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Design and Implementation of Programmed Motion in a Vehicle Using Brain Wave Signals

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Abstract: This paper presents the results of efforts towards understanding the current scenario of brain computer robots and the associated technologies. Brain Computer Interfaces (BCI's) 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. An attempt is made to study the pertinent literature and test the workability of hardware to meet the basic requirements of BCI's.
Keywords: EEG Sensor, Relay Driver, Embedded platform, communication module, image acquisition module, BCI-Brain computer interface.

I. INTRODUCTION

Robotic control is employed extensively in industry. Most of the intelligence for control is embedded in the robot itself. External control of robots via wireless communication is preferred for obvious reasons. Brain wave sensing is an eclectic discipline which has received lot of attention in the present days. Generating a signal transmitting it and actuating a device in a common practice but actuation by a thought signal is something that has fascinated engineers and scientists.

For electronic and telecommunication engineers studying and handling brain waves has been a non-trivial task. The present work focuses on a study and implementation of brain wave sensor to perform a particular function. The available scant literature speaks about special interfaces such as sip-and-puff systems, single switches and eye tracking systems [1]. These interfaces may not work for patients with severe disabilities.

All the electrical waves sensed by the brain wave sensors are converted into data packets and transmitted through Bluetooth medium [1]. Level analyser unit (LAU) will receive the brain wave raw data and it will extract and process the signal using MATLAB platform. Then the control commands will be transmitted to the robotic module to process. With such systems, 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 pre-processing, 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, pre-processing, 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 on-going 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 Steady State Visually Evoked Potentials (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.

In the present work, an earnest attempt is made to review relevant literature, demonstrate a working prototype and report the observations. The focus is on achieving one or simpler device actuations through a sensing device. It is felt that studying such systems having special applications in neurology is an enriching experience for electronic and communication engineers.

II. DESIGN AND IMPLEMENTATION

Brain-controlled mobile robots are divided 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.

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 embedded into the Brainwave headset, for this Brainwave headset we need to supply 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 wears 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 does not blink the headset is powered on but not connected to with the computer’s Bluetooth. If the blue colour LED does not blink, it means the headset is powered on and connected. If the red or blue colour blinks it shows that the battery getting low.

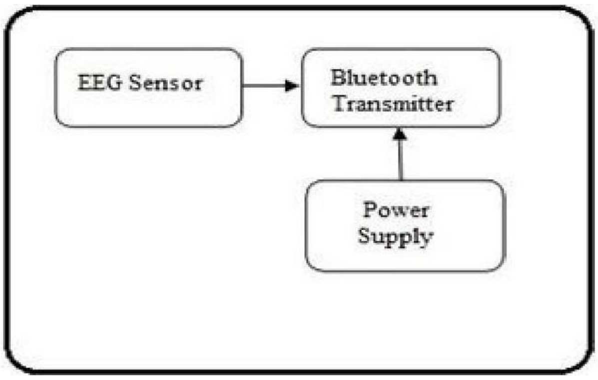

Fig 1: Brain secret card section [2]

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 analyzed 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.

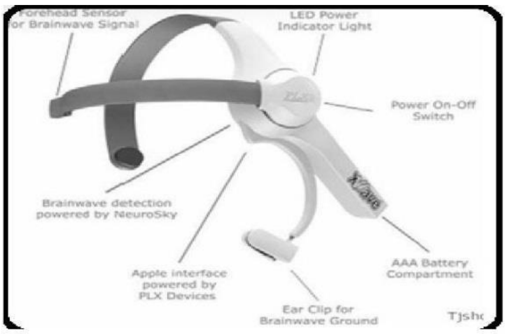

Fig 2: Brainwave Headset provided by NeuroSky[2]

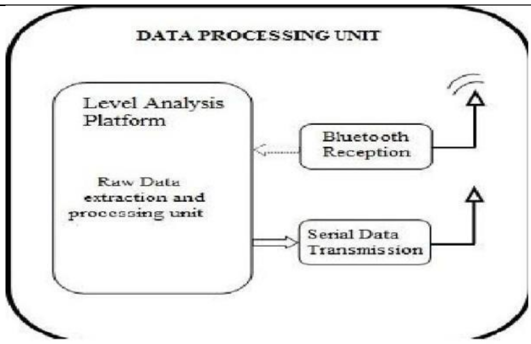

Fig 3: Data Processing Unit[4]

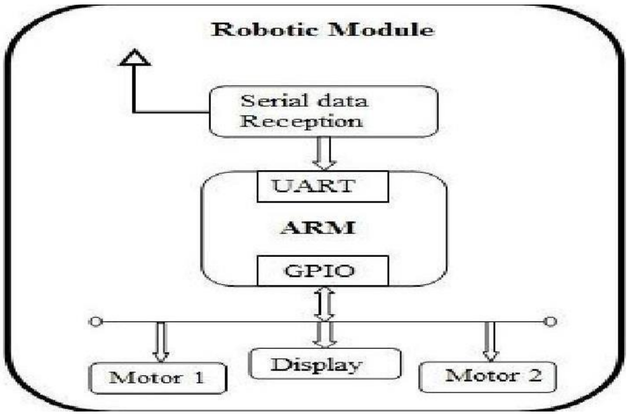

Fig 4: Robotic Module[6]

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. ARM7 processor used in this work 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 from driver circuit the motors will rotate to cause forward movement in 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 robot. The driver circuit will connect 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 Universal Asynchronous Receiver / Transmitter (UART) [7]. The computer will transform the data which is analysed by using the level analyser unit using MATLAB. 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 usingNeuroSky 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

(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.

