



Home Appliances Control Using Brain Wave Sensor by EEG

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Abstract - This paper presents a brain controlled home appliance based on Brain-computer interface (BCI). Today even though technology is helping some of the handicapped people to perform their tasks, but some of them are completely paralysed while their brain is still working. This paper presents a brain wave analysis technology that helps physically paralysed but mentally active people to operate external device, by using their brain power and their eye blinking mechanism. BCIs are systems that can transfer the information from brain to computer by interfacing through muscles and brain waves movement by the collecting electrodes placed on scalp of brain. These waves are intercepted by dry electrodes in brain wave sensor. For analysis of brain waves alpha and beta waves of EEG output are used to control the home appliances operation through ARM controller by transferring serial data from brain waves through serial communication.

Keywords— ARM, EEG, BCI, Serial Communication, MATLAB

I. INTRODUCTION

Owing to the developments in the neurosciences and computer technology, it has become possible to link brain activity to the operation of computers and devices, creating a direct communication channel between mind and machine. This is done by using BCI. Thus BCI is used to collect the information from the brain and at the same time give commands to computer interface and operate different appliances. There are methods of data acquisition techniques in BCI. In this paper EEG is used.

EEG is used to acquire biological signals. This is an electrical activity that records brain waves from scalp of the brain. The recorded waveforms reflect the cortical electrical activity. The EEG signals are measured in smallest range therefore signal intensity measurement is of the order of micro volts (μV).

Depending on the frequencies of the brain waves of human, EEG signals are arranged into four categories. They are Alpha, Beta, Gamma, and Delta.

TABLE 1 Different EEG signals

	EEG Bands (Hz)	Distribution	Subjective feeling	Associated tasks & behaviors	Physiological correlates
	Delta 0.1-3	Distribution: generally broad or diffused	deep, dreamless sleep, non-REM sleep, unconscious	lethargic, not moving, not attentive	not moving, low-level of arousal
	Theta 4-8	usually regional, may involve many lobes	intuitive, creative, recall, fantasy, imagery, creative, dreamlike, drowsy	creative, intuitive; distracted, unfocused	healing, integration of mind/body
	Alpha 8-12	regional, usually involves entire lobe	relaxed, not agitated, but not drowsy	meditation, no action	relaxed, healing
	Beta 12-30	localized	alertness, agitation	mental activity, e.g. math	alert, active
	Gamma >30	very localized	Focused arousal	high-level information processing, "binding"	information-rich task processing

II. METHODOLOGY

In this paper EEG signals are used for acquisition and depending on EEG Signals collected, eye blinking is done and devices are operated. This is done through BCI. EEG signals are intercepted using Mind Wave sensor MW001 that contains bipolar electrode. One is placed on forehead to collect electrical activities of brain and the other is ear clipped to reference (ground). This is recorded and transmitted through Bluetooth. In this paper two signals used are alpha and beta. When alpha waves are active, commands are given to Brain wave sensor and when beta is active corresponding commands are given to operate devices. The Flow of EEG signals are as shown in below Fig 1.

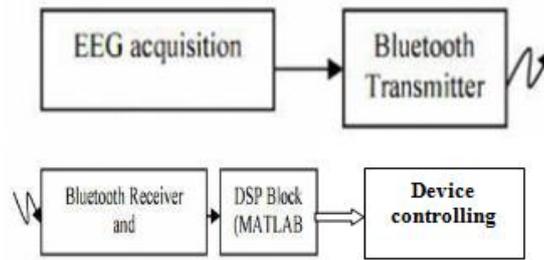


Fig. 1 Signal Transmission from EEG to Device Controlling

As shown in the fig.1 the raw signals are collected and EEG signals acquisition is done in Mind wave sensor MW001. This sensor consists of a headset called Neurosky headset that is used to measure EEG signals and Eye blinking which are then transmitted to digital signal processing block by Bluetooth and commands are given to PC by Bluetooth receiver wireless module. EEG signals are classified into 2 signals: one is meditation signal and other is attentuation signal which are given to device controller accordingly.

The BCI interface and its control is explained by “J. Williamson in ‘Interaction design for brain computer interfaces ‘[2].

