done by Calm Seale, he designed an algorithm that reads signal data from EEG source and process this data for determining whether the person is undergoing an epileptic seizure or not. This program ports to mobile devices. He also used the Android OS which provides hardware support for Bluetooth to connect it with the Emotive EPOC Headset. He used HTC wildfire smart phone whose specs relevant to the project. The result demonstrates the possibility of significantly enhancing the range of technology available to support mobile healthcare [6].

Figure 2.1 below illustrates the connection between the EEG headsets with the HTC mobile phone through PC. The full intention in this paper is to allow the PC to act as a relay device. Thus, it allows the Emotiv EPOC Headset to transmit data to the Android mobile device in a real time. This PC used to buffer data from the headset (sampling at 128Hz) into frames of 1024 samples for transmission to the Android mobile phone every seconds. The main aim was to merge the Client app with the classification program and allow

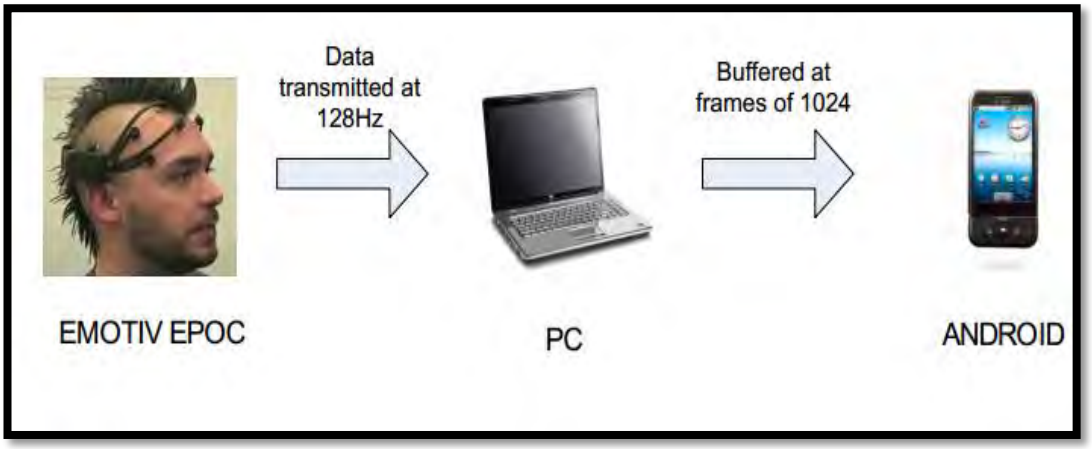

Figure 2.1: High- level design for mobile detection of seizures (Seale, 2012)

Neurophone system developed by [7], the author describes a Smartphone Brain Scanner with a low-cost wireless 14 channels Emotiv EEG headset that interfaces with multiple mobile devices. The system enables minimally invasive and continuous

capturing of brain imaging data in normal settings. It also applies an inverse Bayesian framework to spatially visualize the activation of neural sources real-time in a 3D brain model.

Figure 2.2 demonstrates the connection of EEG headset directly to Smartphone. This Smartphone Brain Scanner provides multiple functions including stimulus delivery, data acquisition, logging, brain state decoding and 3D brain activity visualization. The author uses a wireless EEG to acquire the raw data with sampling 128 Hz while the 3D model contains 1028 vertices and 2048 triangles. However, the user can interact with the 3D model on the device using touch gestures.

Figure 2.2: Smartphone Brain Scanner Running in different Types of Phones (Stopczynski,2011).

2.2 Smart Phone Devices

A Smartphone is a mobile phone that built on a mobile operating system. It has more advanced computing capability and connectivity compare to a feature phone. Most of smart phones have Bluetooth Wireless Technology module that inbuilt in the device for various small range wireless applications such as headset, transferring file, inputting wireless devices and etc. The proposed concept exploits these features of the Smartphone to use it as a transmitter and control device completely eliminating

the need for a separate transmitter block. According to the research studies and advisory firm GartneInc [7], the global market of the smart mobile phone system is the in the fourth quarter of 2011 is controlled by the android system from Google by 50.9%, IOS from Apple by 23.8% and Symbain from Nokia by 11.7%. Furthermore, android system is also relatively easily accessible from a development point of view since its Software Development Kit is an open source and free of charge. As a result, these circumstances made the decision to base the front end part of the prototype on the Android platform.

2.3 Electroencephalogram (EEG)

Electroencephalogram (EEG) are recordings of electrical activity and electrical potential that produced by the brain. It can measure voltage fluctuations which result from ionic current flows through the neurons in the brain. In the past, interpretation of the EEG was limited to visual inspection by an electroencephalographer, an individual trained to qualitatively distinguish normal EEG activity from localized or generalized abnormalities contained within relatively long EEG records. This approach left clinicians and researchers alike buried in a sea of EEG paper records. The advent of computers and the technologies associated with them has made it possible to effectively apply a host of methods to quantify EEG changes. With this in mind, this chapter provides a brief historical perspective followed by some insights regarding EEG recording procedures and an in-depth discussion of the quantitative techniques used to analyze alterations in the EEG [9].

2.4 Wireless EEG Headsets

The wireless Emotiv EPOC is high resolution and processing a neural signal acquisition. It is mainly designed for gaming purposes by detecting the emotions, conscious thought and head rotation. It is also used to collect raw EEG data from brain's users. The features of the wireless EEG headset are:

- 14 channels plus 2 references which are placed in the brain to read signals from different areas of the brain.
- Generates optimal positional information by gyroscope.
- Connection to PC by Bluetooth.
- USB dongle that is compatible and requires no drivers.
- Software Suites provided by Emotiv that allows the connection to each channel to be tested and the raw EEG can be monitored from a test bench program.
- Lithium Battery that provides 12 hours used continuously.

The EEG headset documentation includes programs written in C++ that allows the user to log the preprocessed EEG raw data from the headset. This headset provides cheap and an affordable platform for portable wireless capture of EEG data. However, the Emotiv EPOC headset is only compatible with windows PC and that affects the project due to the limitation of the EEG headset. And also the Emotiv EPOC is not a programmable. Thus, to capture real time data and process it on mobile device, a method had to be devised of transferring the raw data over wireless connection to the handheld [6].

2.5 Brain-Controlled Interfaces

Based on the recent studies, it says that Samsung is currently implementing newer technologies to the Smartphone. To be more specific, Samsung is studying the ways on how the user's brain wave can control the Smart phones. However, other studies already implemented this technology. And the interface between the mobile phone and brain are done for certain application and the wireless EEG headset has some limitations. However, there many practical challenges remain to make this vision to real due to some reasons. One of these reason is the research grade EEG headsets are expensive but it offers a much more robust signal than the cheaper headsets. The EEG headset also is not compatible with android operating system and that's may be quit challenging. Therefore, the cheaper headsets have a significant

amount of noise in its data. This requires more sophisticated signal processing and machine learning techniques to classify the noises [10].

On the other hands, the cheaper headsets provide an encrypted wireless interface between the headset and computer allowing for mobility but that will make the design of a clean brain mobile phone interface more complex. Since the mobile phones are not designed for supporting continuous neural sensing application, it cost much more energy due to continuous streaming raw neural signals over the air interface and classifiers on the on the phone [1]. This is considered as the main challenges that neurophone system face. Figure 2.3 illustrates the neurophone system in use for brain mobile phone interface using EEG headset with iPhone.

Figure 2.3: Neruophone System for Brain-mobile Interface (Mukerjee,*TR2010-666*)