Optimal Design Report
Integrated Virtual Reality and Head Movement Tracking System

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1. Optimal Design

1.1 Introduction

The client, Dr. John D. Enderle, has asked us to design a device that can create visual and auditory stimuli tests with head tracking capabilities. The client will be using our device during his design process to build a future device that can diagnose mild traumatic brain injury. Every year, nearly $17 billion is spent towards the 1.1 million Americans that suffer a concussion. The client has focused the last thirty years of his research on saccadic (rapid) eye movements and their neuronal activity. He believes that he can diagnose concussions based on a subject’s eye movements. In future stages of his design process, he will add a high speed or infrared camera to the device that will be able to track the subject’s pupil during eye movements for a diagnostic analysis. For now, our goal is to create a portable device for the client that will run the visual and auditory stimuli tests, as well as display the real time XYZ positions of the subject’s head.

The main component of our device is the virtual reality glasses that will display the visual stimuli tests. For our optimal design, we’ve decided to use the Wrap 1200VR video eyewear from Vuzix. We chose this product because it is very lightweight and portable, has excellent aesthetics, it has superior specifications for the virtual display screen, because it is extremely customizable so that anyone can use it, and because it comes with the Wrap Tracker 6TC. The Wrap Tracker 6TC is a built-in head movement tracker. The Wrap 1200VR is truly the leading technology in its class.

The Wrap 1200VR eyewear will be connected to a laptop through a VGA cable. The laptop will run a series of visual stimuli tests. The visual stimuli will be displayed on the virtual screen of the Wrap 1200VR glasses. The auditory stimuli tests will be initiated on the computer and will be use a programmed microcontroller. The microcontroller will control the speakers on the speaker board to run the appropriate tests. The Wrap Tracker 6TC will be used to track the head movements of the subject during both the auditory and visual stimuli tests. Figure 1 displays a flow chart of the sequence of events during both the auditory and visual stimuli tests.
1.2 Subunits

Our device can be broken down into several subunits that will be discussed below.

1.2.1 Virtual Reality Glasses

The product that we’ve chosen to use for our virtual reality display is the Wrap 1200VR glasses from Vuzix. Vuzix is one of the leading companies in the design of virtual reality eyewear and the Wrap 1200VR is their most recently released product. We chose this product over our alternative options because the Wrap 1200VR is superior in almost every manner. We need a product that meets all of our specifications and the Wrap 1200VR is the ideal choice for our device which will be explained in detail below.
When we were choosing a product to display our visual stimuli tests, our biggest concern was the portability/weight of the product; the Wrap 1200VR weighs less than 3 ounces. Our second big concern was the size of the display screens. The virtual display we want needed to be large enough that we could stimulate eye movements of up to twenty degrees in the horizontal direction and 15 degrees in the vertical direction. The Wrap 1200VR glasses create a 75 inch virtual screen as viewed from ten feet away (approximately three meters). The virtual screen has a 16:9 widescreen aspect ratio and a 35 degree diagonal field of view. Therefore, the Wrap 1200VR virtual screen gives a 17.5 degree vertical field of view and over a 30 degree horizontal field of view, which is ideal for our visual stimuli tests. The Wrap 1200VR contains twin high-resolution 852 x 480 LCD displays. The glasses can support input resolutions up to 1280 x 720. These differences in screen resolutions will play a part when it comes to defining the location of individual stimuli on the virtual screen versus the computer screen.

One of the major appealing factors of the Wrap 1200VR glasses is that they are very customizable. Basically, the glasses do not discriminate and anyone can use them. They have 24-bit true color (16 million colors) and on-screen display adjustment with adjustable brightness, hue, contrast, and color saturation. The glasses can support 2-D and 3-D formats, however, we will only be concerned with the 2-D format. The glasses can be worn over prescription eyeglasses and have individual right and left eye focal adjustments (diopters) of +2 to -5. The separation between the two screens can also be adjusted. Furthermore, the Wrap 1200VR glasses have an adjustable hypoallergenic nose-piece and Accuitilt® hinge angle adjustment for the optimal viewing angle.

