



International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 8, August 2014

Brainwave Controlled Robot Using Bluetooth

Silveru Ramesh¹, K.Harikrishna² J.Krishna Chaitanya³

PG Student, Department of ECE, Vardhaman College of Engineering, Hyderabad, India¹

Professor, Department of ECE, Vardhaman College of Engineering, Hyderabad, India²

Associate professor, Department of ECE, Vardhaman College of Engineering, Hyderabad, India³

ABSTRACT: This paper describes about a brain controlled robot based on Brain-computer interfaces (BCI). BCIs are systems that can bypass conventional channels of communication (i.e., muscles and thoughts) to provide direct communication and control between the human brain and physical devices by translating different patterns of brain activity into commands in real time. With these commands a mobile robot can be controlled. Here the robot is self-controlled with the ultrasonic sensor. The intention of the project work is to develop a robot that can assist the disabled people in their daily life to do some work independent on others. Here, we are analysing the brain wave signals. Human brain consists of millions of interconnected neurons.

KEYWORDS: EEG Sensor, Relay Driver, Embedded platform, communication module, image acquisition module, BCI-Brain computer interface.

I.INTRODUCTION

The patterns of interaction between these neurons are represented as thoughts and emotional states. According to the human thoughts, this pattern will be changing which in turn produce different electrical waves. A muscle contraction will also generate a unique electrical signal. All these electrical waves will be sensed by the brain wave sensor and it will convert the data into packets and transmit through Bluetooth medium [1]. Level analyzer unit (LAU) will receive the brain wave raw data and it will extract and process the signal using Mat lab platform. Then the control commands will be transmitted to the robotic module to process. With this entire system, we can move a robot according to the human thoughts and it can be turned by blink muscle contraction.

The basic idea of BCI is to translate user produced patterns of brain activity into corresponding commands. A typical BCI is composed of signal acquisition and signal processing (including preprocessing, feature extraction and classification) [2]. Although some BCI systems do not include all components and others group two or three components into one algorithm, most systems can be conceptually divided into signal acquisition, preprocessing, feature extraction, and classification. The brain signals that are widely used to develop EEG-based BCIs include P300 potentials, which are a positive potential deflection on the ongoing brain activity at a latency of roughly 300ms after the random occurrence of a desired target stimulus from non-target stimuli the stimuli can be in visual, auditory, [3] or tactile modality SSVEP, which are visually evoked by a stimulus modulated at a fixed frequency and occur as an increase in EEG activity at the stimulus frequency and the event-related de synchronization (ERD) and event-related synchronization (ERS), which are induced by performing mental tasks, such as motor imagery, mental arithmetic, or mental rotation [4].

Although many researchers have developed various brain-controlled mobile robots, to the best of our knowledge, none of the existing brain-controlled mobile robots is brought out of a controlled laboratory environment. The main reason for this is that the BCI is not stable due to the non-stationary nature of the EEG signals. Thus, to make these mobile robots usable in real-world situations, stable BCI systems need to be explored. If a BCI system is not stable, other techniques should be further developed to improve the overall driving performance. Rebsamen *et al.*, Iturrate *et al.* also combined a P300 BCI and an autonomous navigation system to develop a robotic wheelchair. The main difference between them is that the latter allows a wheelchair to move in an unknown environment. In addition, the user is able to control the wheelchair to turn left or right at any time by focusing his/her attention on the “turn left” or “turn right” icons at the lower section of the visual display to elicit a corresponding P300.

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 8, August 2014

II. DESIGN AND IMPLEMENTATION

This paper is implemented in an effective way we divide brain-controlled mobile robots into two categories according to their operational modes. One category is called “direct control by the BCI,” which means that the BCI translates EEG signals into motion commands to control robots directly who first developed a brain-controlled robotic wheelchair whose left or right turning movements are directly controlled by corresponding motion commands translated from user brain signals while imagining left or right limb movements, and tested this system in real-world situations [5]. The robotic platform is illustrated also used a BCI based on motor imagery to build a brain-controlled mobile robot, as illustrated which can perform three motion commands including turning left and right and going forward, and validated this robot in a real world.