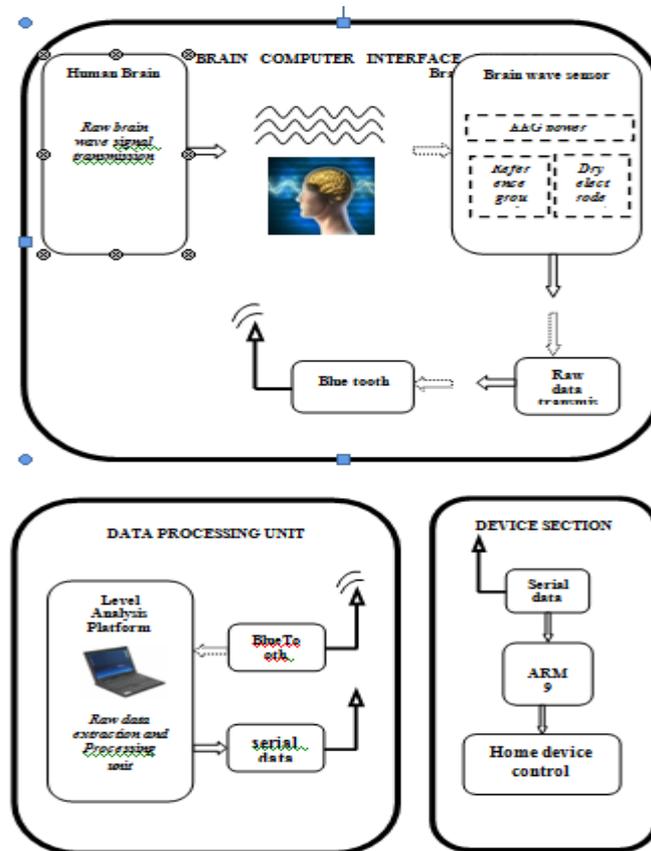


Fig. 2 Block Diagram

III. IMPLEMENTATION

Mind Wave sensor or Neurosky sensor transfers the signals through software application called ThinkGear to MATLAB. MATLAB collects the signals periodically and accordingly transfers the information to digital signal processing unit and maps continuously the appropriate actions and gives instructions to controller to operate external device unit.



Fig. 3 Hardware Kit

Table 2 Commands to Control Device

COMMANDS	EEG SIGNALS EXTRACTED
Operate Devices	Attenuation (BETA)
Operate first device	1 Eye blink
Operate Second device	3 Eye Blinks
Stop device	Meditation

The external device is controlled through ARM Controller and LCD display is placed to verify operation. Power supply of 12V is supplied to operate the external device unit.

Working of BCI is as shown below in Fig. 4

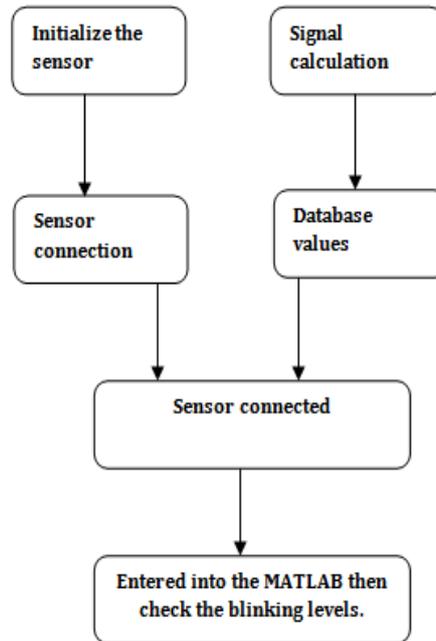


Fig.4 Software Flow of BCI

The signals collected from the Mind wave is transmitted to PC through Bluetooth and ZigBee and devices are controlled through ARM9controller.

IV. IMPLEMENTATION

A. ARM-LPC2929

The LPC2929 contains an ARM968ES CPU core with two integrated TCM blocks operating at frequencies up to 125 MHz, Full-speed USB 2.0 OTG and device controller, CAN (Controller area network) and LIN (local interconnect network), 56KB RAM, up to 768KB flash memory, external memory interface, three 10-bit ADCs, and multiple serial and parallel interfaces in a single chip. To optimize system power consumption, the LPC2929 has a very flexible Clock Generation Unit (CGU) that provides dynamic clock gating and scaling.

The ARM968E-Sisa general purpose 32-bit RISC processor, which offers high performance and very low power consumption. The ARM architecture is based on Reduced Instruction Set Computer (RISC) principles, and the instruction set and related decode mechanism are much simpler than those of micro programmed Complex instruction Set Computers (CISC). This simplicity results in a high instruction throughput and impressive real-time interrupt response from a small and cost-effective controller core.

Amongst the most compelling features of the ARM968E-S are:

- Separate directly connected instructions and data Tightly Coupled Memory (TCM) interfaces
- Write buffers for the AHB (Advanced High performance bus) and TCM (Tightly coupled Memory) buses.

The input of the microcontroller is from PC through ZigBee Module and the result of the data is displayed in PC and L293D driver which initiate motor to rotate.

