Portable stimulator for BCI system

Project Proposal

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February 6, 2013

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I. Introduction

Brain Computer Interfaces (BCI) based on Electroencephalography (EEG) allow for the monitoring and analysis of ongoing brain activity in real time. The signals measured by this technology can be used to control user interfaces without the requirement of the human motor system. This technology can benefit those with paralysis and other severe disabilities. As of now, the majority of BCI systems are currently large and immobile, and therefore impractical for use in everyday life outside of a lab. There are several components to a BCI system such as data acquisition, a classification system, as well as stimulation, all of which must be made portable to create a portable BCI. To address this problem, we would like to focus on making a portable stimulator that can interact, through wifi, with the BCIs that are monitoring brain activity. The stimulator will consist of flickering LEDs at predefined frequencies, with attention to luminescence (we don't want our LEDs to blind the user so it must be at the right intensity for each user) as well as controls to adjust the frequencies while maintaining signals timing. Our design goals are to make the stimulation for the BCI and EEG portable and be integrated wirelessly so that users are not confined to just a lab setting and that the system could be tested and used in different environments.

Purpose

Most brain computer interfaces (BCI) are limited to laboratory settings. We would like to make a BCI stimulator based on electroencephalography (EEG) that is portable, and therefore useful in real world applications. This could be a great advancement in allowing people with paralysis to communicate without any type of movement.

Goals

- Design circuit with optimal settings for a glasses-mounted stimulator
- Usable in everyday life
- Wireless communication with control panel
- Painless to user’s eyes

Benefits

- Portable
- Lightweight
- Operable from a distance
- Simple real-time controls

Features

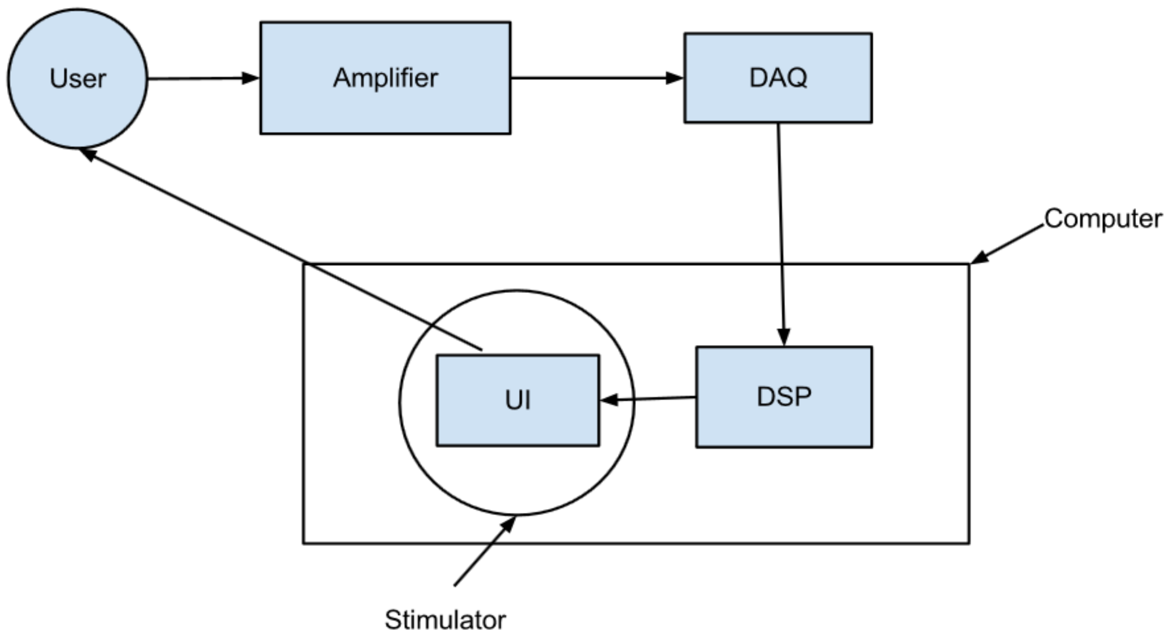
- Wireless controls
- Variable frequency
- Variable duty cycle

