CALIFORNIA STATE UNIVERSITY SACRAMENTO

SENIOR DESIGN

Sonic-Vibe Design Documentation

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May 10, 2016

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Sonic Vibe Final Documentation

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***Abstract*—Accidents involving pedestrians wearing headphones have increased drastically in recent years. Wearing headphones limits the pedestrians ability to hear oncoming cars and other dangers. This can be solved through the engineering of a wearable device. While other engineers have attempted solutions to similar problems, their devices have been clunky and impractical. Sonic Vibe will address all of these issues while meeting the objective of aiding individuals who have difficulty hearing.**

***Index Terms*—CAD, Wearable Device, Hearing Impairment**

I. Executive Summary

Many people enjoy wearing headphones and listening to their favorite music while walking around town. In recent years, it has become obvious that this is a luxury that not everyone can afford to do, because the number of pedestrian accidents in urban areas involving someone wearing headphones has increased. This lead us to come up with the idea for the Sonic Vibe, a device that will help people who want to continue wearing headphones to prevent dangerous accidents.

While listening to music through headphones, it is impossible to distinguish the music from important warning sounds that may come from a car, ambulance, or a train. This illustrates the need for either a change of behavior or a device that can help people identify these warning signals. Considering people generally do not like to change behavior that they take pleasure in, we made a device that will be able to prevent this increasing trend in accidents with pedestrians wearing headphones. The device functions by replacing the brain's ability to locate where sound comes from with a very small computer, which can be mounted on a pair of headphones and worn around the waist. The device will determine where sounds come from, and then it will produce a vibration along the waistband corresponding to the correct direction.

This small and cheap device could be purchased by anyone who can afford a pair of headphones. It's sleek design makes it hard to notice, and its functionality is excellent. The Sonic Vibe will revolutionize the electronic wearable world!

II. Introduction

The Sonic Vibe is a device to detect the direction of sound. This paper is a discussion of the problem statement, the design idea, the work breakdown structure, the associated risks, marketing, and test documentation. The design documentation includes a user manual and a description of the prototype as well as any schematics and diagrams associated with this project. The Sonic-Vibe consists of three main parts-the headband, the waistband, and the User Interface-all of which have been further broken down. The result is a device that detects the direction of sound and translates it into vibrations around the waist to notify a deaf or hearing impaired person of anything in their surroundings that they cannot hear themselves.

III. Problem Statement

Hearing impairment and deafness are prevalent problems in our society. Hearing loss in general is the second-most common health issue and more people suffer with it than with Alzheimer's, epilepsy, diabetes, and Parkinson's combined [6]. Since 2000, the number of people suffering from hearing loss has doubled in the United States and increased 44 percent on a global scale [6]. In addition to natural causes, there are many environmental causes of hearing loss such as loud noise and even some medication. Another common cause of hearing impairment, even though temporary, is wearing headphones. No matter the cause, being hearing impaired can render one unaware of their surroundings and therefore increase the odds of potential danger.

A. Pedestrians and Headphones

Headphone use is becoming more and more popular in today's society. This can be especially problematic when it comes to pedestrians and cyclists. Headphone technology has even improved to include features such as noise cancellation. This type of technology essentially renders the wearer deaf and, as a result, much less aware of their surroundings. In fact, pedestrians wearing headphones in big cities has resulted in an increasing number of pedestrian-versus-car accidents [9]. These accidents are more than likely due to the fact that the user was listening to music and was unaware of what was going

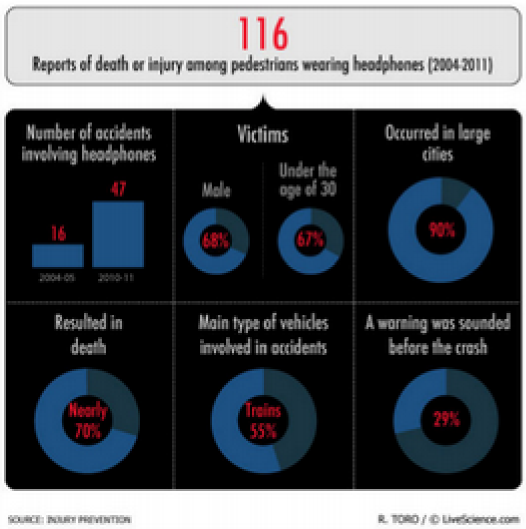


Fig. 1. Death Reports Involving Headphones, 2004-2011

on around them. According to a study conducted by the University Of Maryland School Of Medicine and the University Of Maryland Medical Center in Baltimore, headphone related pedestrian injuries have more than tripled in the last six years [9]. Figure 1 shows the 2004 to 2011 statistics of 116 headphone related pedestrian accidents reviewed during this study. At least 29 percent of those could have been avoided if the victim was able to hear the warning sounded before the crash. With the increasing trend of pedestrians wearing headphones, the number of victims has increased and is likely to continue to do so.

B. Existing and Previous Solutions

While technology exists that can improve hearing, less than 30 percent of people over 70 that could benefit from using hearing aids have ever used them [8]. That number drops to 16 percent for those aged 20 to 69 [8]. Even with the use of hearing aids, people with noise-induced hearing impairment would never make a full recovery. A wearable technology that alerts the deaf and the hearing impaired of loud sounds and the direction from which they are coming would benefit them greatly and help to avoid all of the aforementioned dangers that they may face without it.

There have been previous devices that researchers have designed for the purpose of aiding hearing impaired people in their daily lives. The devices typically consist of microphones for detecting environment acoustics, a tactile sensor for translating an acoustic signal to a sensation on the body, and other electronics for power and processing the signal. These devices include Automatic

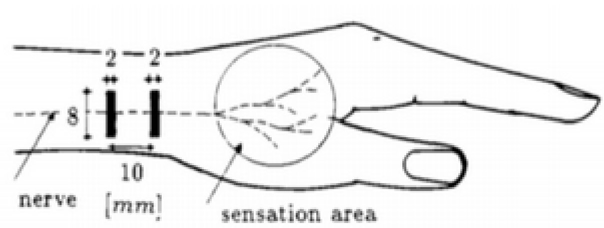


Fig. 2. TIPS Device

Danger Detection, an Electrotactile Sensor, and an Alert System for the Deaf-Blind.

Uvacek and Moschytz presented a system they called TIPS Tactile Identification of Pre-classified Signals [12]. They discussed algorithms for determining characteristics of common signals such as a doorbell, car alarm, fire alarm, and speech for the purpose of translating this information into tactile stimulation of the hand, which can be seen in Figure 2. They mentioned a few problems encountered in the implementation of their wearable device, all of which were the result of using an electrode for the tactile stimulation.

Frank A. Saunders published an article in which he describes a device used to localize sound [10]. The device consists of a microphone on each side of the users head along with electrodes which transmit electrical pulses to the head according to the direction, intensity, and frequency of sound in the environment. Saunders device can be seen in Figure 3. He reported good results from two people who wore the device for two days, however, the device is clearly very cumbersome for the wearer.

Lastly, Damper and Evans developed something similar to the TIPS system [11]. They defined certain signals of interest (doorbell, telephone, smoke alarm) and distinguished their auditory characteristics in order to alert a deaf man of signal occurrence. Their model is a slightly improved version of the TIPS device because they use small motors for alerting the users. The motor used for tactile sensation is designed with an out of balance weight on the motors shaft, which makes the sensation of feeling stronger for the user. Damper and Evans claimed to have installed and tested this system in the home of a deaf man, and other than occasional problems with kitchen sounds being mistaken for the doorbell, the deaf man said that the system worked splendidly.

C. A New Solution

Our goal is to offer an affordable solution to the aforementioned problems that hearing impairment can cause. We will improve upon previous solutions while

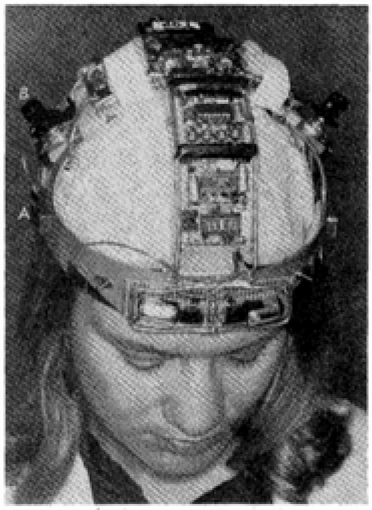


Fig. 3. Saunders Electrotactile Sensor

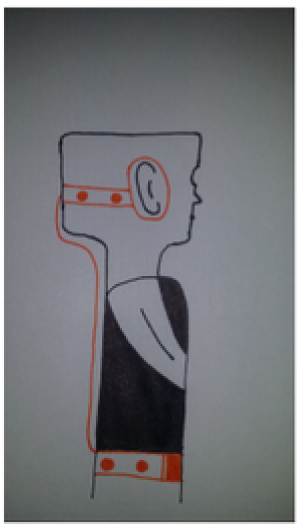


Fig. 4. Sonic-Vibe Sketch

taking a slightly different approach. Our device will be an example of a modern wearable technology. It will consist of a band that stretches across the back of the head with an array of small microphones. The headband will be connected to a waistband that has an array of vibrating motor discs, which will alert the wearer to an increased level of sound and the direction from which it is coming. Manual and automatic calibration will be controllable via Bluetooth communication from a phone. A rough sketch of the device is shown in Figure 4.

IV. Design Idea Contract

The design needs to provide a solution to the lack of awareness of ones surroundings that is created by natural hearing impairment or wearing headphones as a pedestrian. This design is required to capture sound and emit a tactile sensation that alerts the user of the sound and the direction it is coming from. This solution needs to be portable, reliable, and capable of being used safely and easily. There is a wide variety of design constraints that come with designing any type of project, but there is a lot more to consider when designing a device that is wearable. All constraints have been carefully considered and addressed in the design for the Sonic-Vibe.

A. Design Constraints

There are many requirements that will limit the performance of this device. For example, the device needs to be small in size so as to remain unobtrusive to its user. It must also be lightweight and portable. These features, especially the portability, will limit the amount of power that can be supplied to the device. Power is important because this device needs to be reliable to the hearing impaired user and if it were to lose battery quickly, it would put the user in danger. A microcontroller will have to be chosen that can manage multiple components at the same time without draining too much power. Another performance constraint would be possible interference between the microphones and the rest of the electronics. This can be addressed by separating the two and putting the microphone on the headband and the rest of the electronics around the waist.