The Wrap 1200VR glasses are compatible with several accessories. We will be using the Wrap™ Lightshield (shown below) to help completely immerse the subject into the tests by blocking out any undesired light. Other accessories that we may consider purchasing in the future are the Deluxe Carry Case and the Wrap Fashion Shades. These are not items that we need, but should we have leftover money in our budget towards the end of the Spring semester, they would help improve the packaging of our device. The glasses are also compatible with many mobile devices such as cellphones and ipods through optional cables. This is a nice option.
to have in terms of the portability of our device. In the future, it might be possible to run the stimuli tests via an ipod as opposed to a laptop.

![Figure 3: Wrap™ Lightshield](image)

The biggest asset of the Wrap 1200VR video eyewear to our project is its ability to track head movements. Originally, we had planned on using the Wii remote and sensor bar to collect the head movement data. However, the Wrap 1200VR comes with a built-in head tracking system called the Wrap Tracker 6TC. The Wrap Tracker 6TC will be discussed in detail in Section 1.2.2.

The box contents that are included along with the Wrap 1200VR glasses are a Wrap VGA adapter, the Wrap Tracker 6TC, detachable premium quality noise-isolating earphones, three sizes of noise isolation earphone inserts, the manual, warranty and safety instructions, and a soft carrying case. The total price of the Wrap 1200VR video eyewear and box contents is $599.99. The price of the Wrap™ Lightshield is $19.99. The cost of shipping both the video eyewear and the lightshield is $16.68, bringing the total cost to $636.66.

![Figure 4: Vuzix Product Box](image)
1.2.2 Head Tracker

As stated in section 1.2.1 the Wrap 1200VR glasses offer us head movement tracking abilities. The glasses come bundled with Vuzix’s Wrap Tracker 6TC, as seen in figure 5. The Wrap Tracker 6TC is Vuzix’s newest and most advanced head tracking technology available. It uses gyroscopic sensors and multiple magnetometers to calculate the movement and positioning of the head in real time. Gyroscopic sensors measure orientation based on conservation of angular momentum. Many different types of magnetometers exist; the ones used in the Wrap Tracker 6TC are vector magnetometers. The vector magnetometers work by utilizing the magnetic field of the earth in order to complete calculations. Since earth’s magnetic field at any point is a three-dimensional vector, has both a magnitude and directions, it is possible to calculate changes in earth’s magnetic field vector from a previous vector. Magnetic fields from other objects, such as large metallic objects and magnets, can affect the accuracy of magnetometers in the Wrap Tracker 6TC. This means that if the glasses are moved into a different environment they must be calibrated to the surrounding conditions accordingly.

Vuzix provides a free download of their VR Manager with the Wrap Tracker 6TC in order to simplify and speed up calibrations. This software kit provides calibration for yaw, pitch, and roll of the head, but not X-Y-Z axis movements. If it is determined that we need X-Y-Z head movement data, then software will need to be created in C, LabView, or a specific language that we determine based on ease of integration into our system that accurately gets this data from the device. In addition to calibrating the magnetometers for different environments, the gyroscopic sensors must be zeroed before each use to ensure accuracy. This can be done by implementing automatic zeroing when the device is first turned on. Different environmental calibrations may also be saved and implemented in an auto calibration setting to speed up boot up time. These calibration improvements can be saved as a script we create that runs automatically whenever the device software is opened.
The gyroscopic sensors and magnetometers allow the Wrap Tracker 6TC to provide six degrees of freedom in head movement tracking. That is, the head can move in six distinct ways, which include yaw, pitch, roll, and X-Y-Z axis movements. Figure 6 shows a visual representation of the six degrees of freedom of the head. Yaw, orange in Figure 6, refers to the ability to rotate your head to the left and to the right around a vertical axis. Roll, green in Figure 6, refers to the ability to tilt your head laterally to the left and right. Pitch, light blue in Figure 6, is the movement of tilting you head forward and backwards. X-Y-Z movements determine what position your head is in three dimensional space. Being able to acquire data from these head movements will be crucially effect our ability to make eye movement corrections. As the head moves in the direction of stimuli, the degree to which the eyes have to move to see the stimuli is greatly decreased. Since eye movement data is the major concern of our client, we would like to make be able to make corrections based directly on the degree to which the head moves toward the stimuli.

