Robot Control using Brain Waves

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***Abstract*— EEG based Brain Computer Interface (BCI) can be classified as one of the new communication channel that exists between the Human & Computers only through the biological signals by avoiding the use of muscular activity in association for executing different applications involved in it. There are many available technologies & interfaces that are facilitating in reading the bio-electrical signals from human brain associated with explicit commands in controlling various devices. In this work, a technological based application is developed in bringing an engineering solution in development of a conceptual framework, as a part of enhancement in remote controlled communication of a robot through Brain (EEG) signals interacted by the end-users.**

***Keywords*— Brain Computer Interface, EEG, Robot Movement, Emotiv Epoc, UART**

I. INTRODUCTION

The enhancement in use of technology has provided a major change in the way the users are utilizing the interface of the systems. With main increase in usage of computers with its supporting devices, smart phones, tablets etc. has been observed that the interaction between users and its applications taking place with more efficient & effectively. A greater research has been carried out for the support of the appropriate utilization of these systems in wireless based application control without the use of human hands.

With this context, Brain Computer Interface is one among technological advancement of the Human Machine Interface (HMI), which uses human brain signals related to the user's mental activity rather than any muscular activity in controlling or utilization of these devices. Payam et al. [1] developed a distributed framework that controls video game using BCI, Andrew et al.[2] designed an application for the use of neurophone to make a call using neural signals, Kusuma et al. [3] proposed an EEG based authentication system to lock & unlock the computer system screen, Siddharth et al.[4] developed an virtual keyboard for computer system controlled through brain signals and many more applications are already in the progress of making human life much comfortable.

BCI is one of the mode involves in the interaction between human beings and computers started with the discovery of electrical activity of the human brain called Electroencephalogram (EEG) by Hans Berger in the year 1924 [5]. BCI mainly works from the reception captured directly by human brain signals. The capturing of signals are classified into three types, i.e. (i) Invasive, (ii) Partially Invasive and (iii) Non-Invasive. The classification the different types of BCI. The functionality of a BCI system is characterized into different levels [6] (Figure: 1).

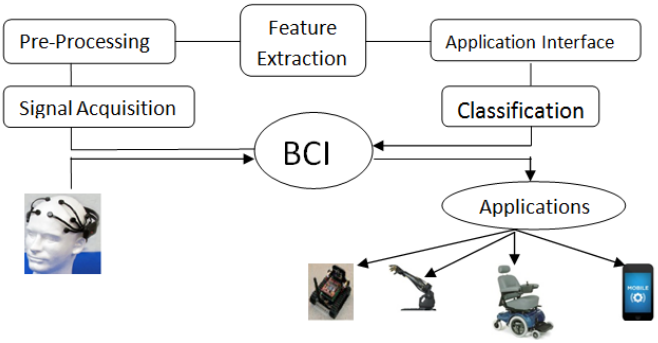

Figure 1: Architecture of BCI

Monitoring of the user's brain activity resulting in brain signals called EEG signals are acquired and processed to gain features grouped under feature extraction. The extracted feature is later translated into a command in order to execute an action for the BCI application (like Wheel chair, Virtual Keyboard, Mobile, Robot etc...). The results of such actions can be utilized by the user who can modulate his/her brain activity to assure his/her intents [7]. Applications of Brain Computer Interface in today's real world are growing hugely towards great extent majority in all fields and are not limited to figure 1.

Another new emerging area is on Robotics, where the use of these robots has increased to a greater extent in day to day life. In today's world the most frequently use of robotic field is in health care (medical) applications. The most common use is the Mobile phones that really help in communicating to other people staying far away [8]. Robots are the machines that have been designed according to the use of application oriented concept and the control of this robot is the input given by the user and the output expected is the motor activity happened by the robot. These inputs are given to the robot through many forms of communication channels for the controlling of its activity.

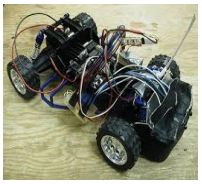

Figure 2: Robots

A. Motivation

Currently there are many different options available in order to control the robotic activity. Mainly robots are controlled through remote (wireless), wired devices etc... Many other options used for robot controlling are discussed in section 4 of this work. After studying all the forms of robot controlling, an idea is proposed in order to enhance the robot control through EEG or Human Brain wave signals that is nowhere found in the literature.

B. Related Work

Robotics is one of the interesting fields where every engineer can showcase his/her creative & technical skills. The user can able to control the robot by making a video call to the 3G enabled phone attached to the robot from an another 3G enabled cell phone that can send Dual Tone Multiple-Frequency (DTMF) tones by pressing the numeric buttons and can view the video output for a cell phone based controlling of robot [8].