The scope of our project includes 4 componentsa headband with microphones to detect sound from each direction, a waistband with buzzers corresponding to the direction of oncoming sound, and a phone app to manage the settings of the headband and waistband. The cost, time, and scope constraints directly affect each other, so altering any aspect of the scope would in turn alter the cost of our project and the time it would take to complete it.

In addition to the aforementioned constraints, there are also constraints associated with the environment and safety. The Sonic-Vibe is a wearable device that will be comprised of a variety of electronics. While the waistband can be covered with clothes, the headband is left vulnerable to the outside environment. There are a variety of weather conditions such as rain, fog, or humidity that could cause damage to the device or harm to its user. Something else to consider in the design of this device is the possibility of the user sweating. If the sweat were to come into contact with the device, it could cause a shock that could harm the user. Because of this, the device will have to be designed accordingly and more than likely weatherproofed.

B. Design Idea

There is always more than one way to design an engineering solution to a problem. Some problems may be solved with a quick and easy fix and others need intricate solutions. With regard to the problem of natural hearing impairment and pedestrians wearing headphones, there are a variety of solutions for each component. Broadly speaking, the system must be capable of capturing sound and emitting a tactile sensation to signify where the sound is coming from. It must also be able to calibrate to the current environment or to the user's preferred threshold.

1) Sound Capture: Capturing sound must inevitably be done with the use of microphones. Different types of microphones are available, but they must be relatively small in order to remain unobtrusive to the wearer. Electret microphones are small and cheap, but their quality will be lacking compared to more expensive microphones. More expensive microphones may work too, but they must not require too much power to operate.

The human auditory system uses the difference in time of arrival of a sound to each ear in order to distinguish where a sound comes from. The main idea behind the Sonic-Vibe is to imitate this with two microphones; the microphones will be placed on a headband and situated directly above the wearer's ears.

2) Tactile Sensors: Tactile sensors are electronic components that translate into a sense of touch. One method of tactile stimulation of the body is with electrodes. A small voltage applied across the electrode will be felt by someone wearing the electrode. This can cause problems if the wearer sweats, which can cause a voltage to form across the electrode, resulting in a small shock.

Another option for a tactile sensor is a small motor with an intentionally loosened shaft. Using this type of a motor causes a stronger vibration than if the motor was designed for its conventional uses. This has an advantage over electrodes because the sensory stimulation is done mechanically instead of electrically.

3) Processor: A CPU or a micro-controller will be necessary to interface the method of sound capture and tactile stimulation. A CPU such as the Raspberry Pi would be more than sufficient to accomplish all the necessary tasks but it would be too slow to start up; a micro-controller would be a better option. A variety of micro-controllers are available: Arduino, Propeller, etc. The micro-controller of choice will have to meet the requirements of capturing sound and translating it to tactile stimulation in a small amount of time. The Arduino is not equipped to do parallel processing in a convenient way, whereas the Propeller has 8 cores available. A multiple core processor may be necessary for the lag time between audio capture and sensory stimulation to be negligible.

4) Controlling Device Settings: The user of our wearable device must be able to initiate a calibration mode. An automatic calibration mode would consist of an algorithm that produces a sound intensity threshold level based on the wearer's current environment. A manual calibration mode would consist of the wearer setting the decibel minimum that would trigger a sensory stimulation. Ideally, both automatic and manual calibration can be made as available features of the device.

One option for controlling the device's settings is to include buttons and switches on the belt buckle. Another option is to have a Bluetooth module that can communicate with a phone with a phone application that sends control signals to the micro-controller. Having controls on the belt buckle would be an easier solution than a phone application, but it may also take away from a potentially appealing design. A phone application would also enable the device's features to be expanded through software updates only. For example, setting the intensity threshold manually could be done in a graphically interactive way, or a map could be created on the user's phone corresponding to the current sound environment. Ultimately though, vanity should not be placed ahead of functionality.

V. Resources

Resources that our team will need will range from lab equipment to a tailor to create the waist and headband. We also need input from people who experience our societal problem on a daily basis. This can include anyone that has suffered from a hearing disorder to students that love to blast music while walking around. Lab equipment will be utilized to trouble shoot and initialize hardware components to our project. We will also need software to be able to compile and write our code for the processor.

A. Punch List

Our device involves three main features. Among these features are the headband, the waistband, and the User Interface.

1) Headband: The headband will need to be the most fashionable feature. It is the only feature that will be visible and not covered up by a T-shirt. The headband will need to feature an array of microphones that will either be at the same height or offset. Figure 5 shows the microphones we decided to use for our prototype. The headband needs to be made of a comfortable material that will not bother or irritate the user. The material of the headband will need to have an elastic property to ensure that is stays on the users head. It will also need to be adjustable or offered at various sizes. This will ensure that the product can accommodate users with different size and shaped heads. The headband must include multiples microphone that are located internally. The properties of the microphones need to be lightweight and be able to be sewed within the headband with comfort in mind.

We will need to implement two to five small microphones in the sleek headband. They will all need to be identical microphones. Having identical microphones will ensure that the sensitivity levels of each one will be the same. The microphones essentially need to be small in size and extremely light weight. Lightweight and small microphones will allow the headband to remain comfortable. The microphones will need to be able to connect to the microcontroller through an audio jack. This will require some type of connection between the multiple microphones and the microcontroller. Technically speaking the microphone must be less than a half an ounce in weight. The diameter of the microphone should be around or less than twenty millimeters. An Artificial Neural Network will be needed to implement machine hearing, or the ability for the microcontroller to be able to identify the source of the sounds that the microphone picks up.

The current plan is to design the headband with two small microphones with built-in amplifiers from Adafruit, a Microchip dsPIC30F4012 and a Microchip Bluetooth module. Using these small components will allow for a slim and sleek headband that will be comfortable to wear. The Adafruit microphones also have an option for automatic gain control, which would allow for the device's effective radius to be set automatically, if such a thing ends up being desirable. The dspic30F4012 is a 16-bit microprocessor that is designed for digital signal processing. It will be responsible for computing the cross-correlation between the left and right microphones. After processing, the microprocessor sends the information via Bluetooth to the waistband and phone.

2) Waistband: The waistband will be located around the waist near the belly button of the user. Similar to the headband, it will need to be comfortable and lightweight. The processor and battery will be located on some type of buckle, which will be connected to the waistband. The headband and waistband will need to be in constant communication via wire. The power supply, which will consist of a lightweight battery, must be able to fit inside the buckle.

The buckle will connect the straps of the waistband and include the micro-controller and power supply. The

Fig. 5. Microphone

Fig. 6. Vibrating Mini Motor Disc

power supply will just be a DC battery big enough to provide power to the microcontroller, microphones, and vibrators. The plan is to 3D print the buckle; the buckle needs to be big enough to house the microcontroller and battery and contain enough room for ports to connect the microphones and vibrators.

We plan to use five Vibrating mini motor discs. The vibrating mini motor discs must be smaller than a dime, about 10 mm. There voltage can vary between 3-5 volts with a current draw anywhere from 40-100mA. They will be powered and controlled by the micro-controller.

3) Phone App: Our device will need to be connected to an app on a smart phone with a Bluetooth connection. The app must allow the user to be able to adjust different variables and sensitivity levels. The app needs to be available to most smart phones and also needs to be easy for anyone to use.

VI. Funding

For now, the prototype will be funded by the members of the team but we are considering the idea of getting a patent in the future. Should we choose to move forward with mass producing this product, we will need to find interested parties to help fund this effort. Alternatively, we could look into bank loans, however, it would be better to have the support of other companies during this process.

VII. Work Breakdown Structure

The aforementioned features of our projectthe headband, the waistband, and the user interfacehave been broken down further into individual tasks. These individual tasks were then assigned to a team member.

A. Headband

The headband portion of the wearable is primarily responsible for capturing sound from the environment. It is essential for the headband to be comfortable and easy to take on or off. The headband has a number of microphones for detecting sound from the wearer's surroundings. On the software side, certain sounds need to be classified and saved as reference signals to compare with incoming signals. Also, with a difference in position of the microphones, it is possible to determine the direction a sound comes.

B. Microphone Selection and Placement

In order for the wearable to be comfortable and appealing, the microphones should not be too large. Depending on the algorithms used to translate the direction of a sound to tactile sensation, the microphones could be either uni-directional or omni-directional. With uni-directional microphones, the intensity of sound could be the variable that determines if a vibration will occur on the waist.

C. Determining Sound Direction

With at least two microphones on the headband, it is possible to perform a mathematical operation to determine the phase difference between two similar signals.

$$\theta = \cos^{-1} \frac{\mathbf{x} \cdot \mathbf{y}}{\|x\| \, \|y\|} \tag{1}$$

This phase difference is significant because it is a function of the angle that a sound source makes with the microphones. In equation 1, θ is an angle that results from a formula relating the inner product of two vectors with the cosine of the angle between them, but it does not necessarily have a physical meaning. The picture represents the two dimensional angle formed between the sound source and two microphones. In this particular configuration, the right angles that are formed allow us to determine how the angles ϕ_L and ϕ_R change when the point P is translated vertically.

$$\phi_L = \phi_R = \tan^{-1}(\frac{d_S}{d_M/2})$$

In the limit as d_S, goes to infinity, both angles converge to 90 degrees because the distance between the microphones, d_M, does not change.

However, when d_S does not change, but rather moves around the arc shown, the angles become unequal. The difference between the angles should be zero when the sound source is positioned directly in the middle. If the sound source is directly to the left or directly to the right, the difference between the angles will have a magnitude of 180 degrees and a minus sign depending on which angle is subtracted from the other.

This geometric diagram represents how angles formed between microphones and a sound source is a result of the distance from the sound source to each microphone. When the distances to each microphone are identical there is no phase difference between the physical pictures. Also, left and right sections along a circle traced about the center of the microphones should result in a phase difference of equal magnitude and opposite sign. Both of these characteristics should be consistent with the angle θ from equation 1. The angle θ does not need to be equal to the difference of the angles made in the physical picture, but there does need to be a consistent correspondence between the two.

If this correspondence exists, it allows us to measure the values of θ corresponding to the phase difference, $\Delta\phi$, which is the difference between ϕ_L and ϕ_R. A list can be created for values of theta that correspond to certain locations of a sound source. When a signal is read from by the microphones, the phase difference between the signals in each microphone can be checked with the stored list and output the angle of incidence of the sound source.

D. Making Measurements

In order to make a table of values that can be compared to an incoming sound from the environment, it is necessary to make precise measurements of how the phase difference between similar signals changes as sound changes its location.

