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Manojavitvam - LabVIEW based Thought Controlled Wheel-Chair for Disabled People

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Abstract

The objective of the project is to develop a cost effective Bio-medical Instrumentation system to realize a thought controlled wheel-chair by means of harnessing EEG signals, generated due to particular thoughts in a quadriplegic person, to provide a possibility of easy movement for such physically challenged persons. Quadriplegic subject is trained, to generate thought by focusing on different images on the computer screen with different level of concentration. The EEG signals generated due to different level of concentration, also the eye movement artifacts in the EEG are then processed using LabVIEW software by means of FFT algorithms. Direction of movement of the wheel-chair is decided based on the processed EEG signal. State machine is used to enable the right, left, stop and forward motion of the wheel-chair. Microcontroller MSP430G2231 controls the motor circuitry to drive the wheel chair in a non-jerky manner by means of PWM based motor control strategy.

Keywords: BCI, EEG, Engineering Workbench, FFT, LabVIEW– Laboratory Virtual Instrument, Microcontroller.

I. Introduction

A Brain–Computer Interface (BCI) is a direct communication channel between the brain and an external device. With the advancement in the areas of information technology and neurosciences, there has been a surge of interest in turning fiction into reality. The major goal of BCI research is to develop a system that allows disabled people to interact with the external environments. This project includes an electroencephalogram (EEG) based brain-computer interface (BCI) which will control the movement of the wheel-chair towards right, left, or forward motion. Certain cases of diseases or injury can result in complete loss of muscle control and /or movement despite the subject being fully conscious or aware of his/her surroundings. Recent advancements in brain-computer interfacing (BCI) have presented new opportunities for development of a new wheelchair interface for such patients based on thoughts. Considering these aspects this paper investigates a BCI design for brain-controlled wheelchair (BCW), which comprises three distinct stages: extracting the raw brain waves, processing these signals and classifying them into different control and interfacing to the powered wheelchair.

This project uses “Neurosky Mindwave” headset to acquire real time raw EEG signals from the physically challenged subject. Thus acquired signals are fed into the LabVIEW software. Virtual Instrumentation (VI) programs are used to analyze raw EEG signals by using FFT tool of LabVIEW software. A suitable algorithm is applied for deciphering information contained in the acquired EEG signals. Once the signals are deciphered, text commands are generated using state machine logic. Generated commands are then fed to MAX 232- Level shifter IC, which converts serial data into TTL logic. These level shifted signals are then converted to digital logic using MSP430G2231 micro controller. Digital signals are then fed to motor control circuitry. Based on these digital signals the micro controller in motor control circuit generates PWM signals, which decides the direction and speed of the wheel chair in a jerk- free, gradual, slow speed.

II. Methodology

Block Diagram

The block diagram of the proposed project is depicted in the Figure: 1 below. The user’s brain activity is sensed by Electro Encephalograph (EEG) device called “Neurosky Mind Wave” head-set showed in Fig: 2 it consists of an electrode positioned in frontal position of the user scalp. The electric activity of brain is sensed by the electrode and the corresponding values are recorded. These signals are mapped at a rate of 512 SPS (samples per second). The recorded values are then transmitted in two ways, via USB cable and through Bluetooth dongle.

Analysis of this EEG signal is done using LabVIEW software. It is possible to collect and store data from Neurosky Mind Wave head set and applying signal conditioning techniques to obtain the brain waves like beta waves(12-30hz), alpha waves(8-12hz), theta waves (5-7hz) and delta (0.16-4hz).