Natural interaction among human and computer can also be performed by recognizing the gestures made by human hands in order for controlling of robot. Gesture recognition can be performed among various methods and they include from (some of application areas for gesture systems) Neural Networks, fuzzy c-means clustering, HMM, besides using orientation histogram for features representation [9]. This work is mainly achieved by using algorithms that captures the shape of hand and process it [12, 13, 14].

Some of the human robot machines can also be controlled. Here is the system that makes use of tracking the upper body part for a 9-dimensional configuration space & two multi-layer perception/radial basis function (MLP/ RBF) neural network classifiers, one for each arm. This work can also be classified for gesture recognized robot control [11].

Service robots interacts directly with people to find a natural and easy user interface that posses the ability to control the robot by natural means. To facilitate this requirement the system is designed in which the robot is controlled through Image processing by taking the gesture of the user palms [15].

In order to explore an engineering solution that would allow achieving a remote integration over the internet between a non-invasive BMI and a robot under the concept of navigation remote controller of basic movement through the user's bio-signals [18].

Some of the robotic vehicle can also be controlled through speech recognition system by processing voice commands. It uses I.C called HM2007 that can able to store and recognize up to 20 voice commands. The wireless transmissions are made through R.F transmitter and receiver. It has been tested in accuracy of 75% in correctly identifying the correct voice without noise. This voice-controlled robotic car designed can be regarded as a model of Auto control [10]. This study is taken as a base paper for enhancing the work using BCI controlled robot; its methodologies & novelty of the work are discussed in section 4 under methodology.

C. Proposed Work

A major application of Invasive BCI is done by medical practitioners and engineers are exploring applications of BCI through non-invasive method. Hence the system is proposed with "Emotiv EPOC" non-invasive head set device for EEG data acquisition from the human/user brain. It consists of 12 hour lithium battery, 14 saline EEG sensors (Figure: 3) offer optimal positioning for accurate spatial resolution and a Gyroscope generates optimal positional information for cursors and camera controls that has an effective bandwidth of 0.16-43 Hz (Figure: 4). the sensors formulated with highly conductive electrolyte gel are placed over the scalp of the user [16]. The noise can be avoided from various artifacts are well instructed to the user [17].

Figure 3: Emotiv EPOC Headset

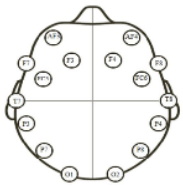

Figure 4: EPOC Headset 14 contacts

Initially the application requires establishing a connection with the Emotiv EPOC neuro headset. The following class diagram (Figure: 5) depicts the connectivity and the working principle of different operations needed for the movement control of the vehicle. It consists of an interface that creates the action mode either towards Left or Right motion for the vehicle. Separate action is also take care for non existing connection with the Emotiv engine. The libraries like edk.dll & edkutils.dll perform the core operations of the Emotiv headset in writing the brain waves of a person to .csv file.

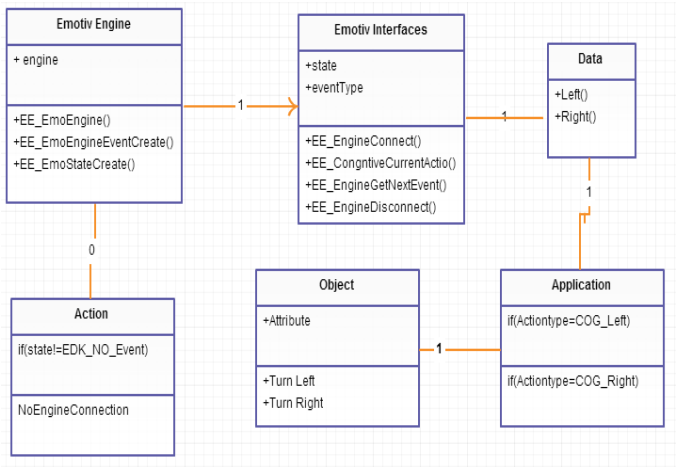

Figure 5: Class Diagram

UART Signal: A Universal Asynchronous Receiver/Transmitter, abbreviated UART is a type of "asynchronous receiver/transmitter", a computer hardware used in translating the data among the parallel & serial forms respectively. It is also used in union with communication standards like RS-232, RS-422 etc. Data transmission speed & its format should be configured according to as indicated in universal designation and that the actual electric signalling levels and methods (such as differential signalling etc.) typically are handled by a special driver circuit external to the UART.