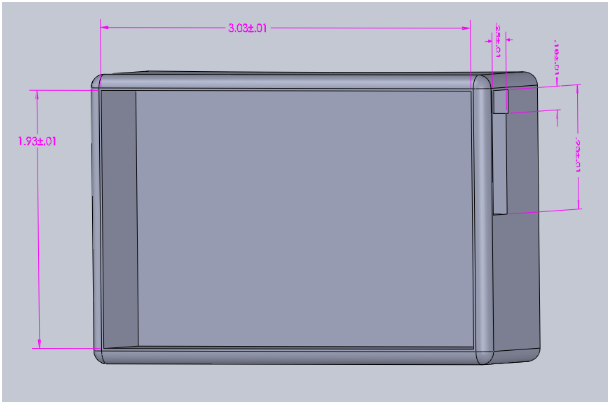


Fig. 7. CAD Design for Headphone Attachment

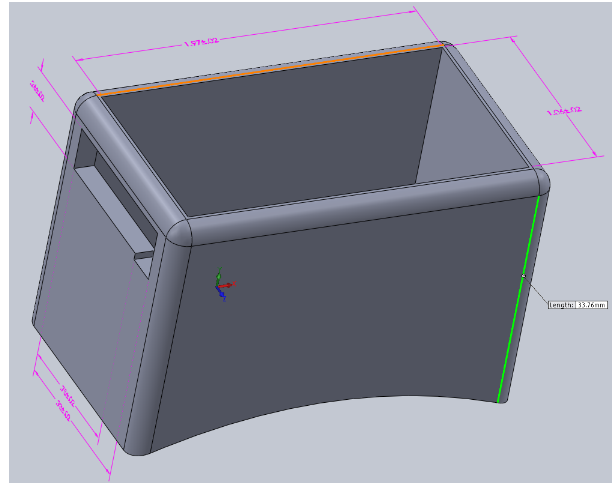


Fig. 8. CAD Design for Buckle

This allows us to determine the measured phase difference resulting from equation 1 and map a range of values to the relative location, which is only known during the measurement process. If consistent measurements are taken, this method determines the location of a sound in a two dimensional plane by creating a one to one correspondence between the phase delay calculated with equation 1 and the difference in angles measured between the source and two microphones.

E. Belt Buckle

The belt buckle will be need to house most of the electronics. The micro-controller is one of the main features located inside the belt buckle. In order for it to be able to control various functions of the belt buckle it will need to be connected to blue tooth, microphones, headphones, and a battery supply. The belt buckle and headphone attachment will be designed in a 3D CAD modeling program. After it is designed, it will then be 3D printed. See figure 7 and 8 for the designs of the housings.

F. Micro-controller

One important aspect of the micro-controller is its ability to communicate with every part of the project. It will also need to be programmed and have its own software. The programming along with the software of the micro-controller will be the biggest and most time consuming task of the project. The overall function of the micro-controller is to program the processor so that it is able read inputs, process the information, then send the appropriate signal to the output. Research on an appropriate micro-controller will be vital. The best micro-controller should be able to do two things. We need one that will be able to process information as quick as possible, while still being lightweight and compact. Price is also important when considering a micro-controller since they can vary in price, finding one that has the most reasonable price is definitely a top priority. This should be the one of the items we invest more money into ensuring that a good product is at the heart of the device.

G. Battery

Along with the micro-controller, another important aspect of the belt buckle is the battery. It will need to be able to power all the electronics which includes: the processor, the motors for the vibrators, Bluetooth, an amplifier for the microphones. The battery will need to be relatively small, rechargeable, and would last throughout the day. In order to find a battery that can provide us with all of those things, doing research is something we need to focus on. We need to search for one that is light in weight, rechargeable with a high amount of milliamp hours, such as 2,500 mAh. We will also need to do a power analysis on all of the electronics. Doing this would allow us to figure out the appropriate sized battery to last a day. The battery will need to be pretty inexpensive as well to allow money to be spent on more important aspects of the project.

H. Connection Ports

To connect everything within our device, connection points will need to be established. We will need ways to plug in the microphones to the belt buckle as well as connect the microphone to the processor. These connections should be small in order for all the parts to fit inside the belt buckle. The connectors should also be made of plastic because it will make the belt buckle more light weight. Although connectors are cheap in price, ordering them as early as possible will benefit us in developing the device faster. The belt buckle will be built around the connectors and must accommodate them.

I. Waistband

The waistband should be comfortable and light weight as it will be worn around all day. Finding one that is lightweight and made of an elastic material would be ideal. This hopefully would allow users to feel comfortable and not constricted while wearing it. The strap should be adjustable to allow for any body type. The waist band not only needs to be comfortable but it should also be wide enough for the vibrating motor discs.

J. Vibrating Motor Disc

Since the whole concept of the device is to alert the user of incoming danger by vibrations, the vibrating motor disc is a vital feature. The vibrating motor discs will need to be small and efficient. Tests will be performed to find out the exact power consumption in order for there to be enough battery for all aspects of the device. The level of vibration should also be taken into consideration because it needs to be able to warn the user, but not be too alarming. The buzzers will need able to operate at variable speeds. This is important because the varying speeds of vibrations will determine what kind of approaching danger there is. We need to research to find a small, efficient vibrating motor disc that will be cheap in cost. Since these devices are quite simple, the price will depend on exactly how small we want the vibrating motors discs to be.

K. User Interface/Phone App

The user interface will be responsible for communication between the user and the micro-controller. This is an important feature of the Sonic Vibe, however, work on this cannot begin until later on when we know exactly how the other features will be implemented. For example, we will need to determine the best micro-controller to use before we can pick the Bluetooth for it and start interfacing with the smart phone. The user interface will allow the user to control the intensity of the vibrating motor discs as well as calibrate the microphones to their current environment. This will be accomplished through the use of a smart phone application that communicates with the micro-controller via Bluetooth.

L. Bluetooth

Bluetooth will be used for communication between the micro-controller and the phone application because of its many advantages. The main advantage of Bluetooth is that it is wireless. Since the microphones will already have a wired connection to the micro-controller, any additional wires will be avoided to make the Sonic Vibe more user friendly and convenient. Bluetooth is also inexpensive and it comes standard with most smart phones. Other advantages include being simple to use with minimal compatibility issues. Bluetooth also has impressive data transfer speeds and since the phone and the micro-controller will always be within a small distance of each other, we don't have to worry about Bluetooth not working well over long distances. Something that will need to be considered will be battery power because despite the low processor power and battery power consumption, the battery can still be drained if Bluetooth is left activated.

VIII. Risk Assessment and Mitigation

An essential part of every project is risk assessment. In addition to a problem statement, work breakdown structure, and time-line; risk assessment is crucial to ensuring successful project completion. Not only is there risk associated with projects in general, but each individual project task carries a unique set of risks. These risks can involve financial, technical, or timing issues among other things. It is important to identify these risks at an early stage of the project so that they may be assessed in terms of likelihood and impact. Then, each risk can be categorized using the risk matrix and an appropriate mitigation plan can be chosen. Risk mitigation is often a choice between eliminating the cause of the risk, transferring the risk to another team member, or assuming the risk and continuing with the original plan. After determining the likelihood and impact, each team member will choose the best mitigation plan for the risks associated with the parts of the project they are responsible for.

A. Microphones

The microphones are the first stage of the device, so they must be evaluated in great detail so that the device works as intended. This means that the risks associated to the design of the microphone system include noise associated with the environment from low quality microphones. To mitigate the damage these risks could cause, one option is to buy expensive parts that will be more likely to work well. Another option is to have multiple microphones available for testing. The last option is to have another team member help.

B. Waistband

The waistband is low risk but it will have a high impact on the overall project. The highest impact related to the waistband will be comfort. Our goal is to make the waistband as comfortable and light weight as possible while still being fashionable. If necessary we will have to make a trade-off between comfort and size to an affordable price.

The battery within the belt buckle will take up the most space and will need to be small. The mitigation for the battery is simply to spend more money on a better, more efficient battery, otherwise the entire device will need to be recharged more often. The battery used will depend on the microcontroller and the buzzers.

The buzzers will need to be as small as possible and efficient. They will need to be able to produce a noticeable buzz with use of little current. If we continue to have problems with powering up the buzzers, we will either look for more efficient buzzers or use a battery solely for the buzzers.

The design of the belt buckle shouldn't cause any large problems. If we have trouble creating something that can house everything we will need to consult with a mechanical engineer to design a more compact buckle, utilizing all free space. For the waistband itself, it will need to be made with comfort as the main priority. The waistband will ideally be adjustable to fit people of all sizes and shapes. If we are unable to create a comfortable waistband, we will have to hire a tailor to sew together a nice strap that can house the buzzers. Also if the waistband cannot be adjusted, we will have to make multiple sizes to accommodate different users. With the waistband being a high impact to the project, the need for alternatives is essential. These alternatives include everything from an extra battery to hiring external professionals.

C. Phone Application

The User Interface is an essential piece of our project. It enables the user to interact with the hardware of our device through customizing settings and viewing logs of the recorded data. Without a UI, our device would practically be useless to a user. We have chosen to create a User Interface for our device in the form of a phone application. This application will consist of a GUI, outbound communication to the microcontroller to calibrate the microphones and control the buzzer intensity, and inbound communication from the microcontroller to log noises detected throughout the day. In implementing this, we will likely face risks involving technical and timing issues.

One technical risk that is involved in writing any code is human error that can result in bugs. The likelihood of bugs occurring is low-medium and can carry a medium-high impact depending on the severity of the bug. The appropriate course of mitigation is avoidance though elimination of the consequence. Extensive debugging and testing will be important in mitigating this risk.

Another technical risk involved in the phone application is the inability for the application to communicate with the microcontroller. The method of communication chosen to do this is Bluetooth. Bluetooth is extremely compatible and easy-to-use so the likelihood of the application being unable to communicate with the microcontroller is low. However, communication between the two is crucial to our project so the risk has a high impact. One possible mitigation would be to avoid this issue by eliminating the cause and using wired communication instead. However, we have opted to assume the risk and continue with the plan.

The obvious risk associated with timing would be the inability to complete the phone application in the allotted time. Since we have carefully planned out our project schedule, the likelihood of this happening is very low. However, as mentioned before, the User Interface is crucial to the project so not completing it would impact our project tremendously. One option for mitigation would be to avoid this risk by sticking to the project schedule and completing the phone application on time. However, things can happen that may knock the responsible team member off of the course of the schedule. In this case, another option would be to transfer other responsibilities to another team member to make more time to complete the phone app.

