A Brain Computer Interface for Smart Home Control

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***Abstract*--. The aim of this study is to control home devices using a non invasive brain computer interface (BCI). The Electroencephalographic signals (EEG) recorded from the brain activity using the Emotiv EPOCH headset are interfaced with the help of mouse emulator to a graphical user interface (GUI) on the computer screen. The user will use this GUI to control various devices in a smart home. This application will be very useful especially for people with special needs.**

I. INTRODUCTION

BCI is a system that captures the brain electrical activity in the form of EEG signals; and translates those specific features of the signal that represents the intent of the user into computer readable commands. These commands can control and operate an electronic device [1]-[2]. This technology is developing very rapidly, as it has innumerable uses, the most important of which is improving the quality of life of human beings in general and elderly and disabled people in particular [3]-[5]. The BCI can be divided into non-invasive and invasive type, where in latter an IC is implanted in the brain by surgery. Hence people prefer non invasive BCI which involves only wearing of a headset or cap equipped with an active electrode system.

In this paper, our main aim is to develop a thought controlled smart home system. We will use a non-invasive BCI device known as Emotiv EPOC headset [6] to capture EEG signals. The EEG signals are transmitted via Bluetooth to the interface computer. The built in gyro sensor in the emotive headset helps to control the mouse cursor in the mouse emulator. Hence the electroencephalography (EEG) signals produced by the brain electrical activity can be trained and used to control the mouse on a graphical user interface of home appliances on the computer screen.

II. METHODOLOGY

Recent research shows that brain computer interface can be used for motion disabled people, however the mean classification rate achieved is above 80%. This means there is still 10-20% error rate [7]. This error may result in loosing user control. Hence in this study we propose a very simple and effective method for smart home control.

A. EEG Signal Acquisition and Event Detection

For EEG signal acquisition the Emotiv EPOC headset is used. It has 14 channels (electrodes) and the sampling frequency is 128 Hz (2048 Hz internal). It has a built in 5^{th} order low pass sinc filter of bandwidth 0.2 to 45 Hz, and is connected wirelessly to the computer through a 2.4 GHz band. Fig.1 shows the Emotiv EPOC headset and the location of the electrodes.

Emotiv EPOC uses three built-in suites to determine the various types of signal inputs: i.e Expressiv Suite for analyzing users facial expressions, the user's emotional state is interpreted by the Affectiv Suite while the Cognitiv Suite analyzes user's intent to control a movement. In addition the gyro can be used as a mouse emulator.

The aim of this project is to acquire and identify the EEG signal that is related with the user intention to operate a device in the smart home. Hence for event detection it is necessary to have a unique profile for each user to map the user's brain-patterns. In this study we have used a simple feature i.e. raise an eyebrow to create an event. So whenever the user will raise an eyebrow a mouse click will be activated. Fig. 2 shows the mouse emulator from the EmoControl Panel. While wearing the headset the mouse emulator in EmoControl Panel will be used to generate a mouse click whenever the user will raise an eyebrow. The set up of EmoKey is shown in Fig.3.