![Figure 6: Six Degrees of Freedom](image)

The head tracking data created by the Wrap Tracker 6TC will need to be transformed into comprehensible information. This will be accomplished by contacting Vuzix and acquiring the source code that runs the Wrap Tracker 6TC. Acquiring this code from Vuzix will save us the hassle of going through the hardware and hard coding everything from the ground up. Using this code it will be possible to transform the data into a form that suits our needs. This code then will also allow us to take the transformed data and integrate it into a LabView program created by us for analysis. For the purpose of testing, displays of real time head locations will be incorporated into the LabView. This will allow us to see and anomalies and fix the coding that is causing the problem. The coding for correcting eye movements based on the head movement data will be written using the data from the Wrap Tracker 6TC. This will be left as a method, so that future projects will be able to pass eye movement data to it and see the corrected information.
1.2.3 Visual Stimuli

The main objective for our device is to make it capable of running visual and auditory stimuli tests. The tests for the visual stimuli will be very similar to those run for the auditory stimuli tests. The visual tests will be composed of three different categories of tests, and they will all be run on a laptop and displayed on the virtual reality screens of the Wrap 1200VR glasses. A cable will be used to connect the laptop to the virtual reality glasses. The virtual reality glasses can support an input display resolution up to 1280 x 720. The client would like the stimuli separations to be based on degrees, relative to the user, with zero degrees being the very center of the virtual reality glasses. Since the stimuli are actually being created on a computer and displayed on the glasses, a distance per pixel ratio will be used to determine the exact pixel location of each stimuli on the screens. Using Windows Paint, it is possible to define individual pixels, making it possible to place our stimuli exactly where they are needed.

The first category of visual stimuli tests is called goal-oriented saccades. During these tests, the subject will have to track the stimuli with his/her eyes. The stimuli will move instantaneously from one position to the next, and may move in the horizontal or vertical direction, or any combination of the two (360°). A second type of goal oriented tests will be smooth pursuit eye movements. During these tests the stimuli will transition in a gradual manner from one position to the next. The subject will have to track the stimulus as it moves across the screen. Once again, the stimuli may move in any direction.

The second category of tests will be designed for anti-saccades. To begin these tests a stimulus will be displayed in the center of the screen (zero degrees). The stimulus will then move instantaneously in either a horizontal or vertical direction. The subject will be required to move his/her eyes in the direction opposite of the direction of the stimulus change. In other words, if the stimulus begins at zero degrees and moves to the right ten degrees, then the subject will have to aim his/her eyes left ten degrees.

The final category of tests will be memory based tests. Many current concussion tests use memory response techniques to diagnose brain trauma. During these tests the subject will be shown a sequence of eye movements, and will then have to repeat the sequence from memory while looking at a blank screen.

1.2.4 Speakers

The stimuli for the auditory test will be provided by an array of 30 high quality small circular speakers. Each speaker has a 32 ohm impedance and positive and negative metal leads to attach speaker wires to. Each speaker will be connected to its own digital input/output on the Arduino Mega 2560 microcontroller, seen in Figure 7. This microcontroller is open-source, has 256 kilobytes onboard flash memory, and has 54 digital inputs/outputs. It also connects directly to the computer to draw its power through a universal bus drive, which also functions to transfer data. The 54 digital inputs/outputs allows for expansion of number of speakers if the client decides that would improve data results from the tests. It also allows for independent operation
of each speaker in order to have more varying test capabilities. The ability to control each speaker separately will allow for the possibility to do a crescendo stimuli from speaker to speaker.

![Arduino Mega 2560](image)

**Figure 7: Arduino Mega 2560**

The arrangement of the speaker matrix will be dependent on the client’s specifications. Depending on the amount of degree variation that is required for the auditory stimuli, the speaker placement and number of speakers may change to satisfy their needs. A rather simple matrix configuration with 30 speakers is shown in Figure 8.