D. Microcontroller

The microcontroller is responsible for hosting the microphone connections, processing incoming sound with the algorithm discussed in the previous section, and sending PWM signals to the vibration motors. If the microcontroller is too slow, it will be noticeable in its inability to produce good results or its inability to produce good results at a fast enough rate. This introduces a risk into the project, which can be mitigated by having multiple microcontroller options available. Three microcontrollers that are available are the Arduino, Raspberry Pi, dsPic, and Propeller Chip. The first choice is the Raspberry Pi because it has built-in USB connections and the next choice is dsPic.

E. User Discretion

This device is meant to assist the hearing impaired with identifying the direction of sound to avoid dangerous accidents with the surrounding environment. The project is not meant to identify the type of sounds and will not physically move the user to avoid collisions with oncoming objects. The project is also not design to aid the user in hearing nor improve the user's hearing capability. The user will use the device at their own risk.

IX. Task Assignments

The work will be divided out evenly among all the group members and everyone has been assigned a task. To divide the tasks, we took into account everyone's strengths and experience. The sole responsibilities of each team member are listed below. See Appendix C for task assignment and scheduling of the project.

A. *Introduction*

The scope of this test for the Sonic-Vibe will cover the microphones, algorithm, headband, waistband, phone application, and the finished prototype. However, the test will not cover any standards or regulation that is forced by any outside party from California State University of Sacramento. The strategic plan for testing the Sonic-Vibe will be done carefully and throughout the development of our device. A time line is provided to accomplish tests on schedule in order to have a complete working deployable prototype.

B. *Reading in Audio Data*

One of the first systems to test will be the two microphones reading in data. We need to verify that each microphone is working and has a reasonable range to acquire the audio signal. The microphones will then be tested simultaneously by verifying that both microphones can provide data within a small time frame of one another.

C. *Primary Algorithm Test*

Once we have successfully converted audio from two microphones with a dsPIC, we must test the algorithm that the dsPIC must perform on a block of audio data to determines the direction of sound. The algorithm consists of an FFT (Fast Fourier Transform), multiplication, complex conjugation, an Inverse FFT (IFFT), and an iterative search for the time when a maximum occurs. This process can be visualized in figure 9. The decision making block consists of searching an array for a maximum value and returning the time at which this maximum occurs. Depending on the sign and the magnitude of the return value, a decision can be made corresponding to left, middle, or right. Afterwards, the two microphones will be switch to prove it will not have any negative influence for the algorithm. The next test will be to crossed the left and right microphone. The

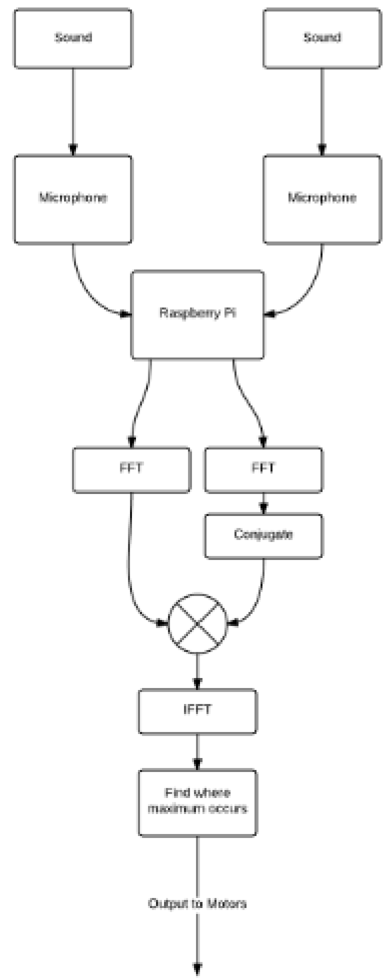


Fig. 9. Determining Time Delay Between Similar Sounds

cross test is to demonstrate that the algorithm can still process the raw data from the microphones and should not affect the outcome. Another key important test for the algorithm test is to determine what are the limiting factors are and the possible outcome from any if else statements.

D. *Bluetooth*

We will be using Bluetooth communication between the phone app and the microphones, the phone app and the waistband, and the microphones and the waistband. As such, we will need to confirm that the Bluetooth communication will work to send accurate data over a distance of at least 3 feet. We will also need to confirm that the Bluetooth in the phone is compatible with the Bluetooth modules for the chips. In order to verify this, we will need to establish all three of these connections and use debug statements to make sure the data that is being sent and received between each connection is correct.

E. Phone App

The phone application needs to work for later models of the iPhone and, ideally, for Androids as well. It also needs to send and receive data to and from the microphones and the waistband as well as store the data that it receives. We will be testing on a few devices to make sure the phone application works on each of them. We will also use debug statements as well as different test scenarios with different types of data to make sure the phone application is sending, receiving, and storing accurate data in all situations. Additionally, we need to test saving the data in order to establish a limit for how much data the phone application should be able to store without taking up too much room on the phones. Power consumption will also be an important part of our testing since Bluetooth can drain phone battery quickly, so we will need to test how much power the phone app is using on each of the phones and work towards reducing it.

F. Systems

The systems test will handle testing all three main components separately. The systems test is conducted to verify that each three main components should be able to operate appropriately to thier specifications. The integrated system consists of three main parts:

(1) Headband, containing the microphones, Bluetooth module, and battery.

(2) Waistband, containing the dsPIC, Bluetooth module, battery, and tactile sensors.

(3) Phone Application: Bluetooth connection to the Sonic-Vibe, allowing control of microphone sensitivity and strength of tactile feedback.

Once each part works independently, the system will be integrated and tested as a whole.

One potential problem that we may encounter is Bluetooth synchronization between the three parts.

G. Functionality Test

Once the System is integrated and before testing in the environment, the integrated device will be tested in a lab where there is minimum amount of noise. The device is then tested for proper functionality as stated in the design contract. The device should be able to distinguish where the generated sound came from produce by the tester. The functionality test shall also include verifying that all three main components are communicating each other and the response time shall be approximated by tester. The test will also verified that the apps can control the microcontroller and log information from the microcontroller.

H. Environment Tests

The Sonic-Vibe is designed for use outdoors and indoors, so it must be tested in different environments.

One essential test to perform, once the integrated device is working, consists of checking that the device correctly identifies the direction of a sound with the device being worn by someone in motion. The Sonic-Vibe is not meant to be worn while running or doing excessive exercise, but it is meant to be functional while the user is walking.

One possible problem that motion could induce is a periodic signal in the form of the user's footsteps. If walking creates a noticeable change in the waveform picked up by the microphones, such that the sound coming from the user's footsteps are louder than a non-local source of sound, it will be necessary to filter out the periodic footsteps. This could be accomplished with an adaptive high-pass filter, as the frequency of walking is going to be a low frequency signal. On the other hand, if the periodic footsteps are relatively quiet compared to the ambiance, it will not be necessary to provide such a filter. Nevertheless, the device must be tested with a user in motion to determine whether or not a footstep filter would be necessary to ensure proper functioning of the Sonic-Vibe.

Another important test for the device that is a likely scenario is being used in a noisy environment. The device should not be effected about the amount of noise and shall still detect the direction of sound.

I. Test for Comfort

Our device is made to be worn during situations that hearing is impaired. With this in mind, we want the user to be comfortable and one test will need to be to verify that the device is wearable and does not effect movement. It will be important to have input from more than one person and to have people of different size try the device.

X. Conclusion

The Sonic-Vibe will be a device to detect the direction of sound that targets pedestrians wearing headphones. Its three main parts-the headband, the waistband, and the phone application-will be carefully integrated together and undergo rigorous testing. Each feature will communicate through bluetooth creating a wireless end product that is both compact and comfortable. This innovative product will hopefully lead to a decrease in pedestrian accidents caused by wearing headphones.

References

[1] American Hearing Research Foundation. Noise Induced Hearing Loss. American Hearing Research Foundation. Elmhurst, IL. http://american-hearing.org/disorders/noise-induced-hearing-loss/intensity. 2012.

[2] Healthwise. Medicines that Cause Hearing Loss. Healthwise. http://www.webmd.com/a-to-zguides/medicines-that-cause-hearing-loss-topic-overview. 2014.

[3] T. Chong. (2014). Futuristic Firefighter Suit Has Sensors, Heads-up Display [Online]. Available FTP: http://spectrum.ieee.org/consumer-electronics/portable-devices/futuristic-firefighter-suit-has-sensors-headup-display

[4] R. F. Fahy, P. R. LeBlanc, and J. L. Molis. (2015). Firefighter Fatalities in the United States [Online]. http://www.nfpa.org/research/reports-and-statistics/the-fire-service/fatalities-and-injuries/firefighter-fatalities-in-the-united-states

[5] G. Derugin (2014) [Online]. Sony ECM-CS3 Stereo Lavalier Microphone http://www.filmbrute.com/ecmcs3/

[6] The Center for Construction Research and Training. (2012). Noise-Induced Hearing Loss in Construction and Other Industries [Online]. http://www.cpwr.com/sites/default/files/publications/CB

[7] Hearing Health Foundation. Hearing Loss and Tinnitus Statistics. Hearing Health Foundation. New York, NY. http://hearinghealthfoundation.org. 2015.

[8] Institute of Physics. Alarms and Sirens. Institute of Physics. London, UK. http://www.physics.org/featuredetail.asp?id=75.

[9] National Institute on Deafness and Other Communication Disorders. Quick Statistics. NIDCD. Bethesda, MD. http://www.nidcd.nih.gov/health/statistics/pages/quick.aspx.

[10] R. Lichenstein, D. C. Smith, J. L. Ambrose, and L. A. Moody, Headphone use and pedestrian injury and death in the united states: 2004 -2011, 3rd ed.Injury Prevention. 18, no. 5: 287-290 2012.

[11] Frank A. Saunders, An Electrotactile Sound Detector for the Deaf, in IEEE Transactions on Audio and ElectroAcoustics, Vol. AU-21, NO.3, June 1973.

[12] Robert I. Damper and Mike D. Evans, A Multifunction Domestic Alert System for the Deaf-Blind, in IEEE Transactions on Rehabilitation Engineering, Vol. 3, NO.4, December 1995.

[13] Bohumir Uvacek and George S. Moschytz, Sound Alerting Aids for the Profoundly Deaf, Swiss Federal Institute of Technology Zurich, Institute for Signal and Information Processing, 1987.

