

**Project Name:** Design of a Neurally-Controlled Audio System

**Project Members:** Benjamin Shih

**Adviser:** Tom Sullivan

### **Abstract**

*A summary of your research question and your project design. Researchers typically write the abstract after they have finished writing the rest of the proposal. Include it as the first section on the first page of your proposal.*

Modern day technology is slowly growing towards a more compact and transportable era. Devices such as bluetooth and GPS have led to the introduction of technology that can be used without much physical interaction. The purpose of my project is to design a hands-free music player, with the capabilities of an audio synthesizer, in order to better understand the allure behind wireless technology. Transmitter technology has introduced a new facet of computing to the wireless domain. Humans are traditionally accustomed to using handheld devices for the performance of everyday activities, ranging from the computer to the car. The tablet has enabled the removal of familiar keyboards from our computers and replaced them with giant touch screens. While the wireless technology is both useful and practical for certain tasks, it is not always convenient for all purposes. Consider the evolution of the telephone. Initially, it was a corded, tethered device that forced its user to remain at a static position. However, the mobile cellular phone was soon introduced, and leaving behind the cord has revolutionized the world of phones. The cell phone started off as a large, clunky device, with people generally still preferring wired telephones, but has become pocket-sized and ubiquitous because of its convenience. With the advent of bluetooth devices, phones have become hands-free and more convenient than ever before. An additional goal is to better quantify electronic music. Current sounds are often made by taking a known sound, and modifying and distorting the signal until it produces a desirable sound. I would like to further examine this process to determine if the arbitrary tweaking done by music producers has mathematical foundations. After combining the two components of my project, the goal of the neurally-controlled audio system is to demonstrate and inspire the next generation of wireless technology by showing the convenience of making a hands-free audio player. The device I aim to produce represents a merge between technology and art, in the way that Apple's iPod both simplified and revolutionized the way that people interact with their music players.

### **Research Question and Significance**

*What is the question that you want to explore in your research and why is this an interesting and important question? In thinking about the significance, try to take the position of an educated newspaper reader. If she or he were to see an article about your research in the paper, how would you explain the importance of your project?*

My project aims to explore two topics: hands-free technology and electronic music.

My project aims to essentially build a wireless music player, but not in the cordless sense. The play, pause, volume control, and other music player features will be built into the audio synthesizer, in addition to other musical effects. However, instead of controlling the commands with the press of a button (although it will be possible, as the audio synthesizer will be a standalone, modular component), the goal is to control these effects with the neurally transmitted signals. Critics may declare that the transmitters are invasive rather than convenient. However, as privacy is a matter of opinion, my project hopes to demonstrate that the

neurally transmitted information is protected from data eavesdropping, and that the pros outweigh the cons. As technology grows smaller and smaller, we will need new ways to physically interact with our devices. Removing the physical touch required by most present-day devices is an area of exploration with enormous potential.

Electronic music is produced through a variety of signal processing techniques. Some of these effects are obtained through "studio sampling" - tweaking various parameters of the audio signal until reaching the desired sound - and thus not well defined. In order to better quantify what is happening underneath the hood, I will analyze the underlying signals that represent some of these sounds, and compare them with known audio effects. In particular, I will be searching for any similarities or patterns in the poorly defined signals, and comparing them with known sounds. This would allow me to associate certain sounds with one another, and also to categorize based on different signal parameters.

The overall goal of the project is to explore signal processing, although in two quite dissimilar fields. The physical object that will be made is a neurally controlled synthesizer, but the synthesizer is also being built as a individually functional piece which should also be able to be used as a midi player (for this part of the project, I wanted to have the experience of putting a synthesizer together and writing my own effects for it). For the neural component, I wanted to use the transmitter to manipulate the sound, as well as control the synthesizer as a regular mp3 player, albeit wirelessly. The transmitter will not be assembled by me, but instead will be purchased from an online vendor reputable for their product.

### **Project Design and Feasibility**

*How will you go about exploring your research question? What will be your methods and timetable? How will this research fit into your schedule? If you are not doing this as part of a course, how will you find the time necessary to do the research?*

I will explore the fusion of mind and music by creating a device that will allow users to modify an audio signal using a variety of audio processing algorithms which can be controlled by the mind using an off-the-shelf neurotransmitter which will be wirelessly connected to the audio player. I will manage my time by treating this as an independent study.

