Andrew Fons

Adrian Moreno

Adebayo Omoyeni

Brian Rockwell

James Simonse

Telekinesis Incorporated: Proposal

1. Introduction

With the advance of modern technology, new devices become available on a consumer level, allowing creation and implementation of novel systems in order to solve previously intractable problems. In the world of therapeutics for children with developmental disorders, technology such as an electroencephalogram (EEG) provides insight into the mind of the child and creates the opportunity to provide a direct correlation between concentrating on a task and a physical response to these focus levels. This will allow such a child to better focus on tasks in the real world and integrate into society easier and at a faster rate than they would have been able to with pre-existing methods.

2. Problem Description

The core goal of the project is to help a child with a developmental disorder increase their ability to concentrate and maintain steady focus on a specific task. Targeted disorders include autism, attention deficit disorder (ADD), and attention deficit hyperactive disorder (ADHD), but any developmental disorder that has decreased levels of the aforementioned qualities should be able to be accommodated. As this project aims to be therapeutic in nature, it should be easily transported, have a low learning curve, and a large amount of adaptability. Thus, the method used to monitor concentration must be non-invasive.

The results of exceeding a certain threshold of concentration must in and of themselves impart a desire to recreate the experience; in other words, the outputs of the device must be enticing. To cover a wide range of developmental disorders, the outputs must be varied in nature. The system must be pleasing audibly and visibly. There should be some amount of variability to stave off disinterest and some sense of reward for progressing to a higher degree of concentration.

3. Proposed Solution

We propose building a therapeutic device that consists of an Electroencephalograph, or EEG, headset connected to computer. The computer will monitor and record the cognitive patterns of a patient wearing the headset and output commands to a board outfitted with a robotic arm, LED arrays and a speaker. By having the patient focus, the board will be programmed to command some action depending on the patient's level of concentration. For example, low level concentration will result in only a few lit LEDs or a soft tone from the speaker. High level concentration will result in more LEDs on, the ND fight song playing, or the arm moving.

The data retrieved from the patient can be used to characterize the patient's ability to think certain thoughts. The patient can also work on their ability to concentrate by playing with the LEDs, speaker output and robotic arm.

To make this a portable device, it will be compatible with most computers.

4. Demonstrated features:

<u>LED circuits</u>

For the LED circuit, we plan to have a set of LEDs connected in parallel. This set will be connected to a transistor circuit controlled by the microcontroller through an I/O pin. The task would be to turn on the LEDs by concentrating. If the user is able to exceed a preset concentration threshold, the LEDs will light up, otherwise,the LEDs will remain off. Future plans consist of modifying the design to comprise five sets of four single color LEDs. Each set of LEDs will represent a concentration level. The user would be encouraged to concentrate to varying degrees and an individual LED set would turn on based on the user's concentration level. Varying concentrations levels, from little to medium and finally to deep, would each be represented by a set of LEDs lighting up. Another set of LEDs would come on when the user is able to maintain a particular concentration level over a predetermined time period (e.g. 10 seconds).

Arm

For this feature, we will have four motors of the arm connected to the micro-controller via a transistor switching circuit. If the user exceeds a preset concentration threshold, the arm will move forward. After the arm reaches full forward extension, it will be moved by the supervisor to its original position. Thus the arm motion encourages the user to concentrate in order to achieve visible tasks. This task set may be expanded to include other motions of the arm in response to different concentration levels or other thoughts. For example, deep concentration could translate to two motors simultaneously moving to achieve an upward motion while relaxing thoughts could correspond to a downward motion. As a safety measure, the operator has the ability to manually override the actions of the user. By seeing an action carried out in response to concentration level, the user is actively motivated to vary concentration patterns, receiving instant feedback in the form of the arm's responsive motions.

Speaker

For this feature, we will have a speaker connected to a transistor switching circuit controlled by our microcontroller. The aim is to play a tune from a sound chip if the user is able to surpass a predetermined concentration threshold. After the stated goal is successfully achieved, we will expand our set up to include three more sound-chip/ speaker combinations. Each of the speaker units would be set up to play a particular sound for every level of concentration achieved. A sound encouraging the user to think harder would be played when a low concentration level is noticed and similarly, a message encouraging the user would be played after successfully surpassing a preset concentration threshold. In a similar fashion to both the arm and LED circuit, the user interacts with the set up based on the sound feedback and is thus encouraged to vary concentration levels as wanted.

