Project ID: 6759003

Abstract

Our device, EyeEcho, is a wireless navigation device that utilizes the concept of echolocation to assist those who are visually impaired. The navigation device is a wristband that contains a telemetry sensor to discern sound waves that have been reflected off of nearby surfaces, and would then calculate the relative distance of obstacles from the user. Then, data collected by EyeEcho would be sent to a chip, which is inserted into the Primary Visual Cortex of the brain, via Bluetooth®. The Silicon-Oxide insulated chip would monitor the flow of the brain and then release electrical impulses using its Brain-Chip Interface (BCHI). This would help the user visualize their surroundings in order to avoid any obstacles. By using EyeEcho, we hope to ensure a safe and effective assistive device that is easy to use.

<u>EyeEcho: Utilizing Echolocation to Help the Blind</u>

Present Technology

According to the National Institute of Health, those who are affected by blindness or visual impairments make up roughly 7% of the world's population. For this reason, a new form of technology has risen. It is called assistive technology and is specifically made to help those who struggle with disabilities. People have always used guide dogs or canes to help walk around, but a new era in technology has provided us with improved devices. New devices today use sensors and Artificial Intelligence (AI) to help the blind and visually impaired to navigate their way around as well as perform daily tasks with much more ease.

We talked to neuroscientists, Dr. Teng and Dr. Sohl-Dickstein, about our project and they provided us with very helpful insight about present technology in this field. One device they discussed was the Sunu band. The Sunu band uses sensors to detect nearby obstacles and also uses vibrations to warn the user about these obstacles.

Another device is WeWALK, a smart walking cane that can warn about obstacles and help guide people around. It also has an app that connects to it, via smartphone, and it can be accessed by speech. The cane itself uses ultrasonic sensors to detect any obstacles that may be around. It also uses a vibrating handle to let the user know if there is an object in the way. The app, which connects to the cane wirelessly, uses voice/speech recognition in order to sense if anyone is speaking and translate what they are saying.

Lastly, Guidesense is a device, which is worn like a heart-rate monitor, that uses audio to warn users about upcoming obstacles. The device itself uses millimeter wave radar sensors in order to detect objects ahead. It is also necessary to have a speaker in order to relay the information to the user.

A problem with today's technology is that it is either too expensive to manufacture, doesn't work as advertised, or poses too big of an inconvenience to make it practical for everyday use. While the devices listed above, plus many more, can help the blind and visually impaired navigate their way around, they can do much more, and at a lower cost. Our main goal is to create a device that is efficient, yet affordable. This is something that we will really focus on in our project, as it can help many people worldwide.

History

Blindness has been an issue for a long time. In the early 1800's, Louis Braille invented Braille, which is a series of raised, textured symbols, giving blind people the ability to read. This language is still used today as a form of communication for the blind. As described earlier, for the past few decades, the blind have been using walking sticks to navigate and scientists have attempted to create devices that assist those who are blind or visually impaired to navigate through their surroundings.

A scientist named Leslie Kim created the SonicGuide glasses during the 1990's. This device was designed to provide a sonic image of the environment. It used three high resolution, ultrasonic spatial sensors on a head mounted device. The three sensors covered a 50° forward field of view, and the auditory "image" was heard through stereo headphones. The SonicGuide glasses used echolocation; The auditory information (The Echo) provided by the three sensors was meant to model the visual information that would be available from the central and peripheral visual field of view. The frequency of the tones provided information about distance, the delivery of the sounds in the binaural headphones provided information about the direction, and the timbre from the multiple reflections provided information about the object's unique surface properties.

In 2009, scientists created the Argus Bionic Eyes for Retinitis Pigmentosa (RP), an inherited disease that causes blindness. It is a device that is implanted in the brain. However, this can only be used if the person's optic nerve is still functioning. There is a pair of glasses with a camera that is worn. It captures images and transmits data to an external, body-worn processing unit. Then, that data is processed and sent to the implanted system, via an external wire. After that, the implanted receiver passes signals onto the retinal implant. Next, the electrode array that is implanted will stimulate the retina. The optic nerve then transmits these impulses through to the primary visual cortex. The impulses are then interpreted as an image in the primary visual cortex.

In May of 2015, The Birmingham City University team created a smart walking cane called XploR. The XploR cane detects faces up to 10 meters away. It has a bank of images stored in an SD Memory Card, and when it recognizes a face, it will vibrate through headphones. The device will guide the person toward the recognized people through Bluetooth®.