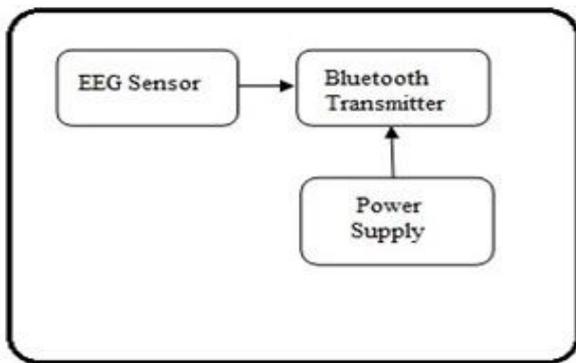


Fig 1: Brain secret card section

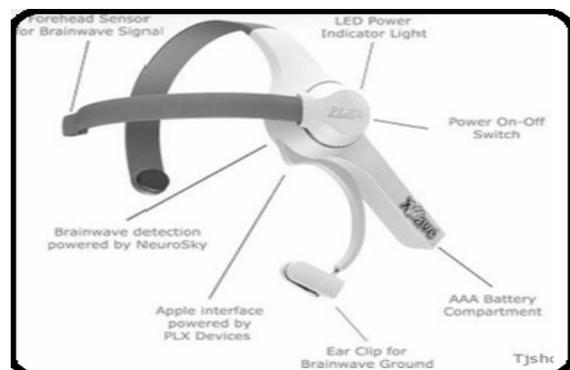


Fig 2: Brainwave Headset provided by NeuroSky

As shown in figure 1 the Brain secret card section contains EEG Sensor to Sense the Human brain, and it will be sensed by using the Brainwave Headset which is provided by NeuroSky. Technologies and those signals will be transferred by using Bluetooth which is there in the Brainwave headset, for this Brainwave headset we need to give power using a AAA battery which is shown in figure 2. The Brainwave headset comes with Power switch, a sensor tip, flexible ear arm and a ground connection Ear clip. In this Headset we use Non-invasive sensor that won't cause any pain to the User who were the headset. After inserting an AAA battery switch on the Brainwave headset using the power switch the LED indicator will blink and if the Red colour light not blinking the headset is powered on but not connected to with the computer's Bluetooth. If the Blue colour not blinking that means the headset is powered on and connected. If the red or blue colour blinks it shows that the Battery getting low.

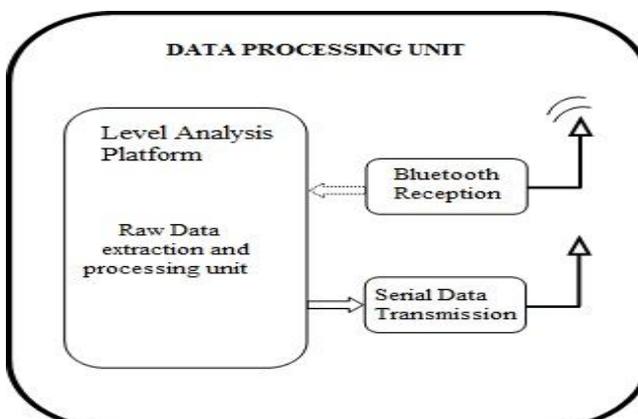


Fig 3: DATA Processing Unit

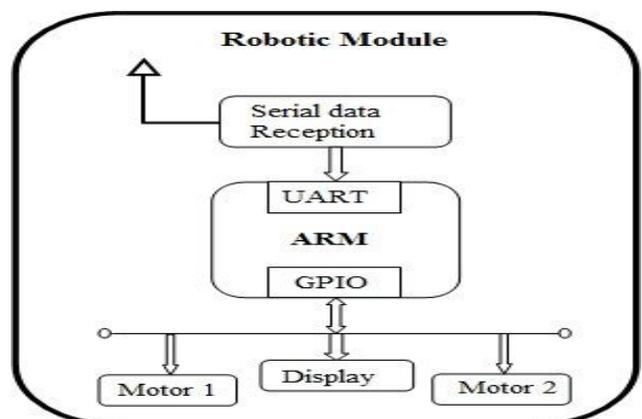


Fig 4: Robotic Module



International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 8, August 2014

As shown in figure 3 the Data transmitted by the Brainwave headset will be received by the Computer's Bluetooth receiver. And then all these data will be analysed by the Level Analysis platform. The Level Analysis platform will extract the raw data using the MATLAB. After the analysis of this data, this data will be sent to the robot module using serial data transmission i.e. using XBee.

As shown in Figure 4, in the robot module there will be an XBee receiver will receive the data which is transmitted by the XBee transmitter. According to the data received by the XBee the ARM processor will give the directions to the motors and the robot is self-controlled robot with ultrasonic sensor and connected with a relay and a driver circuit. And all this information will be displayed on the LCD display.