B. Brain Wave Sensor

EEG is the measurement of electrical activity in the living brain. In this paper brainwave sensor MW001 is used to analyse the EEG signals. Processing and recording the raw EEG signal from the Mind Wave sensor is done in the MATLAB environment and through ZigBee transmission control commands are passed to the Robot section. Mind wave

sensors are not used in clinical use, but are used in the Brain Control Interface (BCI) and neuro feedback (one of biofeedback types). The BCI is a direct communication pathway between the brain and an external device.\

C. L293D

L293D is a dual H-bridge motor driver integrated circuit (IC). Motor drivers act as current amplifiers since they take a low-current control signal and provide a higher-current signal. This higher current signal is used to drive the motors.L293D contains two in-built H-bridge driver circuits. In its common mode of operation, two DC motors can be driven simultaneously, both in forward and reverse direction.

D. Serial Communication (ZigBee)

The XBee/XBee-PRO RF Module [5] is designed to operate within the ZigBee protocol and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between remote devices. The modules operate within IEEE 802.15.4 standard. The data rate is 250kbps at 2.4GHz. Distance range to 10 -100 m line of sight.

V. SOFTWARE IMPLEMENTATION USING MATLAB

MATLAB's Graphical User Interface Development Environment (GUIDE) provides a rich set of tools for incorporating graphical user interfaces (GUIs) in M-functions. Using GUIDE, the processes of laying out a GUI (i.e., its buttons, pop-up menus, etc.) and programming the operation of the GUI are divided conveniently into two easily managed and relatively independent tasks.

The MATLAB allows including thinkgear.dll. This environment has broad support in toolbox, which makes it ideal for a scientific research. This paper presents how recording and processing of the raw EEG signal is performed in MATLAB environment using Mind Wave sensor. The Communication Protocol shows a system of digital rules for message exchange between MATLAB environment and Mind Wave MW001 device. ThinkGear is library file used in MATLAB to get signals from brain wave sensor to MATLAB. This section below presents the main parameters of ThinkGear library.

The connection is established through command: calllib ('Thinkgear','TG_Connect', Id,ComPortName, TG_BAUD_115200,TG_STREAM_5VRAW). In the next step, attempt is made to read a Packet of data from the connection. TG_Read Packets () function is used with ID parameter and number of packet to read. The command calllib ('Thinkgear', 'TG_ReadPackets', Id,1) returns false for error, and otherwise true. The function TG_GetValueStatus () checks if a value has been updated by TG_ReadPackets(). If this function returns true TG_GetValue () function is used to get the updated value of the raw EEG signal.

VI. RESULTS AND DISCUSSIONS



Fig. 5 Mind Wave Sensor Kit

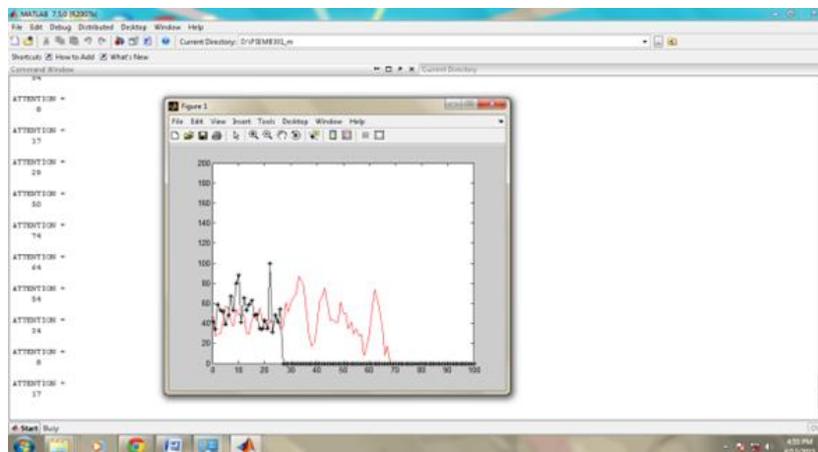


Fig.6 Brain signals displayed in MATLAB

The above Fig.6 represents the attention value and blink strength. Based on this signal device control file is opened and the device is controlled based on the brain signals as shown in Fig.7

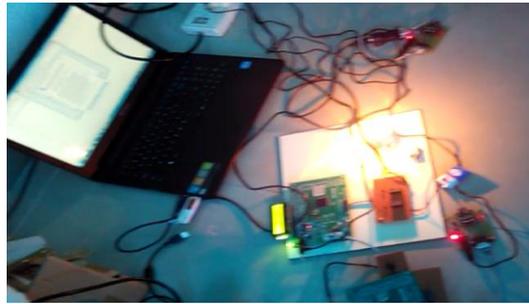


Fig. 7 Home Appliance operated by ARM9

VII. CONCLUSION

This paper discussed about Brain controlled home appliances based on Brain-computer interfaces (BCI). This project developed is designed to be of assistance for disabled people. This project can be enhanced in future with further increase in speed, accuracy, and range of applications. BCI technology could become applicable to larger population and could thereby engage the interest and resources of private industry. Some of them are Automobile applications, Industrial application, Home applications, Monitoring device applications and Remote control applications.

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