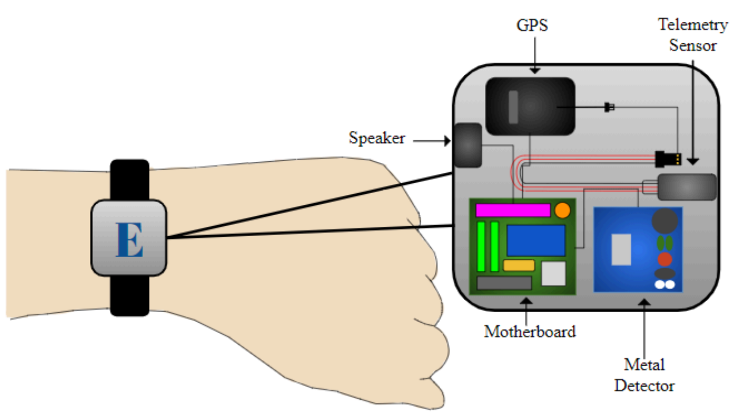
We looked through Dr. Sohl-Dickstein's and Dr. Teng's research paper, and they had created a similar device that also assists the blind. Their device uses a forehead-mounted speaker to emit ultrasonic "chirps" (FM sweeps) modeled after bat echolocation calls. They provided us with a lot of helpful information. Dr. Teng informed us about several examples of past technology; Microsoft Soundscape, Microsoft Seeing AI, and Brainport.

On June 18, 2015, the FDA approved a device called the BrainPort V100 oral electronic vision aid. This device uses electro-tactile stimulations to make the User feel moving bubble-like patterns on their tongue. They soon learn to interpret these patterns into the shape, size, location and motion of objects in their environment. The Brainport technologies website states that many users describe it as seeing with your tongue.

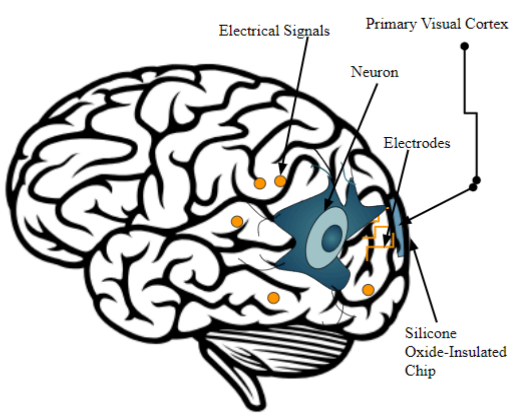
All of these products have benefits and consequences. However, we envision an invention that has higher benefits than these examples. Our goal is to make EyeEcho of higher quality than the devices mentioned above.

Future Technology

In the next 10 years, we will have many technological advancements in the world. Currently, most technologies, such as walking sticks and headsets, alert the blind about any obstacles in their path, but do not describe the motion of the obstacle. Our technology, EyeEcho, would be able to sense and help the blind person visualize the size, distance, and movement of the object using an ultrasonic sensor called telemetry. Additionally, our technology would incorporate a GPS to track the location and movement of the person, and the speaker would give directions to the person. The speaker would also be used to produce the high-pitched sound which would be at the frequency higher than 65,000 Hz. Our technology also includes a metal detector to detect any harmful substances in the user's surroundings. We envision this technology to be in the form of a wristband, that would be strapped around one's wrist.



This technology would be based on many principles that would help detect the blind person's surroundings. The key principle of this device is to recognize the environment the device is in using echolocation. Echolocation is a technique where the emitter releases sound at a designated frequency, and then the sound waves will bounce off of the surroundings and return to the emitter. Then, the time it took for the sound waves to return back would be recorded, which would be used to find the relative distance of the object. This information would be sent to the Silicon- Oxide insulated chip located in the Primary Visual Cortex via Bluetooth®. This chip would use Brain Chip-Interface (BCHI) to communicate the data the chip has collected to the cells of the brain. The Electrolyte-Oxide Field Effect Transistors (EOSFETs) of the chip would track the movement of the ionic currents in the Primary Visual Cortex of the brain to mimic the brain and release necessary information. Other key things that this device may contain would be a GPS tracker. For instance, the GPS tracker would map and guide a person through large spaces using the device's location. If the floorplan of a house is inserted into the device's system, the device could indicate what obstacles may be in front of them. The third principle this device would use may be a frequency detector, such as a telemetry. This device could use telemetry to track and locate sound waves, and recognize the direction these sound waves are coming from, therefore this principle may be used in the future technology to determine the distance of the objects from the person. The last scientific principle that would be used is the effect of the magnetic field, such as a metal detector. With the principle of the magnetic field, a blind person will be notified if there are any dangerous metals or weapons in the area. Also, this principle could help the person navigate because the magnetic field lets us know which direction is North and South. When all of these principles are combined, the future technology, which we envision to be in the form of a wristband, would help the blind person navigate safely.



Breakthroughs

Our design would require a few components in order to function to the best of its ability. Our proposed product is a wristband which can help the blind determine where objects are located. We envision this product to mimic the way bats use echolocation as a navigation technique. We were informed by our meeting with professionals in the field that an ultrasonic sensor could be utilized to produce a sound wave with a frequency beyond what the human ear can not hear. We would also require a sensor which could discern when the sound wave returns back to the wristband. For example, a sound would be produced, and then reflect off of an obstacle, which would then return to the wristband where the sensor will determine how far away the obstacle is. In addition to this, we would also need another sensor to recognize specific objects and a speaker to produce the high pitched sound waves, as well as give directions from the GPS.

The scientists we contacted also informed us that objects will absorb a bit of the sound, and reflect the rest of the sound with the same frequency. The sound reflected will move in multiple directions, which will help determine the physical properties of an object.