III.SYSTEM HARDWARE

3.1 ARM Processor

The ARM processor is 32-bit embedded RISC microprocessor. The ARM7 processor needs very low power, high performance and small size. Here in this paper I'm using ARM7 processor and ARM processor will receive the signals from the Bluetooth receiver and it will process the signals and it will give the signals to the Driver Circuit and according to that signals received from the processor, according to the signals received driver circuit the motors will rotate forward, clockwise and anti-clockwise direction. Here ARM processor will wait until the signals received from the Brainwave headset and after receiving the signals it will moves the robots. The driver circuit will connected to the port 1 of the processor.

3.2 Wireless communication

The XBee and XBee-PRO OEM RF Modules were engineered to meet IEEE 802.15.4 standards and support the unique needs of low-cost, low-power wireless sensor networks [6]. The modules require minimal power and provide reliable delivery of data between devices. The modules operate within the ISM 2.4 GHz frequency band. Here we are using XBee to connect Robot with the Computer wirelessly through a logic-level asynchronous serial port. Through its serial port, the module can communicate with any logic and voltage compatible UART [7]. The computer will transform the data which is analysed by using the Level Analyser unit using MAT lab. The data which is transmitted by the XBee module from the computer will be received by the XBee receiver which is connected to the ARM processor.

3.3 EEG Signals

EEG signals can be collected with electrodes that are placed on the surface of the scalp. The most widely used electrodes are silver/silver chloride (Ag/AgCl) because they have low cost, low contact impedance, and relatively good stability. Furthermore, there are rather mature commercialized acquisition systems including the amplifier and EEG cap with integrated Ag/AgCl electrodes, which have been successfully applied in scientific research and clinical diagnosis. However, using Ag/AgCl electrodes requires removing outer skin layer and filling gel between electrodes and scalp (and thus, this kind of electrodes is also called "wet" electrodes). These operations take long time and are uncomfortable to users. To address these limitations of "wet" electrodes, some researchers have been exploring "dry" electrodes, which do not need to use gel and skin cleaning [8-11]. The main disadvantage of existing dry electrodes is that the acquired EEG signals are worse than those acquired with conventional electrodes due to the increase of contact impedance [12]. Some companies (such as Quasar, Emotiv Systems Inc., and NeuroSky Inc.) have been commercializing acquisition systems based on dry electrodes [13, 14]. Here we are using NeuroSky Brainwave headset. However, they are not yet mature, and some researchers have doubts about what physiological signals these systems actually acquire [15]. Therefore, until now, all brain-controlled wheelchairs adopt "wet" electrodes to collect brain signals.

3.4 NeuroSky Technology

i. Brainwaves:

The last century of neuroscience research has greatly increased our knowledge about the brain and particularly, the electrical signals emitted by neurons firing in the brain. The patterns and frequencies of these electrical signals can be measured by placing a sensor on the scalp. The Mind Tools line of headset products contain Neurosky Think Gear technology, which quantify the analog electrical signals, commonly referred to as brainwaves, and exercise them into digital signals. The Think Gear technology then makes those computations and signals available to games and



International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 8, August 2014

applications. The Table I give a general synopsis of some of the commonly- identified frequencies that tend to be generated by different types of activity in the brain [16].

ii. ThinkGear

ThinkGear is the technology inside every NeuroSky product or partner product that empowers a device to interface with the wearers' brainwaves [16]. It includes the sensor that touches the forehead, the contact and reference points located in the ear clip, and the on-board chip that processes all of the data. Both the raw brainwaves and the eSense Meters are computed on the ThinkGear chip.

Table1. Frequencies Generated By Different Types of Activities in the Brain

Brainwave Type	Frequency range	Mental states and conditions
Delta	0.1Hz to 3Hz	Deep, dreamless, non-REM sleep, unconscious
Theta	4Hz to 7Hz	Intuitive, recall, fantasy, imaginary, dream
Alpha	8Hz to 12Hz	Relaxed, but not drowsy, tranquil, conscious
Low Beta	13Hz to 15Hz	Formerly SMR, relaxed yet focused, integrated
Midrange Beta	16Hz to 20Hz	Thinking, aware of self & surroundings
High Beta	21Hz to 30Hz	Alertness, agitation

iii. eSense

eSense is a NeuroSky's proprietary algorithm for representing mental states. To calculate eSense, the NeuroSky ThinkGear technology intensifies the raw brainwave signal and removes the ambient noise and muscle movement. The eSense algorithm is then applied to the remaining signal, resulting in explicated eSense meter values. Please note that eSense meter values do not interpret an exact number, but instead describe ranges of activity. The eSense meters are a way to show how effectively the user is captivating Attention (similar to concentration) or Meditation (similar to relaxation) [16].