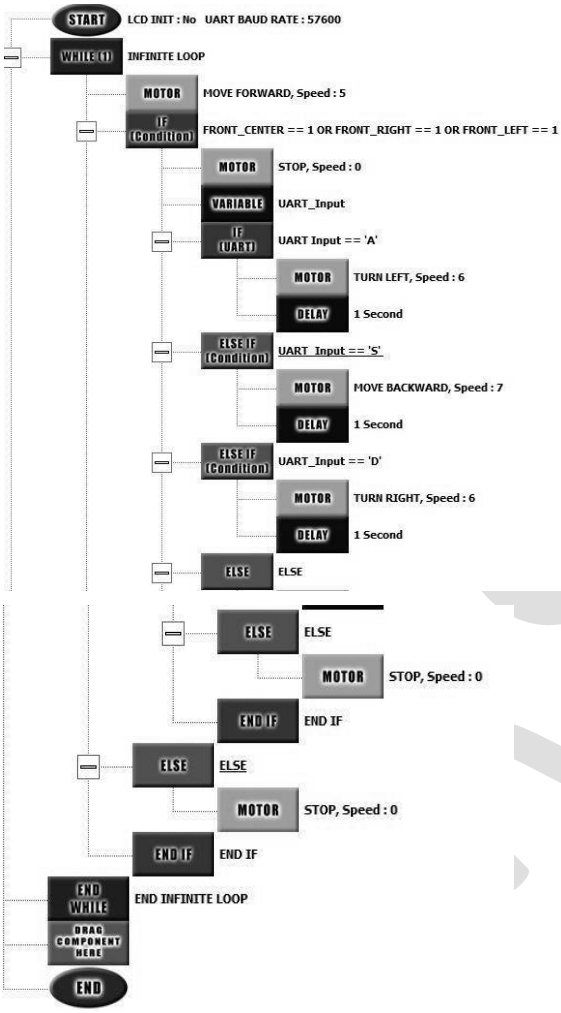

Figure 6: Flow Chart of Microcontroller Program

The Universal Asynchronous Receiver/Transmitter (UART) takes bytes of data and transmits the individual bits in a sequential fashion. At the destination, a second UART re-assembles the bits into complete bytes. Each UART contains a shift register, which is the fundamental method of conversion between serial and parallel forms. Serial transmission of digital information (bits) through a single wire or other medium is much more cost effective than parallel transmission through multiple wires. The following diagram (Figure: 6) depicts the flow chart of a microcontroller program.

A conceptual framework (Figure: 7) represents the present work of the proposed system wherein the transferred brain waves of a user to .csv file is extracted, while processing if "LEFT" or "RIGHT" is found anywhere in the file then the robot moves left or right based on the control signals received by the controller.

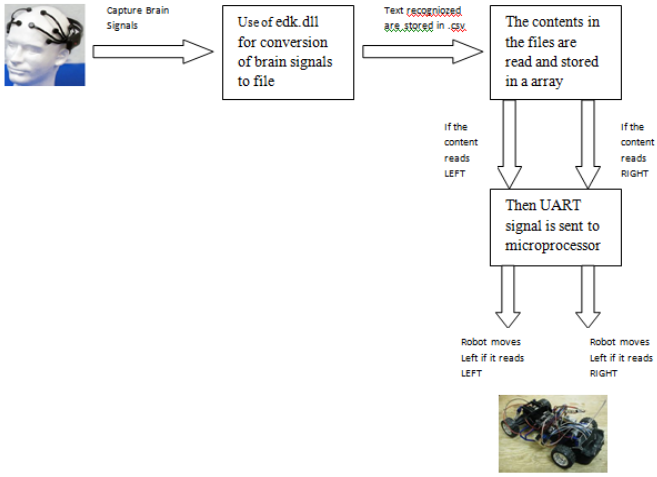

Figure 7: Conceptual Framework

D. Simulation & Results

UART signal displayed on the oscilloscope screen is displayed below figure (Figure: 8).

Figure 8: UART Signal

UART waveform set at bit rate on the oscilloscope to 200 Kbits/s at 1 kHz.

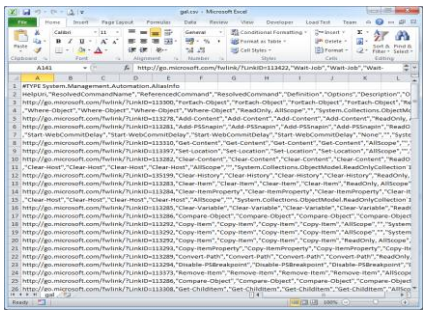

Figure 9: .CSV File

Left, Right commands given by the user are implemented using algorithms & executed successfully as

shown in Figure 7. By selecting suitable software's, microcontroller, circuit design implementation of project work was successful. The training was made to generate thoughts that are needed for the control of the robot movements. The speed of the robot is assumed to be in moderate forward direction.

II. CONCLUSIONS

Human Brain signals (EEG) are acquired from the Brain Computer Interface device are processed for Left & Right commands to control of a forward moving robot vehicle. Necessary improvements were made in design, for achieving the better accurate & reliable of both hardware & software. Using UART signal control codes were done effectively by the microcontroller.

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