![Possible Speaker Matrix Design](image)

**Figure 8: Possible Speaker Matrix Design**

Calculating the width and height of the speaker matrix based on a set 30 degree visual range to all sides of the center requires the use of trigonometric equations. The two variables “L”, in Figure 8 above, represent half the total width that the speaker matrix needs to be at a fixed distance. The diagram of the speaker matrix calculation based on fixed subject distance...
from matrix, “D”, is shown in Figure 8. Given a constant D distance from the matrix, and a set angle of 30 degrees you can use the tangent equation to find the length L. Once you find L, multiply it by two in order to get the width of the matrix. Since the client wants a 30 degree range to all sides of the center, the height is also 2*L because the distance and set angle do not change. The equation is as follows:

\[
\tan(\theta) = \frac{L}{D}
\]

\[
\tan(30) \times D = L
\]

\[
0.57735 \times D = L
\]

\[
2 \times (0.57735 \times D) = 2 \times L
\]

**Figure 9: Speaker Board Size Calculation Based on Subject Distance from Speaker Board**

The overall size of the matrix will affect the configuration of the speakers, so an optimal configuration will need to be decided on. After this, a set distance will be established based on the configuration size needs of the matrix. Once the speaker matrix size and configuration are determined the auditory stimuli tests will need to be created.

### 1.2.5 Auditory Stimuli

The auditory stimuli tests will be the same as the visual stimuli tests. There will be the three categories of tests: 1. Goal-oriented saccades, 2. Anti-saccades, and 3. Memory-based saccades.
However, whereas the visual tests will run the stimuli from a computer and display them on the virtual screen of the glasses, the auditory stimuli tests will be run with the use of a microcontroller. The microcontroller will be programmed to run each of the tests by producing sounds on the speaker board described above.

Once all speakers are configured and connected to the microcontroller a test will need to be done to ensure all connections are good. A test code will be run that outputs a tone for a set amount of time at each speaker in the matrix starting from the top left corner sequentially. If any of the speakers do not produce a tone, or the wrong speaker produces a tone, the connections must be checked and repaired. The programming of the microcontroller will most likely be done in the language of C. Each auditory test will need its own source code file that programs the microcontroller to output to the necessary speaker for that specific test.

1.2.7 Cables

The cables that will be used in this project will serve as the wiring from each part so the entire unit works together as a whole. The glasses need to be wired to the speaker system and the entire device will need have wiring capabilities to a laptop or personal computer. The majority of the wiring will be between the glasses-head movement system and the mini speakers that will be used to project sound in a cascading fashion in front of the user. In order to produce the best and most accurate sound, speaker wire will be used to connect the speakers to the amplifier. Speaker wire contains two or more electrical conductors insulated by plastic such as PVC or Teflon. Like any wire speaker wire has three components that determine its performance, namely: resistance, capacitance and inductance. A theoretically perfect wire has none of these, but the most important factor to keep low is the resistance. The smaller wire gauge has less resistance, but a larger skin effect on the conductor of the wire. Due to the small scale of this project the wire gauge will be very small and ideally the resistance will be kept to a minimum. The speaker wire will also be used to connect the speakers to the amplifier. The other wiring will involve connecting the entire system to a computer in order to transfer the data and run the tests on the device. This will involve standard wiring and USB ports to connect the two.

1.2.8 Software

The software component of the device will be the most important part of running the test because it will actually contain the tests that will be run on the device in order to determine if the user has any sort of brain injury. The software will be programmed using C programming language and the data will be collected and transferred to LabView for analysis. The software will follow a few basic steps in order to output the desired result. The program will follow the following basic outline:

1. Turn on the screen and speakers for the tests to run
2. Display the instructions to the user
3. Open and run the tests for the user to see and hear
4. While running the tests the program will collect the data from the user’s input
5. The data will be transferred to the LabView program for analysis

The most important part of the program is running the tests accurately and efficiently in order to create a positive experience for the user. For the visual test the stimulus will be shown on the screen and the user must track the light with their eyes. Additionally for the audio test the speakers will be wired together, as explained above in the speakers and wiring section of the components, and on a board in front of the user. The program will need to randomly select a speaker to project a sound from and the user will need to follow that sound with their eyes.

Both of these tests will incorporate the head movement tracker because as the user moves their eyes naturally their head will slightly move as well, this movement is unintentional. In order to have accurate results this slight head movement will need to be accounted for in the data analysis and the data needs to be collected and transferred to the LabView program with both tests. Furthermore, the microcontroller will need to be programmed in most likely C or C basic in order for the speakers to work in the device. This will be done prior to the LabVIEW programming and with a much more basic programming language.