[14] R. Schapire. (2008). ”COS 511: Theoretical Machine Learning”. [Online]. Available FTP: http://www.cs.princeton.edu/courses/archive/spr08/cos511/scribe_notes/0204.pdf

[15] R. F. Lyon. (2010). ”Machine Hearing: An Emerging Field”. [Online]. Available FTP: http://static.googleusercontent.com/media/research.google.com/en//pubs/archive/36608.pdf

[16] Wikipedia Organization. (2015). ”Machine learning”. [Online]. Available FTP: https://en.wikipedia.org/wiki/Machine_learning

[17] University of Toronto. (2015). ”Artificial Neural Networks Technology”. [Online]. Available FTP: http://www.psych.utoronto.ca/users/reingold/courses/ai/cache/neural2.html

[18] G. Demirz, H. A. Gvenir (2005). ”Classification by Voting Feature Intervals”. [Online]. Available FTP: http://link.springer.com/chapter/10.1007/3-540-62858-4_74#page-1

[19] M. T. Hagan, H. B. Demuth, M. H. Beale, and O. D. Jess. ”Neural Network Design” 2nd Edition. Oklahoma State University. Martin Hagan 2014.

[20] J. Mrovlie and D. Vrancic, *Distance measuring based on stereoscopic pictures*, 1st ed. Izola, Slovenia: October 2008.

[21] G. Derugin (2014) [Online]. Sony ECM-CS3 Stereo Lavalier Microphone http://www.filmbrute.com/ecmcs3/

[22] Adafruit, https://www.adafruit.com/products/1713

Fig. 10. Device

Appendix A
User Manual

A. How to Wear

The device will strap around the waist and have a strap adjuster that can be tightened for a comfortable fit. The band is elastic and will not need to be overtightened. The headband will be attached to headphones. The user will have to put on the headphones and clip on the waistband. To turn on the device, there is a switch for both the headband and waistband located protruding out of the box. The batteries used are Lithium CR2032 and they interchangeable. After the device is powered on, the user will launch a phone app and manually connect to the headband through bluetooth connection.

Figure 10 shows the device on the user and the appropriate location for the waistband and headband. The user will need to keep in the mind the position of the buzzers and the buckle. The buckle will need to go in from on the stomach of the user. The buzzers will need to be located on each side of the body and one located on the back. The headphones are worn as a normal.

B. How to Use the Phone Application

First, download the Sonic-Vibe app onto your smart-phone from the App Store or from Google Play. Next, power on the Sonic-Vibe device. Make sure Bluetooth is turned on on your phone and discover/pair your phone with the Sonic-Vibe. Once paired, open the phone app. There will be two buttons-'Settings' and 'Logs' as shown in Figure 11.

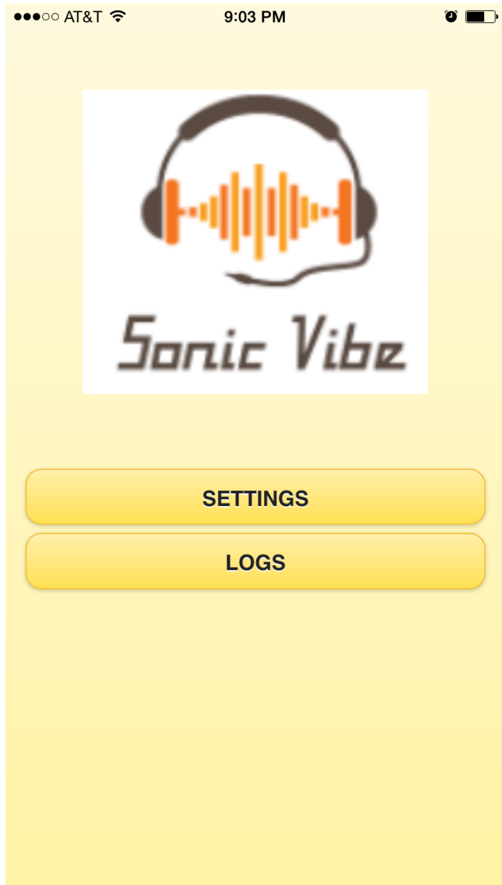


Fig. 11. Homepage for the Phone Application

1) Settings: Figure 12 shows the Settings window in which you will have the option to adjust the threshold for the microphones and the intensity for the buzzers. In order for the changes to take effect, you must press the 'Apply' button. The 'Cancel' button as well as the 'Back' button will take you back to the homepage.

2) Logs: Figure 13 shows the Logs window in which you will have the option of viewing today's logs or the logs for the last 7 days. Clicking on either button will lead you to a table of logs. The 'Back' button will take you back to the Logs page and the 'Back' button on the Logs page will take you back to the homepage.

C. Tips

Remember to power off the Sonic-Vibe device when not in use so that you can save battery. Also, remember to disable the Bluetooth on your phone when not using the device as leaving it on can quickly drain the battery power of your phone.

APPENDIX B
HARDWARE AND SOFTWARE DOCUMENTATION

The hardware portion of this project consists of the microphones, the microcontroller, and the buzzer. The phone application and the code for the microcontroller makes up the software portion.

A. Determining the Direction of Sound

The two microphones on the headband are placed similarly to the way our ears are situated. This spatial difference between the two microphones causes a measurable time difference between the signal captured by each microphone, and there will also be a slight difference in the pressure levels. For example, if a sound is made to the left of the user of our device, the sound will reach the left microphone first and the pressure level will be slightly higher than

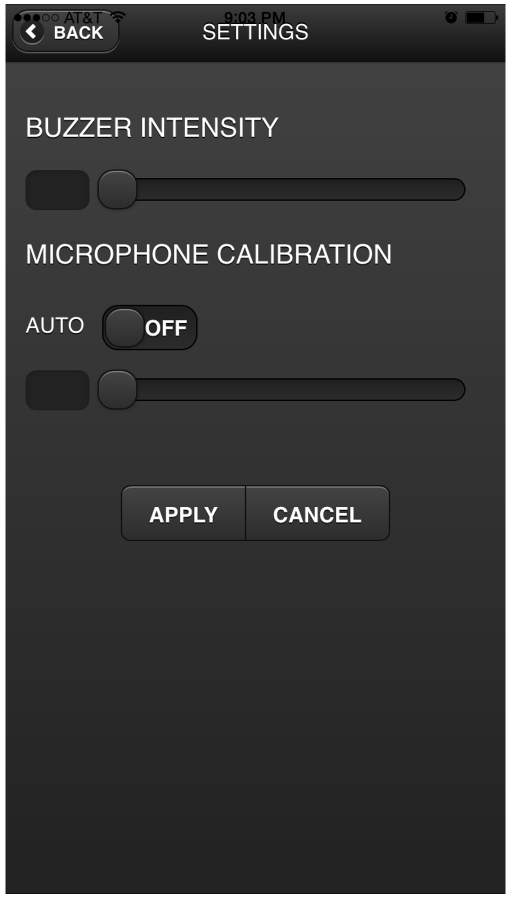


Fig. 12. Settings Page for the Phone Application

the pressure level detected by the right microphone. If a sound is made directly behind the user, the sound reaches both of the microphones at the same time with the same pressure level.

In order to measure the time delay between two signals, we implemented cross-correlation via the Fast Fourier Transform (FFT). Cross-correlation in the time domain between two similar signals will produce a maximum amplitude at the time index where the signals best match each other. If one signal is delayed relative to the other, the time index reveals the amount of delay between the two signals, which we can use to determine where the sound came from.

It is useful to also take into account the difference in the sound level between the two microphones to determine the direction of sound.

In the Python program that performs the function of the block diagram shown in figure 14, some conditional statements must be made in order to output the direction of a sound to the motors on the waistband. If we want to consider the difference in sound pressure as well as the time delay, the number of conditional statements doubles. By combining the two measurements (time delay and magnitude difference) into an artificial neural network (ANN), it is possible to reduce the number of conditional statements that must be checked before outputting a signal to the motors.

B. Waistband Code

```
#include <xc.h>
#include <libpic30.h>
#include <math.h>

// Configuration settings
```

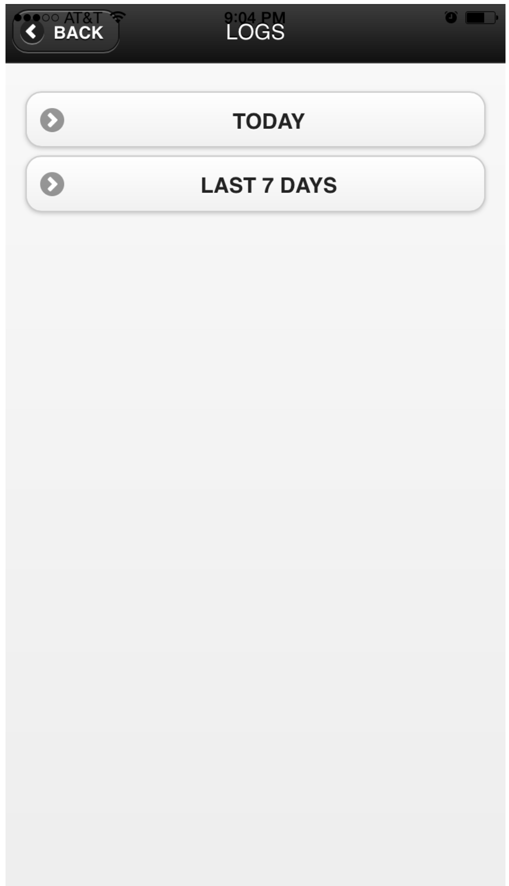


Fig. 13. Logs Page for the Phone Application

```
_FOSC(CSW_FSCM_OFF & FRC_PLL16); // Fosc=16x7.5MHz, i.e. 30 MIPS
_FWDT(WDT_OFF);                  // Watchdog timer off
_FBORPOR(MCLR_DIS);              // Disable reset pin

// Function prototype
void set_duty_cycles(float a, float b, float c);

int main(void)
{
    //PWM output A
    PWMCON1 = 0x0011;        // Enable PWM1 (high and low pins)
    PTCONbits.PTCKPS = 0;    // prescale=1:1 (0=1:1, 1=1:4, 2=1:16, 3=1:64)
    PTPER = 1764;            // 17 kHz PWM frequency (PTPER + 1 = 30000000 / 17000)
    PDC1 = 1200;             // 50% duty cycle on PWM channel 1
    PTMR = 0;                // Clear 15-bit PWM timer counter
    PTCONbits.PTEN = 1;      // Enable PWM time base

    // Use OC1 for PWM output B with Timer 2 as clock source
    PR2 = 1578;              // 19 kHz PWM frequency (PR2 + 1 = 30000000 / 19000)
    OC1R = PR2 / 2;          //
    OC1RS = PR2 / 2;         // Select 50% duty cycle initially
    OC1CONbits.OCTSEL = 0;   // Select Timer 2 as clock source for OC1
    OC1CONbits.OCM = 0b110; // PWM mode
```