(a)Attention eSense:

The eSense Attention meter shows the intensity of a user's level of mental "focus" or "attention", such as that which occurs during intense concentration and directed (but stable) mental activity. Its value ranges from 0 to 100. Distractions, wandering thoughts, lack of focus, or anxiety may lower the attention meter level.

(b)Meditation eSense:

The eSense Meditation meter shows the level of a user's mental "calmness" or "relaxation". Its value ranges from 0 to 100. Note that Meditation is a measure of a person's mental states, not physical levels, so simply relaxing all the muscles of the body may not instantly result in an intensified effect meditation level. However, for most people in most normal circumstances, relaxing the body often helps the mind to relax as well. Meditation is related to reduce activity by the active mental processes in the brain. It has long been an observed that closing one's eyes turns of the mental activities which process images from the eyes. So closing the eyes is often an effective method for increasing the Meditation meter level. Distractions, wandering thoughts, anxiety, agitation, and sensory stimuli may lower the Meditation meter levels [16].

iv. eSense Meter - Technical Description

For each different type of eSense (i.e. Attention, Meditation), the meter value is reported on a relative eSense scale of 1 to 100. On this scale, a value between 40 to 60 at any given moment in time is considered "neutral" and is similar in notion to "baselines" that are established in conventional brainwave measurement techniques (though the method for determining a ThinkGear baseline is proprietary and may differ from conventional brainwaves).

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 8, August 2014

A value from 60 to 80 is considered “slightly elevated”, and may be interpreted as levels tending to be higher than normal (levels of Attention or Meditation that may be higher than normal for a given person) [16]. Values from 80 to 100 are considered “elevated”, meaning they are strongly indicative of heightened levels of that eSense. Similarly, on the other end of the scale, a value Between 20 to 40 indicates “reduced” levels of the eSense, while a value Between 1 to 20 indicates “strongly lowered” levels of the eSense. These levels may indicate states of interruption, agitation, or abnormality, according to the opposite of each eSense.

The reason for the somewhat wide ranges for each interpretation is that some parts of the eSense algorithm are dynamically learning and at times employ some “slow-adaptive” algorithms to adjust to natural fluctuations and trends of each user, accounting for and compensating for the fact that brainwaves in the human brain are subject to normal ranges of variance and fluctuation. This is part of the reason why ThinkGear sensors are able to operate on a wide range of individuals under an extremely wide range of personal and environmental conditions, while still giving good accuracy and reliability [16].

IV. DESIGN FLOW

The flow diagram of Brainwave Controlled Robot unit is shown in figure 6. It shows all the step by step functions of robot, how it will be controlled by using brainwave signals. After Switching on the Brainwave headset and the Robot kit, the processor will initialize and the headset will starts sensing the neurons signals and after sensing the signals it will transfer them to through the Bluetooth and the acquisition module will receive the signals in the processor and in the processor the EEG signals comparison will be done if it is yes then the robot will move according to the signals or else it will go to the relay circuit and robot movement will be there and the process will be stopped.

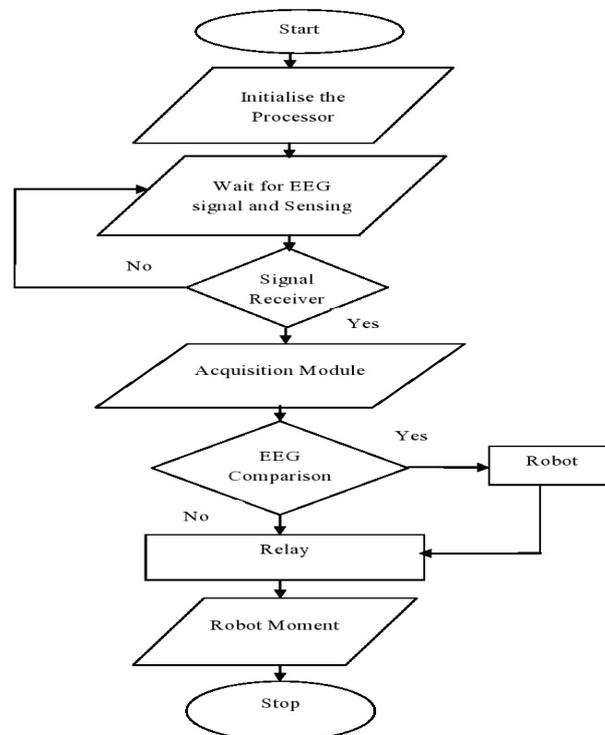


Fig 5: Design Flow

V. RESULT AND DISCUSSION

The research and development of brain-controlled mobile robots have received a great deal of attention because they can help bring mobility back to people with devastating neuromuscular disorders and thus improve their quality of life.