1.2.9 LabVIEW Output

The LabVIEW component of the programming portion of the project is the most important aspect in the analysis of the data collected during the tests. The data will be collected and inputted into the LabVIEW program where the data will be analyzed and placed in to an easy to read format using graphs and charts as a tool. The data from the eye test must be adjusted using the head movement data collected during the eye test and then analyzed to see how well the user tracked the stimulus during the test. This same procedure will be done to the audio stimulus test. The graphical user interface will display the data in an easy to read and easy to use format for the user. The format should be simple because this test will most likely be run in high pressure situations where time is an important factor, so having a system that is simple is important to the optimal design.

2. Realistic Constraints

This project will follow all proper engineering protocol and standards. Ideally the design will be sound and provide the user with the product that they desire. Furthermore, the design practices will be unique to the team and incorporate collective thinking and innovation. The optimal design will have a few realistic constraints that must be considered in the design. These constraints fall under several broad categories outlined and described in detail below.

2.1 Health and Safety

Since the design of this project requires the patient to place a headgear on to them which includes the glasses and attached speaker board on to them, while they are possibly suffering
head trauma, it will be important for the design to ensure that the patient’s health and safety is not compromised any further when using the device. To ensure this the design will be as lightweight as possible since the patient may be experiencing headaches from the injury. Since the design incorporates the Vuzix glasses the weight of those cannot be adjusted, however, those have been designed for optimal use and are only 3 ounces in weight. However, the weight of the speaker board will add to the overall weight of the headgear. The speakers will be very small, approximately 3 cm in diameter and, therefore, are very lightweight as well. Overall the entire system that rests on the user’s head will weigh no more than 8 ounces.

Furthermore, the eye test that is run with flashing lights on the screen will be mindful of the fact that bright lights and intense head movements may cause discomfort to the patient. The lights may induce seizures therefore, it will be necessary to limit the use of the device to people who do not suffer from any seizure disorders. The lights will also be set to an optimal brightness that will not overwhelm the user at any point. Also, the tests will likely require the patient to be seated for the duration of the exam. This will allow the tests to be more accurate as well as be safer for the patient as they may be light headed or dizzy after the injury. The device does incorporate an audio test and so, the user will need to be in a semi quiet area in order to hear the audio stimulus. The quiet area will allow the audio stimulus to be at an optimal listening level versus too loud because the user is in a location with a lot of background noise. This situation may occur if the user is an athlete playing in a stadium with a lot of screaming fans, in this situation it would be best for the accuracy of the tests and the safety of the user to be seated in a comfortable and quiet location. Since the patients that will be utilizing this device will have suffered possible traumatic brain injury it is our greatest concern to ensure their health and safety.

2.2 Manufacturability

The manufacturing constraints to this project will come from the time constraints it will take to manufacture one product. The device will be small and require intricate wiring which will limit mass production and possibly cause a delay in manufacturing. Specifically, the wiring will be very detailed when connecting all of the speakers to the microcontroller in the speaker board. This wiring may take a few attempts to get perfect and to run efficiently. Furthermore, the device will need to be adjustable since the patients will have different sized heads which will cause a limitation on how the device is manufactured. Currently in the design the glasses allow for adjustment, but the speaker board may also need to be slightly adjustable due to users’ different range of motion. Also, the glasses, which will incorporate the head tracker, will need to be tight without causing any further discomfort.

2.3 Ethical

In the production and design of this product very ethical procedures will be followed. These procedures will follow proper engineering standards. No testing will be done on anyone or anything that is not pre-approved and all ideas and research will be done honestly.
2.4 Environmental

The device will need to be weatherproof to an extent which may cause environmental constraints in the design of the project. One concern for the weather is sunlight; since the tests do appear on a screen with flashing lights the surrounding area must be relatively dark in order for the user to comfortably see the screen and the lights. So, the design does incorporate a visor that will help block out the sun and allow the user to easily see the screen without needing to squint or strain their eyes in any way. Furthermore, the design needs to be rain proof. This may not be possible and will likely be able to withstand a slight drizzle, however, in heavy rain the device will need to be used inside which is a constraint of the project. There will be no negative effects to the environment due to the project since the machine will likely be run on batteries and will not be mass produced; therefore, limiting environmental concerns during production.