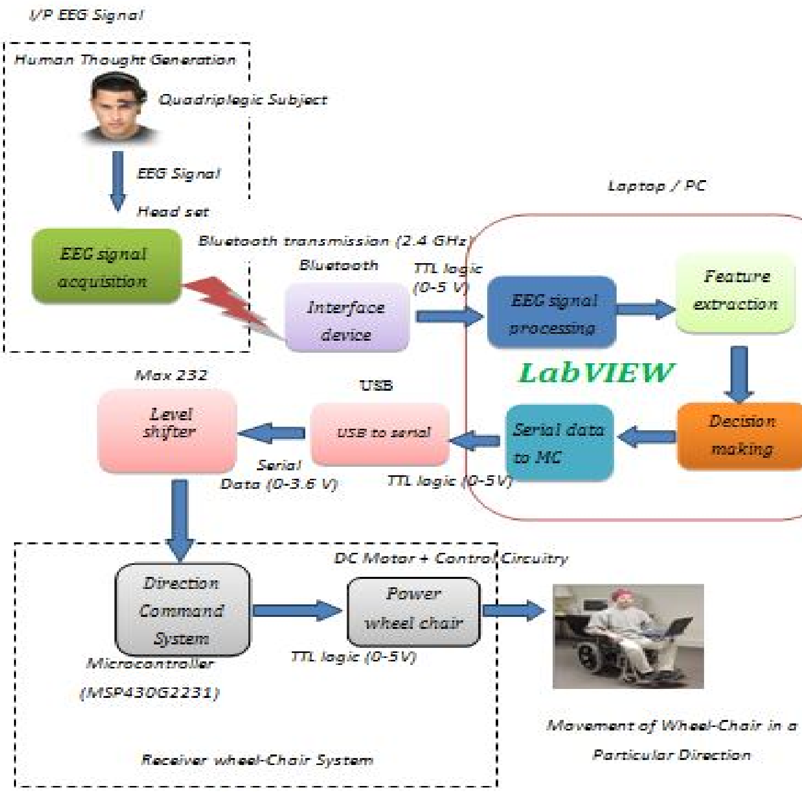

Fig.1. General Block Diagram

Fig.2. Neurosky Mind Wave head set

These signals are analyzed in FFT power spectrum. A suitable algorithm is applied to identify the command for the wheel chair depending upon the attention and meditation level.

The LabVIEW software in the laptop, after performing the above process and identifying the command, generates corresponding data signal. This signal is level shifted using Max 232 IC to interface with microcontroller. The controller identifies the command and generates corresponding control signal, and sends it to motor control circuitry. Motor control circuitry initiates corresponding activity of the motor driven wheel chair. Thus the user is able to manoeuvre the wheel chair safely.

III. Software Module

Different states of state machine are used to indicate different cases of motion. Stop condition is taken as idle case and before going to any other case state machine will be returning in to the idle case. Fig.3. shows the different states of the state machine. The LEDs related to different case are continuously blinking one after other along with “Start Select” LED. When both the “Start Select” LED and case LED is ON, and if subject blinks his eyes the program enters into the respective case. The different case LEDs and “Start Select” LED together performs the operation of preliminary case selection process.

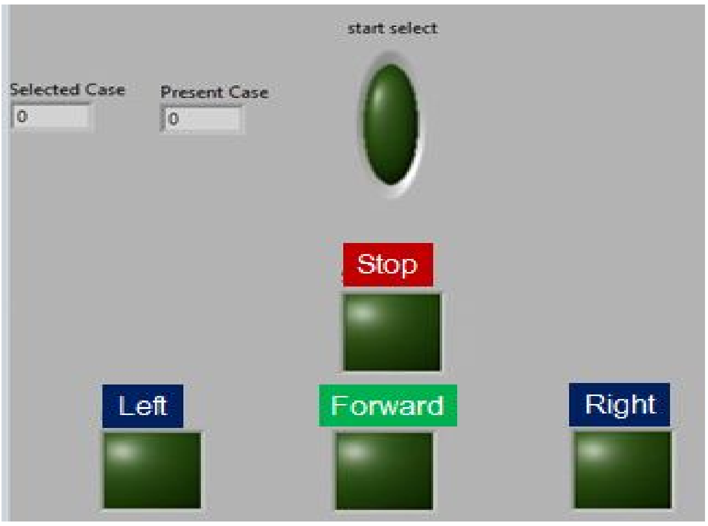

Fig.3. Case Selecting VI

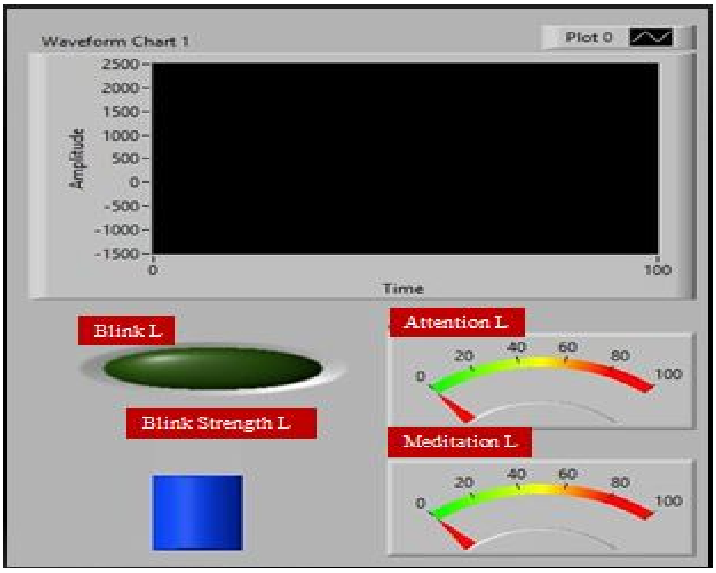

Fig.4. Processing and Output Indicating VI

Characters	Task
a	Forward Start
b	Forward Stop
c	Right Start
d	Right Stop
e	Left Start
f	Left Stop
z	Stationary