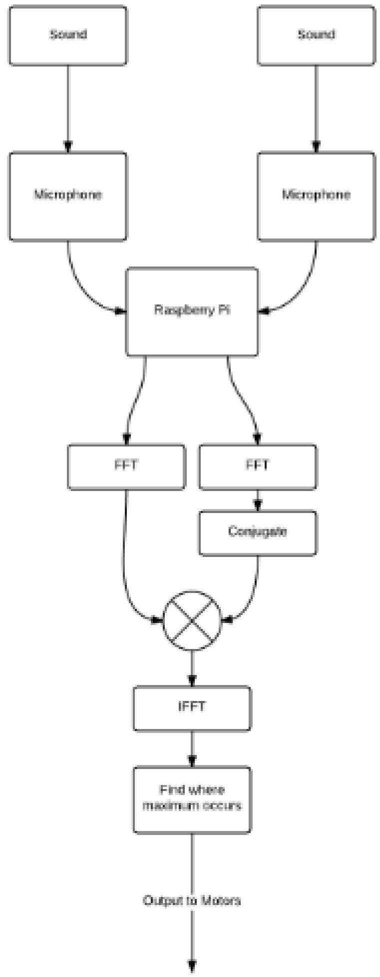


Fig. 14. Determining Time Delay Between Similar Sounds

```
T2CONbits.TON = 1;       // Turn on Timer 2

// Use OC2 for PWM output C with Timer 3 as clock source
PR3 = 1303;              // 23 kHz PWM frequency (PR3 + 1 = 30000000 / 23000)
OC2R = PR3 / 2;          //
OC2RS = PR3 / 2;         // Select 50% duty cycle initially
OC2CONbits.OCTSEL = 1;   // Select Timer 3 as clock source for OC2
OC2CONbits.OCM = 0b110;  // PWM mode
T3CONbits.TON = 1;       // Turn on Timer 3

// Make OC1 and OC2 outputs (same pins as RD0 and RD1)
TRISD = 0b1111111111111100;

// Setup UART
U1BRG = 15;             // 38400 baud @ 30 MIPS
U1MODEbits.UARTEN = 1; // Enable UART

//
// Now, vary duty cycles on the three PWM outputs so that the
// three LEDs pulsate.
```

```
//
// I'm using an inverted squared sine waveform to pulsate
// each LED. Between each pair of LEDs, there's a phase shift
// of 2*pi/3 radians.
//
// It doesn't really matter what's actually happening in this part
// of the program - it's just something to show that the duty
// cycle really is variable on each PWM output.
//
float input, a, b, c, Intensity;
while(1)
{



    if (U1STAbits.URXDA == 1)
    {
        input = U1RXREG;
    }

    if (input < 85)
        {
            Intensity = (85 - input)/85;
            a = Intensity;
            b = 0;
            c = 0;

        }

    else if (input > 170)
        {
            Intensity = (255 - input)/255;
            c = Intensity;
            a = 0;
            b = 0;

        }

    else
        {
            Intensity = (171 - input)/171;
            b = Intensity;
            a = 0;
            c = 0;

        }


    set_duty_cycles(a, b, c);

}
return 0;
```

```
}

//
// This function provides a way to set the duty cycle on all three
// PWM output channels in one go. Arguments a, b and c are the three
// desired duty cycle values - each should be in the range from 0 to 1.
//
void set_duty_cycles(float a, float b, float c)
{
    PDC1 = a * 2 * PTPER;
    OC1RS = b * PR2;
    OC2RS = c * PR3;
}
```

C. Headband Codes

```
#include <xc.h>
#include <libpic30.h>
#include <stdio.h>
#include <math.h>


// Configuration settings
_FOSC(CSW_FSCM_OFF & FRC_PLL16); // Fosc=16x7.5MHz, Fcy=30MHz
_FWDT(WDT_OFF);                  // Watchdog timer off
_FBORPOR(MCLR_DIS);              // Disable reset pin


// Window length, N (greater than 4 and a power of 2)
#define N 64


void configure_pins();
unsigned int read_analog_channel(int n);

void delay_ms(unsigned int n);


int main()
{
    // time and frequency domain data arrays
    int n, k, m;                     // time and frequency domain indices
    float left[N];                   // discrete-time signal, x
    float right[N];
    float z1[N];
    float z2[N];
    int shift1;
    int shift2;
    float z1max = 0.0;
    float z2max = 0.0;
    float intensity = 1.0;
    float scaling = 0.01f;
```

```
// Set up which pins are which
configure_pins();



// Now just blink LED indefinitely
while(1)
{
    // Record N samples @ 10kHz
    for (n=0 ; n<N ; ++n)
    {
        left[n] = read_analog_channel(4);
        right[n] = read_analog_channel(5);
        __delay32(3000); // 100us delay
    }
    _LATD0 = 1 - _LATD0;
    for( k = 0; k < N; ++k)
    {
        for( m = 0; m <= k; ++m)
        {
            z1[k] += left[m] * right[k-m];
            z2[k] += right[m] * left[k-m];
        }
        if( abs(z1[k] > z1max))
        {
            z1max = abs(z1[k]);
            shift1 = k;
        }
        if( abs(z2[k] > z2max))
        {
            z2max = abs(z2[k]);
            shift2 = k;
        }


    }


    if( z1max > z2max) //Left leading
    {
        intensity = z1max * scaling;
        if( shift1 > 7)// Left
        {
            // Buzz left
        }
        else
        {
            // Buzz middle
```

```
            }

        }
        else
        {
            intensity = z2max * scaling;
            if (shift2 > 7)
            {
                // Buzz right
            }
            else
            {
                // Buzz middle
            }



        }
        //delay_ms(100);
    }
    return 0;
}

// Delay by specified number of milliseconds
void delay_ms(unsigned int n)
{
    while(n--) __delay32(30000);
}


void configure_pins()
{
    // Configure digital I/O
    LATD = 0;
    TRISD = 0b11111110;

    // Configure analog inputs
    TRISB = 0x01FF;      // Port B all inputs
    ADPCFG = 0xFF00;     // Lowest 8 PORTB pins are analog inputs
    ADCON1 = 0;          // Manually clear SAMP to end sampling, start conversion
    ADCON2 = 0;          // Voltage reference from AVDD and AVSS
    ADCON3 = 0x0005;     // Manual Sample, ADCS=5 -&gt; Tad = 3*Tcy = 0.1us
    ADCON1bits.ADON = 1; // Turn ADC ON
}

// This function reads a single sample from the specified
// analog input. It should take less than 2.5us if the chip
// is running at about 30 MIPS.
unsigned int read_analog_channel(int channel)
{
    ADCHS = channel;          // Select the requested channel
    ADCON1bits.SAMP = 1;      // start sampling
```

```
    __delay32(30);            // 1us delay @ 30 MIPS
    ADCON1bits.SAMP = 0;      // start Converting
    while (!ADCON1bits.DONE); // Should take 12 * Tad = 1.2us
    return ADCBUF0;
}
```

D. The Phone Application

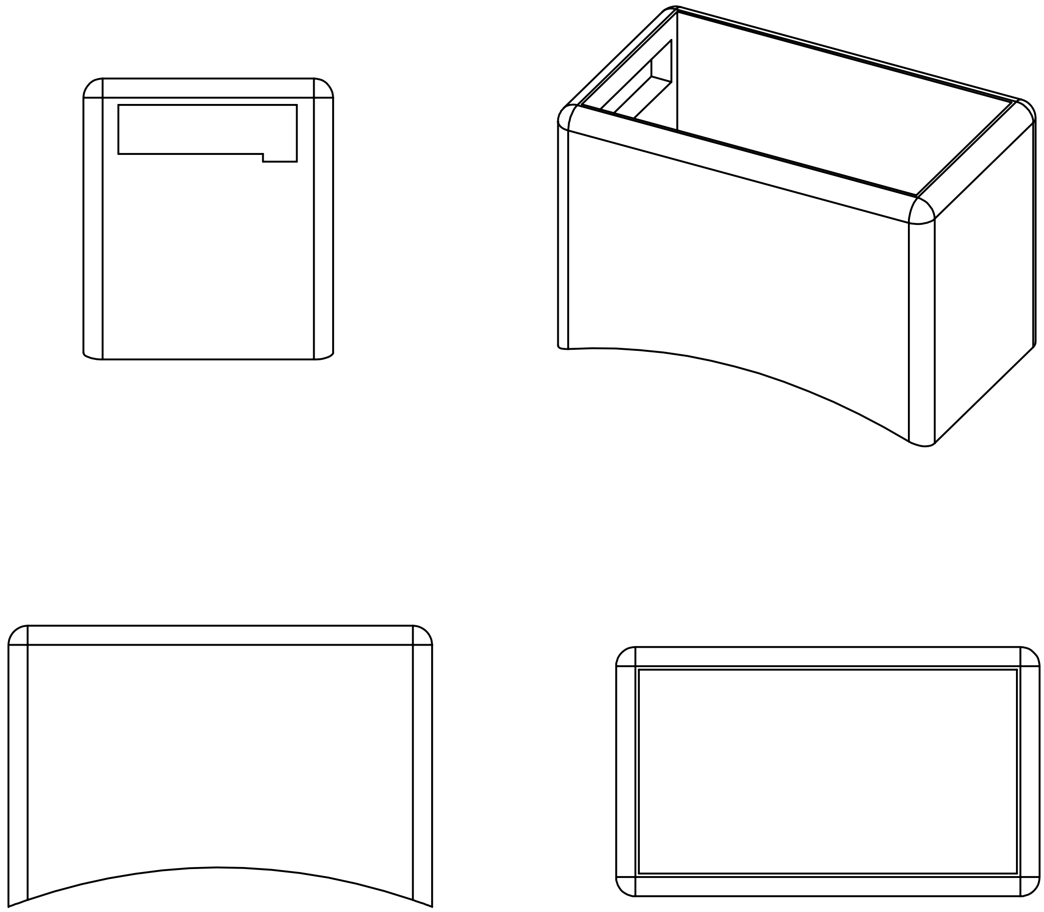
The phone application was written using Phonegap Desktop, which allows for quick deployment to both iPhones and Androids. It is written primarily in HTML 5, Java-Script, and Cascading Style Sheets (CSS) for the GUI and Java for the button and Bluetooth logic. Figure 15 shows the high-level block diagram of the Sonic Vibe, which gives a light overview of how the Phone Application interacts with the rest of the project. The phone application sends output through Bluetooth to the microcontroller. This output is a number that represents calibration settings for either the buzzer intensity, the microphone threshold, or both. When the microphones pick up sound that gets sent to and handled by the microcontroller, the microcontroller then sends data through Bluetooth to the Phone App. This data will include a time, the type of sound, and the direction from which the sound came from and it will be stored in the Logs section of the phone application.