2.5 Sustainability

Corrosion could become a problem with certain parts of the project if it is used outside in high humidity or in the rain. The corroded parts will have to be disposed of in accordance with town, state, and federal law. Furthermore, the test may need to be updated in the future as more research is done on the eye movement system.

2.6 Social/Political

Although this technology would be beneficial to the health of athletes, it may not be welcomed by them. Athletes rarely think about their own safety before they think about going back to their respective sport. If this device prolongs their absence from the sport, although it would be in their best interest, athletes would dread the use of it after suspected traumatic brain injury. This social constraint must be taken into consideration and it may be beneficial to offer education on the long term effects of such a traumatic brain injury before introducing the product.

3. Safety Issues

Safety is always the number one priority when designing a new device. In order to protect the user and the device from physical harm a number of precautions will be taken. While wearing the glasses the user will be unable to see their surroundings. Also, since the user is expected to have suffered traumatic brain injury, they will most likely have symptoms such as dizziness and other symptoms common to brain injuries. Due to these facts the user must be seated when undergoing both the visual and auditory stimuli tests in order to prevent them from causing any bodily harm to themselves or the device by falling for example. While head movement is not the main objective of this device, some users may move their head in conjunction with their eyes to follow the stimuli. If it is deemed that this unrestricted movement of six degrees of freedom is in any way potentially harmful to the user, restrictions in head movements might need to be implemented. A lightweight shoulder mounted restriction cubed, whose final design will be discussed if unrestricted movement becomes an issue, may be implemented to restrict head movements to a certain degree. Quick jerking movements of the
head/neck can sometimes result in slipped disks in the cervical vertebrae, and injuries like this want to be prevented at all costs.

In order to protect the user from any electrical shock and the device from and short circuiting, all electrical exposed wire ends will be covered by heat shrink wrap. This will prevent moisture and water from getting into the exposed wire ends and also block any current and voltage from coming in contact with the user. The Arduino microcontroller that runs the speaker matrix will be housed in what is called a shield. This is basically a good plastic housing that closes off all of the microcontroller’s electrical components from the outside world, while still allowing space for USB connection and digital input/output wires. In addition to preventing moisture from entering the microcontroller the shield also broadens the temperature at which the microcontroller will function. The shield acts as a heat insulator keeping more of the heat produced by the board inside the container. This is important to our client because one of the applications for this device will be the military. The temperature range that the military operates in has changed depending on their location; from the frigid climate of Siberia to the unrelentless heat of the Middle East. The product having a wide operating temperature range will be beneficial. This housing will protect the important intricate circuitry that runs all of the speakers.

Environmental impact of this device was kept to a minimum. All components are capable of running off of the computer/laptop which they are connected to. This includes the microcontroller that runs the speaker matrix as well as the monitors that display the visual stimuli. In military applications where portability is a major concern, running the laptop off and components off of the 12-Volt adapter from a specific vehicle will suffice in providing power to the system. No batteries will be needed, which will reduce the environmental footprint that this device has.

4. Impact of Engineering Solutions

Our device has the potential to make an indirect impact in the world of medicine. Our client, Dr. Enderle is hopefully going to use our design to build a portable device that can diagnose mild traumatic brain injury. He has spent the last thirty years researching saccadic eye movements and is now at a point where he can use the findings from his research to not only diagnose mild traumatic brain injury, but also detect where in the brain the concussion has occurred. He is very early in the design phase, so our integrated virtual reality and head movement tracking system is the very first physical device in his design process. In his future devices, he will most likely incorporate a high-speed camera that will allow him to track the movements of a subject’s pupil during eye movements. Our device will run tests using visual and auditory stimuli that will stimulate the subject’s eye movements. Our device will also track the user’s head movements. Once the client begins recording the actual eye movements, the head movements will be used to compare with the eye movements in hopes of achieving more accurate data.
The client is capable of modeling saccadic eye movements and their neuronal activity better than anyone else in his field. He has the opportunity to become the first researcher to make the quantitative link between rapid eye movements and diagnosing mild traumatic brain injury. Should he be successful, a portable device that can quantitatively diagnose concussions would have a virtually unlimited impact in the world of medicine, the military, and the world of sports.