Functions

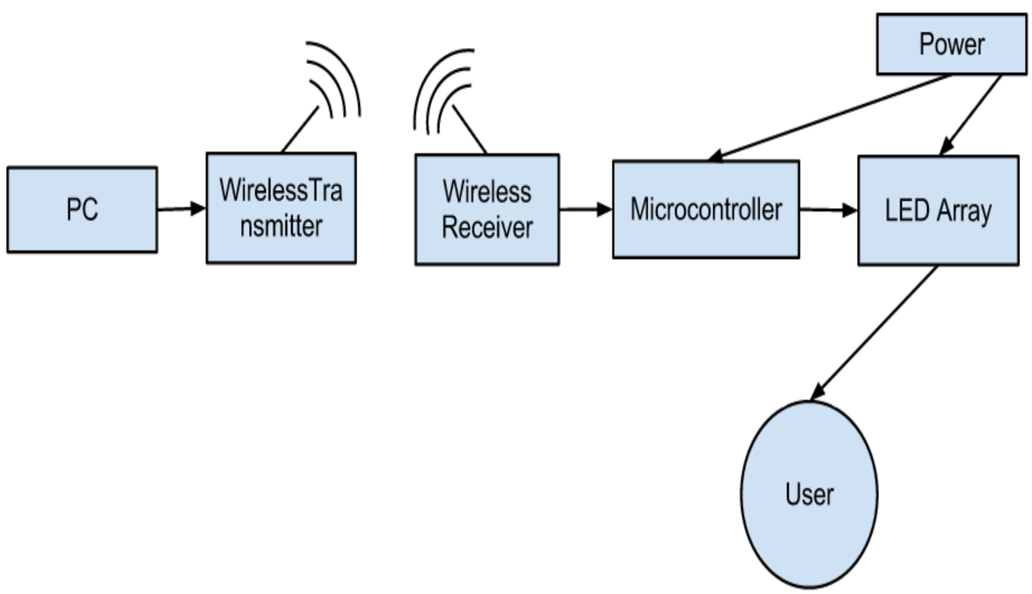
- 5 LEDs (per eye) flashing at varying frequencies
- Wireless communication between controller and computer
- Frequency variable between 1 and 100 Hz
- Duty cycle variable from 10 to 90%

II. Design

Block Diagrams



The Overall BCI system



Stimulator

Block Descriptions

Overall Summary:
A microcontroller will be receiving data from a PC wirelessly. The Microcontroller will control the LED Array through the corresponding program we run on PC. The program will be able to set the frequency and duty cycle of the each LEDs. The LED array will be placed on glasses and powered by batteries for portability.

PC:
The PC will load the program which can control the frequency and duty cycle of the LED array. This will include input from the user to change the frequency of each LED on PC and have the resulting information be transmitted to the microcontroller instantaneously through the wireless components. It will be directly connected to the wireless transmitter.

Wireless Transmitter:
The wireless transmitter will be used to send serial data to the microcontroller that controls the LED array.The wireless component we choose to use is the Xbee module. This may include another microcontroller to mount the transmitter properly. It will connect the PC to the wireless receiver.

Wireless Receiver:
The wireless receiver will receive and interpret the multiple packets of serial data sent from the transmitter, and translate them into a signal for the microcontroller to work with in outputting the correct frequency. The receiver will transmit data from the transmitter to the microcontroller.

Microcontroller:
The microcontroller used for the stimulator will be the Arduino 2560 (MEGA). It is the primary control of the module. The controller input will be serial data from the wireless receiver and will output the frequencies chosen and set by the user through the program to the correct LEDs through the PWM pins, which can also control the luminosity of the LEDs. It will be powered by a 9V source.

Power:
All portable components in the stimulator will require power from this module. The wireless receiver, microcontroller and LEDs will be powered by a 9V battery which is connected to the rest of the components through a Battery snap connector.

LED Array:
The LED array will consists of 5 pairs of LEDs, one for each eye. Each set can be controlled by the microcontroller. The array will have 10 RGB Clear Common Cathode LEDs no bigger than 5mm to allow for easy mounting onto a wearable frame and adjustments in luminosity and light color. The LEDs are powered by 3.2 V in which limiting resistors will be used to protect the

LED’s from burning out. The LEDs will be connected directly to the microcontroller, and will output to the user’s eyes.

User:

When the user is looking at a certain LED with a certain blinking frequency, information about the output brainwave signal from the user will be retrieved by the EEG/BCI system and will determine which LED the user is looking at. Because this portion is handled solely by the EEG and BCI, we will not be testing this portion while testing the stimulator.

III. Performance / Requirements and Verification

PC:
The PC program controlling the Microcontroller must have the proper code and setup of the wireless components in order for any data to be transmitted. This will require proper debugging and code formatting to ensure no bug in the program itself will affect the hardware. We will first design the code that can transmit and set-up the wireless communication, to verify that this will not affect the data being sent to the microcontroller. Then we will design the code that will be adjusting the frequencies of each pair of LEDs, this may be designed in a separate model or in the same code as the wireless set-up, depending on which form of wireless communication we use.

Wireless Transmitter/Receiver:
The Wireless communication must be able to handle multiple packets of serial data on the transmitting and receiving end. We will verify this capability by sending a series of on/off signals through PC module into the transmitter, and confirming that the same signals are being read out through the receiver into the microcontroller.