International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 8, August 2014

- [7] Cytron Technologies, “SKXbee starter kit” [online] Available: http://www.cytron.com.my/datasheet/WirelessDevice/SKXbee_User's_Manual_v1.pdf
- [8] C. Fonseca, J. P. S. Cunha, R.E. Martins, V. M. Ferreira, J. P. M. de Sa, M. A. Barbosa, and A. M. da Silva, “A novel dry active electrode for EEG recording,” *IEEE Trans. Biomed. Eng.*, vol. 54, no. 1, pp. 162–165, Jan. 2007.
- [9] F. Popescu, Y. Fazli, S. Badower, B. Blankertz, and K.-R. Muller; “Single trial classification of motor imagination using 6 dry EEG electrodes,” *PLoS ONE*, vol. 2, no. 7, 2007.
- [10] A. Taheri, R. Knight, and R. Smith, “A dry electrode for EEG recording”, *Electroencephalogr. Clin. Neurophysiol.* vol. 90, no. 5, pp. 376–383, May 1994.
- [11] A. Searle and L. Kirkup, “A direct comparison of wet, dry and insulating bioelectric recording electrodes,” *Physiol. Meas.*, vol. 21, no. 2, pp. 71–83, May 2000.
- [12] G. Gargiulo, P. Bifulco, R. A. Calvo, M. Cesarelli, C. Jin, A. McEwan, and A. van Schaik, *Intelligent and Biosensors*. Rijeka, Croatia: In Tech, Jan. 2010, ch. 6.
- [13] E. W. Sellers, P. Turner, W. A. Sarnacki, T. Mcmanus, T. M. Vaughan, and B. Matthews, “A novel dry electrode for brain–computer interface,” in *Proc. 13th Int. Conf. Human–Computer Interac.*, San Diego, CA, 2009, pp. 623–631.
- [14] T. J. Sullivan, S. R. Deiss, T. P. Jung, and G. Cauwenberghs, “A brain– machine interface using dry-contact low-noise EEG sensors,” in *Proc. Conf. Rec. 2008 IEEE Int. Symp. Circuits Syst.*, Seattle, WA, May 2008, pp. 1986–1989.
- [15] J.d.R.Millan, R.Rupp, G.R.Muller-Putz, R. Murray-Smith, C.Giugliemma, M.angermann, C. Vidaurre, F.Cincotti, A.Kubler, R. Leeb, C.Neuper, K.-R. Muller, and D.Mattia, “Combining brain–computer interfaces and assistive technologies state-of-the-art and challenges,” *Frontiers Neurosci.*, vol. 4, pp. 1–15, 2010.
- [16] Neurosky, “Mind-set instruction manual”, [online] Available: http://developer.neurosky.com/docs/doku.php?id=mindset_instruction_manual.
- [17] X. Perrin, “Semi-autonomous navigation of an assistive robot using low throughput interfaces,” Ph.D. dissertation, ETHZ, Zurich, Switzerland, 2009.
- [18] E. Donchin, K. M. Spencer, and R. Wijesinghe, “The mental prosthesis: assessing the speed of a P300-based brain–computer interface,” *IEEE Trans. Neural Syst. Rehabil. Eng.*, vol. 8, no. 2, pp. 174–179, Jun. 2000. J. Clerk Maxwell, *A Treatise on Electricity and Magnetism*, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.
- [19] N. Birbaumer, N. Ghanayim, T. Hinterberger, I. Iversen, B. Kotchoubey, A. Kubler, J. Perelmouter, E. Taub, and H. Flor, “A spelling device for the paralyzed,” *Nature*, vol. 398, pp. 297–298, Mar. 1999.
- [20] K.-R. Muller and B. Blankertz, “Toward noninvasive brain–computer interfaces,” *IEEE Signal Process. Mag.*, vol. 23, no. 5, pp. 125–128, Sep. 2006.