5. Available technologies

To build a therapy toy for children with developmental disabilities, we have the following resources at our disposal: the Emotiv Epoc, EEGLAB, slave USB, Professors Villano and Schmiedeler and any other contacts that they point us to, SERO, the OWI Arm, LEDs, and a speaker. Do note that all of the following is posited on ready access to a computer. Since the toy will be a therapy tool in a lab, we believe this is reasonable.

The Emotiv Epoc is a consumer grade Electroencephalogram headset. It uses 14 sensor pads wetted with saline solution to gather data, as well as two gyroscopes. This data is transmitted wirelessly from the headset to a USB dongle via a near-Bluetooth frequency. The data is encrypted using 128-bit AES in ECB mode, block size of 16 bytes.[1] The headset's battery provides 12 hours of continuous use[2], plenty for one, perhaps two days of use.

EEGLAB is an open-source MATLAB toolbox designed to process EEG and other electrophysiological data. Although EEGLAB requires the data to be in a specific format, it is possible to import data into MATLAB from a .csv file and from there, export to the required

[1] http://daeken.com/emokit-hacking-the-emotiv-epoc-brain-computer-0
[2] http://emotiv.com/store/hardware/epoc-bci/epoc-neuroheadset/

format. Once the data is in EEGLAB, it can be analyzed with a number of techniques, including independent component analysis, time/frequency analysis, artifact rejection, event-related statistics, and several modes of visualization[3].

We intend for the microcontroller to be connected to the computer via USB. USB allows us to power the board and send it commands for the arm, LEDs, and speaker. The LEDs, speaker, arm, and any other components interfacing with the board will have their own power supplies.

We have two contacts for the therapy aspects of our project. Professors Mike Villano (Psychology) and James Schmiedeler (AME) have both done work with robotics and cognitive function/therapy. We have e-mails in to both of them and will be meeting with Prof. Schmiedeler on Wednesday, February 29th and Professor Villano on Thursday, March 1st. We got information about which faculty to contact from the engineering volunteer group SERO. Among other things, they modify toys for children with developmental disabilities.

We intend for the arm motors to be connected to the microcontroller board via a control circuit that we are building. The microcontroller will send signals directly to the control circuit to make the motors run; no USB connection needed. The arm runs off of 4 'D' batteries, giving the motor either +3 V or -3 V. We measured that one arm motor takes ~230mA of current for continuous operation. For approximately factor of two operating margin, assume 500mA current draw from the battery. Assuming only one motor running at a time, this should allow for about 18 hours of battery life at ≥ 1.1 Volts for a single battery[4]. For two batteries, this should allow 18

---

[3] http://sccn.ucsd.edu/eeglab/

[4] http://www.alliedelec.com/images/products/datasheets/bm/DURACELL/70149241.pdf

hours of battery life at ≥ 2.2 Volts. So we expect that for a fresh set of batteries, the arm could be continuously run for 18 hours.

As part of the suite of therapy features to be included in the toy, we would like the toy to be capable of accepting signals (e.g. your concentration level) and showing the intensity of a particular signal by lighting up colored LEDs. We would like to have five different colors: red, green, blue, yellow, and purple.

Besides LEDs, we would like to incorporate a small speaker, allowing us to provide audio feedback, as well as visual.

6. Engineering Content

The proposed solution may be divided into two general sections: hardware and software. The hardware for the project requires a board incorporating the following components: the arm power circuit, LED array, sound chip & speaker, microcontroller, voltage regulator, and slave USB chip. The group needs to design a control circuit (e.g. an H-bridge) for the OWI arm so that the current to the motors from the battery can be digitally controlled. Another hardware task is analyzing the power needs of the system and ensuring that those needs are met without endangering any components.

On the software side, the program running on the computer must accomplish several tasks. First, it must get and decrypt data from the Emotiv headset transferred by the wireless USB key. Second the program must analyze the signals from the headset to determine concentration levels of the headset user. We intend to use the EEGLAB MATLAB toolkit to accomplish this. Finally, the program must communicate with the microcontroller by means of the USB protocol in order to send commands. Ideally our group will also create a GUI for the user.

7. Conclusions

In the Epoc Emotiv headset, we have a device capable of serial use by multiple individuals in a non-invasive manner. Extracting data with the open-source “emokit” allows us to control the analysis of the EEG signals. Using this data, we can create a unique system to control various physical elements used to attract and maintain the concentration of a child with a developmental disorder. These outputs include audio with a speaker, visuals with an LED array, and motion with a robotic arm. In a therapy session with a lab assistant working with a child patient, the lab assistant should be able to use our system to improve the patient’s ability to concentrate and focus.