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

(b) Meditation eSense:

The eSense meditation meter shows the level of a user's mental “calmness” or “relaxation”. Its value ranges from 0 to100. 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 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).

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 start 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.

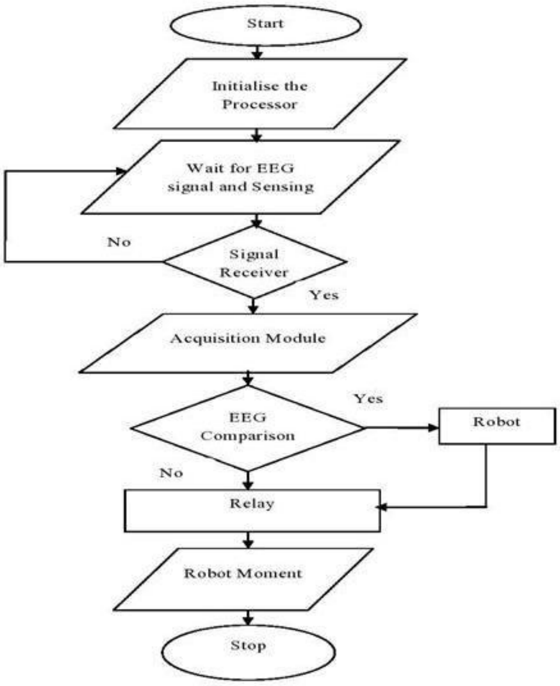

Fig 5: Design Flow

V. RESULTS 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. A comprehensive up-to-date review of the complete systems, key techniques, and evaluation issues of brain-controlled mobile robot is presented. The results with NeuroSky headset, gives up to 95% accuracy of brainwaves. The procedure adapted in the present work involves the following: (a) Installation of NeuroSky (NeuroSky, Inc. is a manufacturer of Brain-Computer Interface (BCI) technologies for consumer product applications,founded in Silicon Valley, California. It works as a Original Equipment Manufacturer, collaborating with industry partners.) software. (b) Connecting head-set via blue tooth. (c) Execution of MATLAB code to open window and display of ‘attention’ & ‘blink signals’ (e) transfer of signals to robot through Zigbee and (f) Receiving of signals, decoding & transfer of control to robotic movement mechanisms.

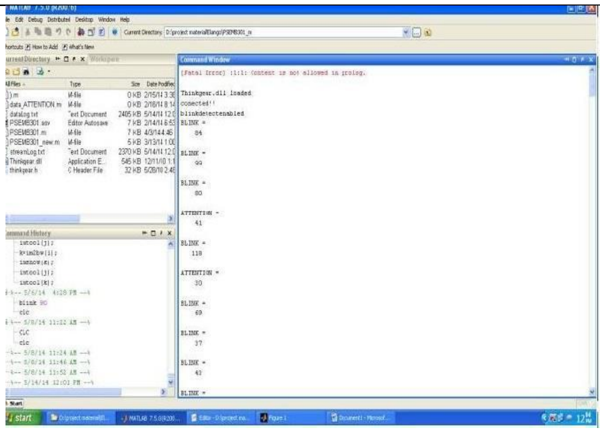

Figure 6: Screenshot of Attention level and Blink level

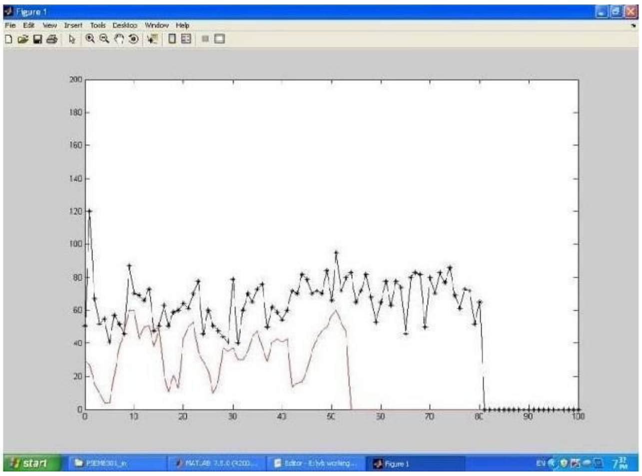

Figure 7: Screenshot of Graph (Black: Blink level, Red: Attention level)

VI. CONCLUSION

For individuals suffering from neuro muscular disorders, brain controlled mobile robots are of great help. The present work focuses on improvising our contemporary understanding of the subject. An attempt is made to design a simple BCR to perform basic functions.

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