Mild traumatic brain injuries cost the nation an estimated $17 billion every year. Every year, approximately 1.1 million Americans suffer a concussion. Most people who are diagnosed properly will fully recover, however, people who are not diagnosed or are wrongfully diagnosed are likely to suffer long-term symptoms. These symptoms can include persistent headache, confusion, pain, cognitive and/or memory problems, fatigue, change in sleep patterns, mood changes, and sensory problems such as hearing or vision. If a person who has suffered a concussion experiences another heavy impact to the head, that person is at a severe risk to suffer life-long post-concussion symptoms or even death. Therefore, it is extremely important to properly diagnose mild traumatic brain injury when it happens so that the patient may take the correct precautions and rest in order to fully recover.

There are several portable concussion tests on the available today, however, all of these tests are cognitive and/or memory based tests. There is a huge market for portable concussion tests in professional sports, emergency rooms, and in the military. When it comes to the world of sports, almost all athletes will give false responses or try to cheat concussion tests so that they do not have to sit out of any competition. This is why the client’s device would make such a large impact in terms of diagnosing concussions. The fact that the subject is being judged on his/her eye movements eliminates the problem of the subject cheating. Using a baseline prediction for what the subject’s eye movement responses should be, and then quantitatively comparing them to their responses during the actual test, it will be possible to factually conclude a diagnosis. Furthermore, the ability to run three different types of tests using both auditory and visual stimuli gives the client the ability to detect where the concussion occurred in the brain. It’s not hard to imagine that the client’s device could one day become the standard for diagnosing mild traumatic brain injury.

5. Life-Long Learning

While going through the process of designing our device we have learned valuable knowledge that will help in all aspects of life, most of which do not have any impact on engineering. Most of this knowledge was not taught but learned from research, trouble shooting and building the device as a team. As a group there are many different perspectives to be seen on how each person see’s the device being built and functioning. Being able to take all of these perspectives and utilize the best concepts and innovations is key aspect in designing the best possible overall product. This is much like working with different engineering disciplines in industry. As a biomaterials major you may not know as much as a computer science engineer, but you must be able to use their knowledge and ideas and apply your background to further improve a product. The more idea bouncing off one another there is, the higher chance there is that a viable idea of product design will be discovered.
Understanding client specifications was very important to the overall understanding of how the final product was supposed to function. Choosing specific components and off the shelf devices that met those requirements was one of the main challenges of designing our device. Client communication is a key aspect in understanding their specifications. Just because members of a team believe certain devices meet client specifications, the client may not see the device being created using that underlying technology. This is why constant communication with the client is absolutely necessary. A functional final product may not be “functional” in the client’s eyes and that’s why research of all technology options must be explored and then the ideas that stem from that research be run by the client.

Hours of research was done in order to determine what technology was available to us to be able to track head movement, display visual stimuli on small personal monitors, and create auditory stimuli. The knowledge gained through research was about how similar products on the market use technology to do the things that we need to do, such as head tracking. Devices at the heart of some products such as gyroscopic sensors, magnetometers, infrared technology, and microcontrollers, needed to be studied to understand the pros and cons in order to decide on an optimal technology for our device. This knowledge allows team members to apply those techniques in order to solve our overall design problem. Integrating all of the decided upon technology will require a lot of coding, and this coding will provide new knowledge as to how each component of the device works together in order to perform the overall task.

With all of the engineering reports that have been due so far in senior design, writing skills of all team members have improved. In industry all advances in technology and research are documented, and this helps get the team members ready for that. Writing documents that follow the form of IEEE publications provide useful practice, since this is the form of publication that is a standard in industry. Public speaking skills will also be improved through in class presentations and the weekly presentations of design progress with all project advisors. Public speaking is crucial in industry because most companies have weekly meetings to highlight any important findings of the last week and to outline how to move forward.

6. References


<http://www.traumaticbraininjury.com/content/symptoms/mildtbisymptoms.html>.