Table.1. Character Operations

According to the pre-selected case left, right, forward and stop, the program enters into the respective signal processing part. In each case EEG signal is acquired and fed to LabVIEW software for processing. Every time 1000 samples of EEG signals are taken together and filtered using 3rd order Butterworth Band pass filter with cut-off frequencies 5-50 Hz. The filtered signals are analyzed based on the FFT power spectrum algorithms. Based on frequency allocation of the signals and their power levels, attention and meditation levels of the subject are calculated. Depending upon attention and meditation levels of the subject, the decision is made to perform particular task and respective ASCII value is sent to the hardware. The program will be continuously checking for the strength of the eye blink and if the strength goes beyond certain level it is considered as emergency stop and respective ASCII value is sent to the hardware through USB COM port. Fig.4 gives the blink strength, subject's attention level and meditation consistency of the subject. Table.1 shows the character convention for respective task and its ASCII value that is sent to the hardware module.

IV. Hardware Module

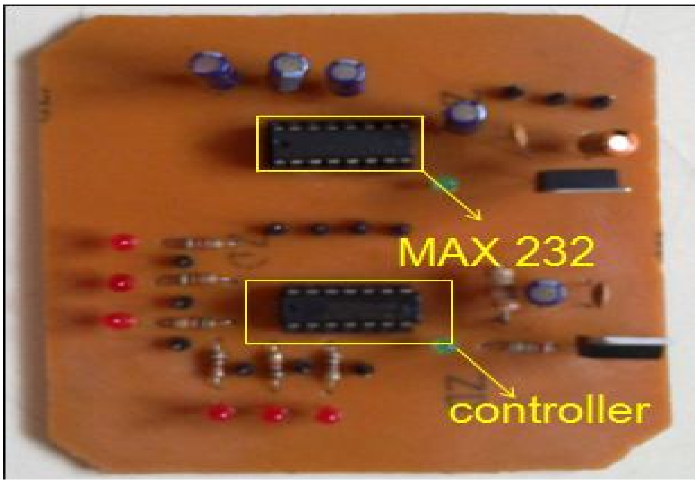

Fig.5. PCB of MAX232 and MSP430G2231

The ASCII values sent from the software through USB COM port are accessed using USB to serial converter. It is then sent to the level shifting circuit. The integrated circuit MAX232 is used to convert RS 232 logic to TTL logic signals. The PCB of the MAX232 and the Microcontroller MSP430G2231 is shown in figure 5. Microcontroller is programmed such that it detects the ASCII values received and converts it into the 3bit digital data. These digital signals are then sent to the next microcontroller to drive the motors. Table.2 shows the 3 bit digital signal generated from the microcontroller for each character.

Characters	Digital signals		
a	0	0	1
b	0	1	0
c	0	1	1
d	1	0	0
e	1	0	1
f	1	1	0
z	0	0	0

Table.2. digital signals generated corresponding to different character

Based on the digital signal received, the second controller generates the Pulse Width Modulated signal to control motor driver circuit intern it controls motor. Bit 6 and Bit 2 of microcontroller are configured to generate PWM signals. Table.3 shows the PWM mode assigned for respective digital signal.

Digital signals			PWM pins
0	0	1	BIT6, BIT2 (PWM Increase)
0	1	0	BIT6, BIT2 (PWM Decrease)
0	1	1	BIT6 (PWM Increase)
1	0	0	BIT6 (PWM Decrease)
1	0	1	BIT2 (PWM Increase)
1	1	0	BIT2 (PWM Decrease)
0	0	0	None

Table.3. PWM assignment of different digital signal

Hence the character sent from the PC will cause increase or decrease in PWM signal of particular pins of the microcontroller which intern drives the motors to control the wheel-chair.

V. Result

Right, Left, Forward and Stop commands given by the quadriplegic person are deciphered and suitably executed.

Cost effectiveness of overall project is optimized by selecting appropriate ICs and circuit designs. The quadriplegic user is given suitable training to generate the required thoughts to control the wheel-chair movements. The speed of the wheel-chair is assumed to be of constant at a deadly low speed value to gain confidence of the quadriplegic subject. Wheel-chair's reverse movement is prohibited for safety reasons.

VI. Conclusion

Acquired EEG signals are processed using FFT spectrum and different cases of motion are deciphered distinctly on LabVIEW platform. For achieving better accuracy and reliability of both hardware & software, improvements in design are necessary. Character recognition and generating control codes are done efficiently by the microcontroller. Also, PWM based motors control for smooth movement of the wheel chair is an important feature, useful for quadriplegic users.

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