Microcontroller:
Since each pair of LEDs has to be controlled with a different signal, so with 5 LED per pair, there will need to be at least 5 control signals being output from the microcontroller. We will verify that each signal coming from each PWM pin is capable of operating at the correct frequency with the microcontroller alone by using an oscilloscope to monitor the signal waveforms and frequencies being output, in which we will program into the microcontroller during testing.

Power:
The power given off by the batteries must supply sufficient energy to all the portable components which are connected through the microcontroller. We will test the power source by using a multimeter for the batteries, wireless receiver, microcontroller and resistors in series with the LEDs, making sure the correct voltage is being provided to the microcontroller and its subsidiaries.

LED Array:
The LED array must show correct operation with the microcontroller as well as be modified to the correct luminosity in order to minimized user discomfort. The frequency of the LEDs will be tested by an oscilloscope. We will test LED intensity with a photodetector, if necessary, ensuring that each LED is at the right luminance.

Tolerance Analysis

Our design of the LED array must be precise with the duty cycle and frequency of the LEDs, because all the data gathered by the BCI and EEG system is in real time. The input (in this case, the rate of the blinking lights displayed in front of the user) must be exact in order for proper monitoring of the brain's response.

One way the duty cycle and frequency can be affected by other parts of the circuit is by the wireless transmission of our controls from the computer. Thus, extensive testing and analysis of the tolerance of the frequency and duty cycle that is affected by the information transmitted by bluetooth in real time must be accounted for in our design of the stimulator.

Also because the final output of our stimulator system is into the user's eyes, we must preserve the comfort and visual perception of the user, meaning that the LED array must account for not only precise frequencies and duty cycle output, but also safe operating limits for various users such that no discomfort or harm will be done onto the user's vision through the use of the blinking lights. This will require proper testing and research on operating limits that are safe for long periods of exposure to blinking lights to the human eye.

IV. Cost and Schedule

Cost:

Name	Hour Rate	Total Hour Invested	Total = Hourly Rate x 2.5 x Total Hours Invested
Siyuan Wu	$35	150	$13,125
Bonnie Chen	$35	150	$13,125
Randy Lefkowitz	$35	150	$13,125
Total	$105	450	$39,375

Item	Cost per Unit	Quantity	Total Cost
LEDs	$0.50	20	$10
XBee RF Module	$30	1	$30
Wireless Shield	$30	2	$60
9V Battery	$2.5	5	$10
Battery Snap	$0.10	1-2	$0.20
Arduino MEGA 2560	$39	1	$39
Glasses Mounting Frame*	$0	1	$0
PCB*	$0	2	$0
Resistors*	$0	10	$0
Total:	$102.10	44	$149.20

*UIUC Senior Design Lab resources

Component	Cost
Parts	$149.20
Labor	$39,375
Total	**$39,524.20**

Schedule:

Week	Task	Responsibility
2/05	Hand in proposal	Siyuan
	Order XBee transmitter and Wireless shield; start designing wireless module	Randy
	Order LEDs and microcontroller; write microcontroller code to control frequencies	Bonnie
2/12	Write mock design review	Siyuan
	Integrate wireless components into microcontroller code	Randy
	Find safe operating limit values for frequency of LEDs, integrate into Arduino code	Bonnie
2/19	Finalize Design Review	Siyuan
	Test and debug entire stimulator circuit	Randy
	Design and order mounting frame	Bonnie
2/26	Turn in Design Review	Siyuan
	Continue debugging stimulator	Randy
	Create and order PCB for stimulator	Bonnie
3/05	Replace breadboard with PCB	Siyuan
	Debug new issues from PCB insertion	Randy
	Test stimulator in lab with EEG system	Bonnie
3/12	Test full BCI outside of lab	Siyuan

	Fix issues created by external stimuli	Randy
	Debug BCI	Bonnie
3/19	SPRING BREAK	Siyuan
	SPRING BREAK	Randy
	SPRING BREAK	Bonnie
3/26	Fix remaining issues	Siyuan
	Fix remaining issues	Randy
	Finish up Mock Demo	Bonnie
4/02	Start final paper	Siyuan
	Start working on presentation	Randy
	Finalize testing of stimulator	Bonnie
4/09	Continue working on final presentation	Siyuan
	Final testing with BCI and EEG	Randy
	Continue writing paper	Bonnie
4/16	Continue working on presentation	Siyuan
	Continue working on final report	Randy
	Continue working on final report	Bonnie
4/23	Finish up Final Demo for Presentation	Siyuan
	Finish up Final Presentation	Randy
	Finish up Final Paper	Bonnie
4/30	Final presentation and turn in final report	Siyuan
	Final presentation and turn in final report	Randy
	Final presentation and turn in final report	Bonnie