Figure 16 shows a component diagram of the phone application. Again, the input from the microcontroller goes to the logs part of the phone application via Bluetooth and the User interacts with the phone application to retrieve the logs data. On the other hand, the user interacts with the phone application to view and change the settings, which are then sent over Bluetooth to the microcontroller.

Appendix C
Mechanical Drawing and Supporting Documents

2 1

B B



A A

		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±		NAME	DATE
			DRAWN		
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			ENG APPR.		
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		MATERIAL	Q.A.		
		FINISH	COMMENTS:		
NEXT ASSY	USED ON				
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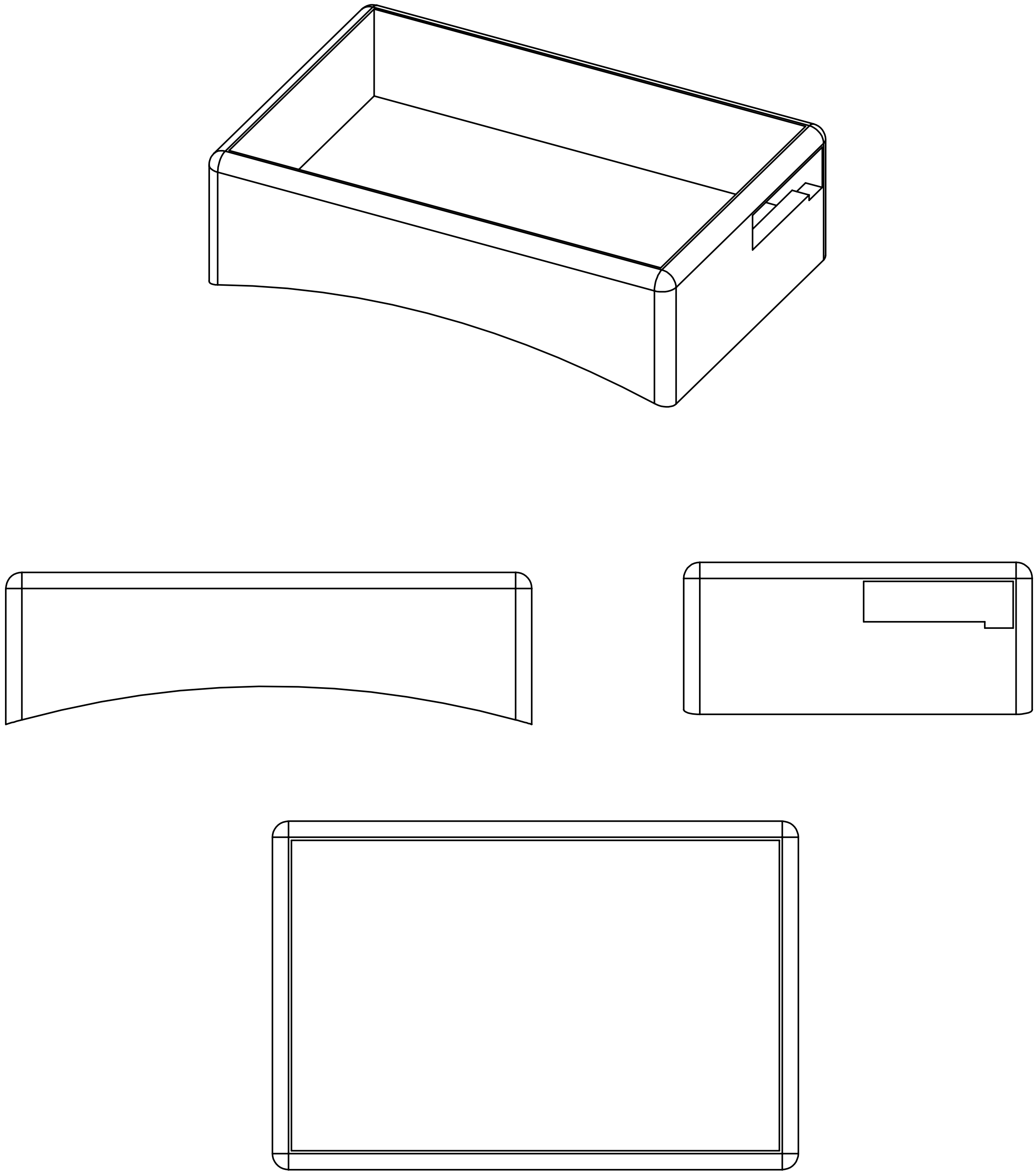
SIZE **A** DWG. NO. Case_4_24_2 REV.

SCALE:1:1 WEIGHT: SHEET 1 OF 1

2 1



PROPRIETARY AND CONFIDENTIAL

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DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

SIZE	DWG. NO.	REV.
A	Waistband	

SCALE:1:2 | WEIGHT: | SHEET 1 OF 1

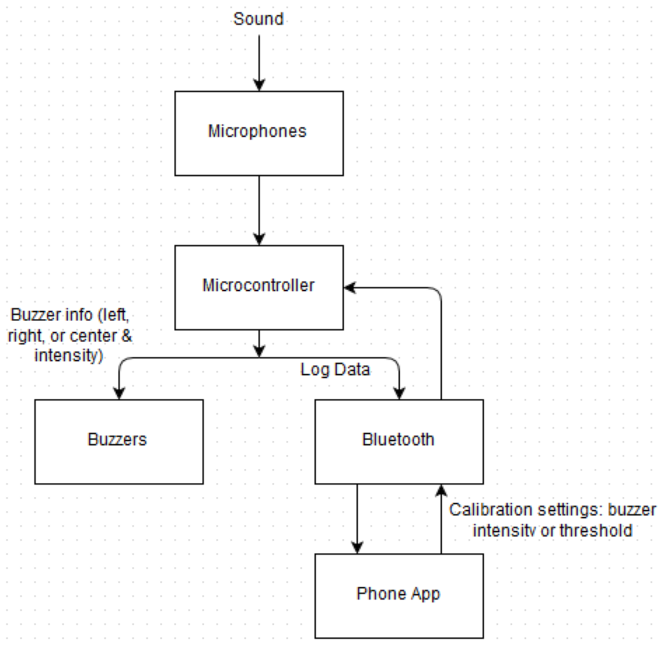

Fig. 15. High-level Block Diagram of the Sonic-Vibe

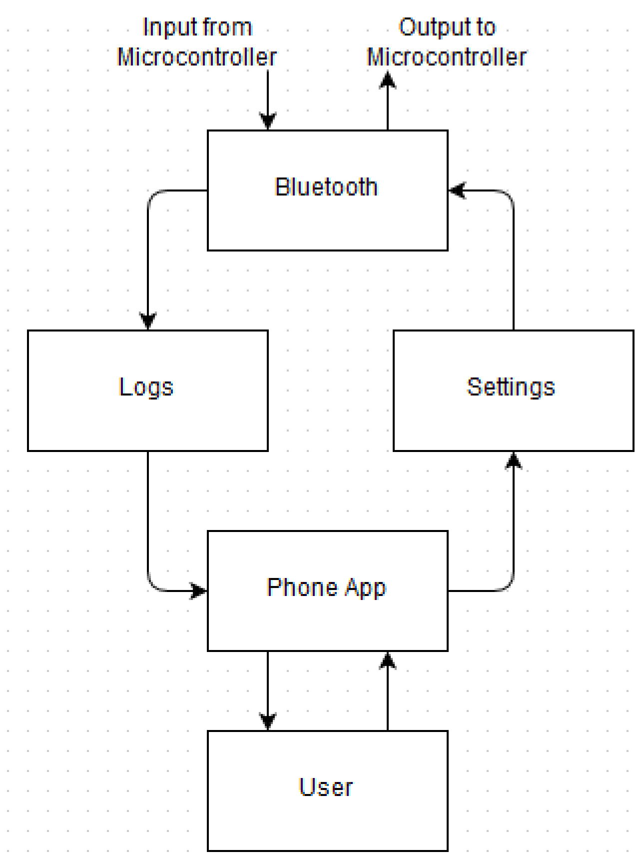

Fig. 16. Phone App Component Diagram

APPENDIX D
RESUMES

YAKIRA JOHNSON

yakiracherie@gmail.com

OBJECTIVE

To work with my Senior Design team to create an innovative product that improves the lives and aids in the safety of the deaf and hearing impaired

EDUCATION

Bachelor of Science, Computer Engineering — Expected May 2016

CSU Sacramento

- Related Coursework: Senior Design, Computer Interfacing, Advanced Logic Design, Network Analysis, Signals and Systems, System Programming (Unix/C), Computer Hardware Design, Embedded Systems, Computer Network and Internet, Computer Architecture, Data Structure and Algorithm Analysis (C++, Java), Operating System Principles (C), Operating System Pragmatics, CMOS and VLSI, Linear Algebra, Differential Equations

SKILLS & ABILITIES

Programming Languages

- C, Java, x86 Assembly, C++, Verilog, Apex, Javascript, HTML, some Python

Software/Equipment

- Salesforce, Eclipse, PuTTY, jGRASP, IDLE, Multisim, Xilinx ISE, Wireshark, MS Office, Open Office
- Experience with Arduino Uno, Parallax Propeller, Digilent Analog Discovery, Microchip PICKit3, Raspberry Pi, Spartan 3E, DMMs, oscilloscopes, function generators, etc.