Fig. 1. Emotiv EPOC headset and electrodes location

Fig. 2. Mouse emulator

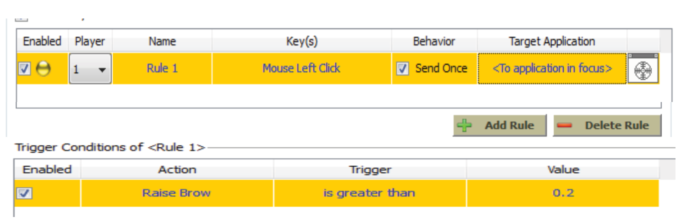

Fig. 3. The setup of EmoKey

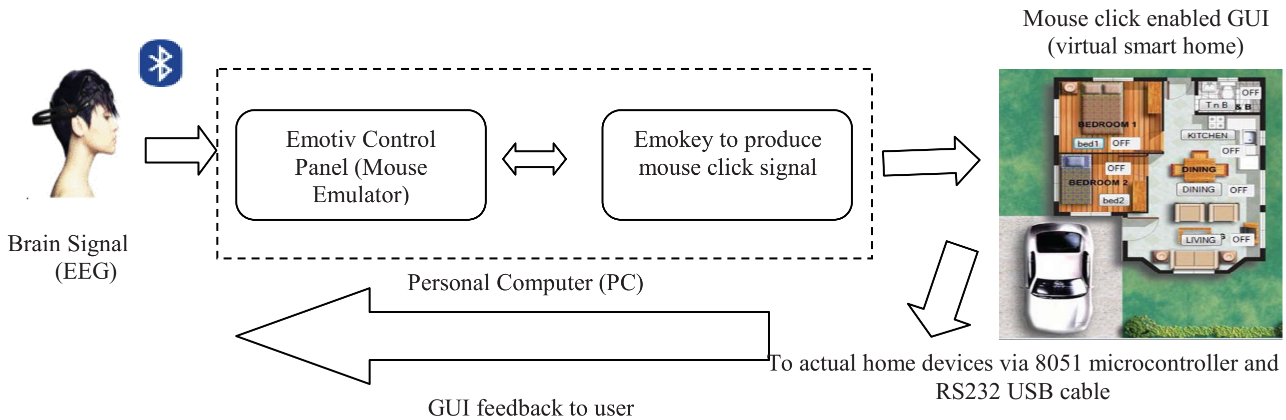

Fig. 4. Block diagram of brain controlled smart home system

B. *Setup of Virtual Smart Home System*

In order to control and operate the home using brain signals, a virtual home environment has been created. In the virtual environment there is indoor and outdoor access, it consists of many rooms, each having many devices like TV, MP3, lights, temperature control, doors to operate. All these commands can be shown via a graphical user interface (GUI), on the computer screen. The user will select his desired application using a raise of an eyebrow (or a smirk, or a combination of actions if needed and to incraese the sensitivity of the system), that will cause a mouse click on the desired control, as a result the control will be toggled. For example, the subject can turn on the light of a room by selecting the light symbol, and reselection means light will be turned OFF. The interface between the Emotiv EPOC and the GUI has been written using Microsoft Visual C5 using Common Language Runtime (CLR). Fig. 4 shows the block diagram of the brain controlled smart home system. A simple flow chart of the flow of events in a brain controlled smart home system is shown in Fig. 5.

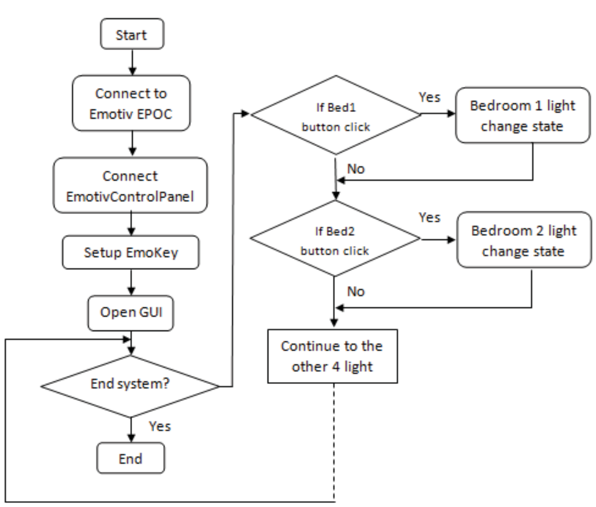

Fig. 5. A sample flow chart of event detection and control in a smart home

III. Conclusion and Discussion

The main goal of this paper is to design, develop and implement a brain controlled smart home system. In this system, the brain EEG signals are acquired using Emotiv EPOCH headset. A single feature i.e. raising an eyebrow along with mouse emulator is used to control a virtual home environment using a graphical user interface. Each click on the desired home icon by using a raised eye brow signal (feature) will activate the control of that home item, like turn off the light. All this will happen in real time. It is possible to add more controls to the virtual environment by using a combination of activities like raising an eyebrow and a single or multiple blinks. The system has been trained and tested with 4 subjects. The preliminary results show a thought controlled smart home system can become a reality in the near future. It will result in a drastic change in the type and quality of life of individuals and disabled and elderly people. In addition it will also result in an increase in demand of consumer electronics devices that can be easily interfaced with BCI systems.

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