The project can be split into four main components. The duration for each part of the project is an estimate:

1. Creating audio effects in MATLAB. This will initially take three weeks to examine and play with a variety of signals. I will imitate the methods some music producers use to make sounds - by taking known sounds and arbitrarily modifying them. It is possible that entirely new sounds will be created, but until electronic music is better quantified and categorized, it is hard to determine what has and has not been previously produced.
2. Building the audio synthesizer and using it manually. Construction will take about five weeks, in which I physically assemble the synthesizer parts. This time period accounts for debugging any wiring issues that may occur, or hardware components breaking.
3. Interfacing the neurotransmitter with the synthesizer. This will take about three weeks because the transmitter is manufactured by a company working specifically to produce it. The transmitter has an established API and software development kit, and was recommended to me by people who have used it in the past.
4. Writing the software for manipulating the synthesizer and using it wirelessly. Combining the components should take about two weeks. Programming the transmitter itself is more difficult because it will involve learning about new hardware. However, after both the synthesizer and transmitter have been finalized, manipulating the synthesizer should

simply involve mapping different signals emitted by the transmitter to different commands on the synthesizer.

The additional time in the semester will be used as a buffer for any exceptionally strenuous weeks or unforeseen illness, accident, etc.

## **Background**

*What courses or work experiences have prepared you to undertake this project?*

My experiences that have prepared me to undertake this project span a variety of disciplines. I have taken/currently am in microelectronic circuits and electromagnetics, which provide me with circuit analysis/design skills that will allow me to schematic, wire, and assemble the synthesizer. My courses in probability, linear algebra, and signals give me the mathematical background needed for modifying audio signals and analyzing and configuring the transmitter signal. I also have algorithms and programming experience from introduction to computer systems and fundamental data structures and algorithms that will help me to both program the neuroheadset to transmit the appropriate data and write the synthesizer effects, such as audio distortion, echo, autotune, and flanging.

Outside of classes, I also am a lab teaching assistant for the introductory signals and systems course, which has given me plenty of experience in debugging MATLAB code. I have also had prior research experience in the form of summer REUs, so I am familiar with the research process. Lastly, I am also an avid electronics hobbyist so I have worked on many independent projects for a variety of topics. In particular, I have completed many projects based on the Arduino ATmega328 microprocessor. This pertains to the neural component of my project because all of my previous work contributes to my knowledge in putting together pieces of hardware. However, I do not have much experience with wireless hardware configuration and operation. As a result, this project will further bolster my skills in hardware tinkering, specifically with wireless signals and networks. .

## **Feedback and Evaluation**

*Who will provide feedback on and evaluate your project and according to what schedule and what criteria?*

I will be given feedback on and evaluated by Professor Tom Sullivan. His primary interests include electroacoustics and audio and music systems. He has extensive experience designing and constructing these systems. We will have either weekly or biweekly meetings to ensure that the project is proceeding smoothly throughout the semester.

## **Dissemination of Knowledge**

*How will you share the results of your project? What form will your final report take? You should include Meeting of the Minds.*

My final report will take the form of documentation on how to build the audio synthesizer and interface it with the neurotransmitter. I will look at how accurate the transmitter is in determining what command is issued to the synthesizer, and why a wireless audio player may be more convenient than a traditional handheld device. I will present my results at the annual Meeting of the Minds. I would like to prepare a poster as well as a live demo, so people can try transforming their own thoughts into music.

## Budget

*Please also consider your budget carefully. Include a list of all the items you propose to purchase and your best estimate of the cost of each item and they should include specific vendor information - where you plan to purchase the item(s) and how much each item costs. All expense items should be explained either in the body of your proposal or in a budget narrative included on your budget page. For example, if you are asking for funds to purchase a piece of software, is that software available in a public cluster? Does a faculty or staff member have the software that you could use when they aren't there?*

Item	Cost	Vendor
EPOC neuroheadset	\$300.00	<a href="http://emotiv.com/emortal/cart/">http://emotiv.com/emortal/cart/</a>
Synthesizer Buttons	\$10.00	<a href="http://www.sparkfun.com/products/7835">http://www.sparkfun.com/products/7835</a>
Pickit3 PIC18 Programmer	\$70.00	<a href="http://www.mouser.com/ProductDetail/Microchip/DV164131/?qs=uxmOeTEqoPzbrD3Bd9cDjQ%3d%3d">http://www.mouser.com/ProductDetail/Microchip/DV164131/?qs=uxmOeTEqoPzbrD3Bd9cDjQ%3d%3d</a>
Encasing Materials + Machining Fees	~\$65.00	Home Depot
	\$40.00	<a href="http://www.sparkfun.com/products/9022">http://www.sparkfun.com/products/9022</a>
Top Button Bezel	\$4 x 2 = \$8.00	<a href="http://www.sparkfun.com/products/8746">http://www.sparkfun.com/products/8746</a>
Bottom Button Bezel	\$4 x 2 = \$8.00	<a href="http://www.sparkfun.com/products/8747">http://www.sparkfun.com/products/8747</a>

Total: \$500