Other Skills

- Excellent verbal and written communication skills
- Great problem solving and analytical skills
- Excellent at multitasking and works well under pressure
- Exceptional organization and prioritization skills
- Exceeds standards working independently or in a team environment
- Ability to learn new things quickly

EXPERIENCE

Software Developer — Dec 2015 to present

POS Portal

- Software developer for P2—POS Portal's CRM Salesforce Implementation and PAT—their Partner Assisted Transaction Salesforce Implementation
- Communicates with clients on a daily basis to provide support for P2 and carry out custom development projects
- Wide variety of knowledge in Salesforce including building reports, configuring permissions, and developing Apex triggers, classes, and Visualforce pages

Software Developer Intern — June 2015 to Dec 2015

POS Portal

- Communicates with clients on a daily basis to provide support for P2—POS Portal's CRM Salesforce implementation
- Responsibilities range from helping clients with simple administrative tasks to implementing custom development in their Salesforce organizations
- Wide variety of knowledge in Salesforce including building reports, configuring permissions, and developing Apex triggers, classes, and Visualforce pages

June 2014 to present

Tour Guide
North Bay Brewery Tours

- Uses excellent customer service and public speaking skills to lead groups of up to 20 on bus tours to and around several breweries
- Demonstrates responsibility by keeping the group under control while maintaining a safe, fun environment for the customers

Sourcing Assistant – Hard Goods June 2014 to Aug 2014
CamelBak

- Used excellent verbal and written communication skills to maintain a good relationship between CamelBak and their suppliers
- Collaborated with other departments to determine materials needed to build and qualify new products and sourced these materials in a timely manner so as not to delay project schedules
- Used excellent multi-tasking and prioritization skills to work on and monitor multiple projects in all stages to ensure project completion
- Completed various individual projects such as creating interactive tools for multiple departments using Excel

Server/Assistant Manager/Social Media Rep Dec 2007 to Aug 2012
Straw Hat Pizza

- Provided excellent customer service in-house and over the phone, served and bussed tables, washed dishes, and restocked
- Promoted Straw Hat Pizza specials and events with enthusiasm and maintained the restaurant's social media presence
- Took prospective hires through the interviewing process and trained new employees
- Supervised opening and closing shifts and wrote the weekly schedule

JASON VOSSOUGHI

ADDRESS: Contact for info

PHONE: Contact for info

EMAIL: JasonVossoughi@gmail.com

WEBPAGE: http://athena.ecs.csus.edu/~vossougj/

OBJECTIVE: To obtain a challenging internship position in electronics engineering for the fall & summer semester of 2015 that provides exposure to cutting edge technology and real-world applications.

EDUCATION: BS, Electrical & Electronic Engineering, Minor in Mathematics, California State University, Sacramento; Expected May 2016

RELATED COURSES:

-Micro Electronics w/ Lab	-Intro to Feedback Systems	-Intro to C Programming
-Advance Math Science & Engineering I & II*	-Intro to Logic Design w/ Lab	-Intro Circuit Analysis
-Applied Digital Signal Processing	-Differential Equations	-Physics Mechanical/Electromagnetics w/ Lab
-AC Circuit Analysis	-Electrical Machines	-Calculus I, II, & III
-Signals and Systems	-Applied Electromagnetics w/ Lab	-Intro to Microprocessors w/ Lab
-Intro to Machine vision*	-Probability+Random Signal*	** In progress as of Spring 2015*

KNOWLEDGE AND TECHNICAL SKILLS:

Computer Applications: C++, Python, Verilog, Assembly, Spin Code, HTML, MATLAB, PSpice, Advanced Design Systems, MS Visio; MS Word, Excel, PowerPoint; Multisim, Linux, Windows 98, XP, 7 & 8

Design: Microchip, Raspberry Pi, Parallax Propeller, Arduino

Tools: Oscilloscope, Digital Multimeter, Soldering, Drill Press, 3D Printer, Forklift

PROJECT EXPERIENCE: Additional details on http://athena.ecs.csus.edu/~vossougj/

Mobile Turret: With a team of four engineers, custom built an RC car, using a propeller micro-controller programmed in Spin language. The car was programmed to go forward and reverse and was powered by a DC motor. A servo motor controls the steering. The car includes a motion activated laser that rotates up, down and side to side. My role was to design the car and remote then wire up the hardware components.

Automated Temperature Controller: On a printed circuit board designed a proportional controller using an Arduino, three temperature sensors, and a fan. The Arduino found the hottest temperature which rotated the fan to our desired sensor. The fan speed would then rotate proportional to the temperature. I contributed to programming the code in C, and soldered the electronics onto the circuit board.

Digital Signal Processing: Working solo, I programmed different digital filters and plotted frequency spectrums to analyze data. Digitally created filters for instrumentation including electrocardiograms and artificial limbs.

WORK EXPERIENCE: *Working 16 hours per week, while carrying 14 units per semester and maintaining a 3.309 GPA*

Started as Merchandiser promoted to Sales Associate, **The Home Depot**
June 2010 - Present

Assist customers with finding the right tool for the job and handling special orders. Maintain a clean, safe work environment. Stock products, drive forklift, and assemble products. Responsible for training new employees.

Lube Bay Associate, **Helser Chevrolet**
January 2010 - June 2010

Worked with mechanics on auto repairs including alignments, changing fluids, transmissions, replacing head gaskets, tune ups, and electronics. Detailed cars inside and out. Maintained a clean, organized and safe shop floor.

ACTIVITIES AND ACCOMPLISHMENTS:

- Tau Beta Pi Engineering Honors Society – **Member**
- Institute of Electrical and Electronics Engineering, IEEE - **Member**
- 3D Printing Club, CSUS - **Member**
- ROP Automotive Services - **340 hours, Certificate**
- Associated Students, Inc. - CSUS - **Election Worker Volunteer**
- North Highland Gourmet Food Truck Jubilee - **Volunteer Worker**

Eric Carmi

Email: edc49@csus.edu

Education

CSU Sacramento:

Major: Electrical & Electronic Engineering (Graduating in Spring 2016)

Minors: Math and Physics

Summer 2013:

Participated in a research project, with Dr. Zeigler of the Sac State Mathematics department, where we studied topics related to signal processing: applications of the Fast Fourier Transform to audio signals, composing signals using Fourier's Theorem, simple amplitude modulation in the form of a ring modulator, and some analysis of implementing the audio effect known as a "phaser" by creating a chain of digital all-pass filters.

Individual Projects

EEE 122 (Biomedical Digital Signal Processing): Created an algorithm that can encrypt a person's unique speech pattern (rhythm and tone) as a password. The algorithm was successful in maintaining security even when another person was given the exact password.

EEE 184 (Introduction to Feedback Systems): Using a Raspberry Pi, I used a sound source to control the position of a motor. The Raspberry Pi was responsible for the signal processing and the motor control simultaneously. I was able to set the angular position of the motor by increasing or decreasing the frequency of the sound source.

Group Projects

EEE 193A (Senior Design Project): We made a wearable electronic device that detects the direction of a sound source and translates this information into tactile sensation on the waist. This can help people with hearing impairments be aware of certain environmental sounds that are important to detect quickly, such as an approaching car, train or ambulance.

EEE 178 (Machine Vision): Using a stereo camera rig, we were able to accurately measure distance to an object based on simple geometry. In addition to measuring distance to an object, we also approximated the area and volume occupied by an object.

EEE 174 (Introduction to Microprocessors): We designed a prototype for an underwater data gathering device with a Raspberry Pi and Arduino. The goal was to make it capable of measuring temperature, water flow, audio and video. The device was tested in the American River by waterproofing the electronics in a plastic container and it was successful in taking pictures and recording audio while in the river.

Current Employment

Sac State Math Lab Tutor - Employed for 3 years

Other Skills

-Python, C++, C

-CAD Design and 3D printing

Ou Saejao

Secret Clearance

osaejao@yahoo.com

OBJECTIVE: A challenging intern position in electronic and electrical engineering.

EDUCATION

In progress: **BS Electrical/Electronics Engineering** • CSU, Sacramento • GPA 3.3 • Spring 2016
Advanced Individual Training Electrical & Avionics Repair • US Army
Related Courses

Logic Design	Network Analysis	Computational Methods/MATLAB
Introduction to Microprocessors	Transmission Lines & Fields	Electromechanical Conversion
Control System	Digital Signal Processing	Robotics
AC Circuit Analysis	CMOS Design	Modern Communication
Machine Vision	Probabilty and Random Signal	

SKILLS

Software/Hardware
MATLAB • Verilog • PSPice • Multisim • Parallax Propeller • Advance Design System • Latex • MSOffice
Function Generator • Oscilloscope • Digital Multi-meter • Cisco VPN • State Machine • Cadence
Programming Languages
Java • MATLAB • C/C++ • Parallax Spin Code • Verilog HDL • MASM
Communication/Organization
Elementary Japanese language
Coaches Assistant/volunteer junior tennis
Experienced group/team leader, group/team member, individual worker

PROJECT EXPERIENCE

Mobile Laser Turret Controller
- Responsible for design, troubleshooting, and collaborating codes for the microcontroller which control the laser turret pitch and yaw movement.

Automated Proportional Temperature Controller
- Derived proportional equation relating to temperature, fan speed, and voltage applied to the fan.
- Designed and debugged C based language codes for reading temperature, creating a feedback loop, controlling fan speed, and the rotational position of the fan.

Differential Drive Robot
- Designed and wired circuits with microcontrollers connected to external power source and sensors.
- Programmed a differential drive robot to autonomously follow both a line and other robots.

Digital Signal Processing
- Design and implemented digital low pass, high pass, and band pass filter for digital signals.
- Written over 500 lines of codes used for analyzing biomedical signals from gathered data.

PROFESSIONAL EXPERIENCE

Information Technology Specialist ***CA National Guard*** 6/2012 – present
- Setup and maintenance of computer hardware and software – 1 weekend per month and 2 weeks per year.
- Troubleshoots automation equipment and systems.

Apache Helicopters Armament, Electrical, and Avionics Repair ***US Army*** 6/2009 – 6/2012
- Diagnosed and repaired malfunctions in the AH-64D electrical and avionic systems and components including solid state and subsystems according to safety procedures.
- Prepared and replenish over 1000 inventories in hostile environment and in garrison.

PROFESSIONAL ACTIVIES AND ACCOMPLISHMENTS

Member: Vice President of 3D Printing Club, Institute of Electrical and Electronic Engineering
Member: Tau Beta Pi, Delta Epsilon Pi
Dean's Honor List
Military Awards: Army Achievement Medal, Certificate of Achievement, Army Commendation Medal