One primary reason as to why this technology doesn't exist today is due to the cost. To make an advanced device like this, a large amount of money would be required to manufacture it. While it makes sense why this would be expensive, it can not be put on the market. This device must be easily accessible, but it is not affordable.

The most important required breakthrough is a sensor that can discern when the sound wave returns back to the wristband, after being produced and echoed. Since the frequency of the sound is higher than 65KHz (65,000 Hz), we require a device that can hear this frequency because humans cannot. Dr. Teng and Dr. Sohl-Dickstein informed us that an ultrasonic sensor can sense sounds with frequencies above the limit of the human ear. We need to find out how the

device will analyze the sounds and the magnitude of the frequencies. We must also determine how to include a frequency meter to measure the frequency of the sound waves.
Additionally, we would have to learn how to create a frequency meter small enough to fit inside the wristband. Next, we would have to incorporate a Central Processing Unit that is programmed to calculate the displacement of the sound using equations, with frequency being a variable. Our product will require a few measurements of data in order to have the best performance result. This includes time (s), distance (m), frequency (Hz), and the speed of sound (m/s). The distance would be the length from the wristband to the object in front of the wearer. The time would be how long it takes for the sound waves to hit the object and come back to the wearer. The scientists we contacted mentioned that the frequency of the echo would be the same frequency as the sound emitted. The frequency of the sound waves will need to be higher than 65,000 Hz, so humans and other animals will not be able to hear it. We can find that the speed of sound is 343 meters per second. This will help determine the distance between the object and the wristband.

A procedure that is necessary for our invention to work is the process of inserting the Silicon-Oxide Insulated chip into the Primary Visual Cortex. The scientists we contacted explained to us how this would take place. The chip would be inserted into the brain, similar to how cochlear implants are inserted. The skull would be opened, and the chip would be carefully inserted into the brain. Different insertion systems would lower electrodes into the brain, and make it difficult to restore eyesight. Therefore, we now have enough data for our invention.

Design Process

Our team had considered three other alternative features before EyeEcho that would address the issue of blindness. Though, the most effective solution was to create a wristband that would send out sound waves that humans and most other animals are not able to hear, higher than 65,000 Hertz. Then, this wristband would use echolocation to find out the displacement and movement of a surrounding object, and send this data to the Primary Visual Cortex. Even though this technology wouldn't help the blind see color, it would still be more efficient than the current technologies and the three other alternatives we considered.

We had to consider the form of representing EyeEcho. First, we considered representing EyeEcho as a hearing aid, which would have helped the user sense the reflected sound waves emitted. This device would be connected to the Superior Temporal Gyrus instead of the Primary Visual Cortex, so the blind person could echolocate instead of the device. Though, we rejected this alternative because this device may interfere with the person's hearing capabilities because this device is plugged into the ear. Therefore, this alternative would not be an effective way to address the issue faced by the blind.

Secondly, we had to incorporate a sensor in EyeEcho that would sense the sound waves that bounced off nearby surfaces. First, we considered using a basic Frequency Domain Sensor that is normally used in two-way radios. Though, we realized that the range to detect these frequencies were significantly low. When we contacted Dr. Teng, he recommended using a form of ultrasonic sensor. Therefore, we decided to incorporate a telemetry sensor which can sense a larger range of frequencies. This type sensor would help the wristband accurately sense the surroundings of the user so that the user can visualize any obstacles in their path.

Then, we needed to decide on a form to communicate the data collected by EyeEcho to the Primary Visual Cortex of the brain. Our alternative was to use wires that would connect the wristband to the brain with a surgical implant. After talking to neuroscientist Dr. Sohl-Dickstein, we realized that wired implants through the brain could result in major infections. Additionally, wired connection can limit a person's range of motion. Therefore, we decided that it is best if we transport this data wirelessly, via Bluetooth®, to a Silicon-Oxide insulated chip located in the brain, which was recommended by Dr. Sohl-Dickstein to prevent oxidation in the brain.

Additionally, this chip would use BCHI to track the movement of the brain and release information periodically so the brain doesn't receive unnecessary information at any given time. We had decided this was the best way to communicate the displacements calculated by EyeEcho.

Our future technology idea is better than the other alternatives because it provides the most effective and efficient way to help the blind visualize their surroundings. Firstly, the wristband would not interfere with the other senses of the person, while in our first alternative idea, the hearing device may interfere with the person's hearing. Secondly, the wristband would need an accurate sensor to help the user visualize their surroundings, therefore we decided to incorporate a telemetry sensor. Lastly, this device does not potentially hurt the human body such as brain infections because our device uses an oxide-insulated chip, which uses BCHI to transfer data from the wristband to the cells of the brain wirelessly. Though, there are still some consequences to the overall use of this device.

Consequences

All technological creations have positive as well as negative consequences. Throughout this project, our goal was to create an electronic wristband that had few cons and countless pros. We have created what we believe to be the best design for a device that can be most beneficial to the visually impaired, by figuring out their environment as well as their surroundings. Using an electronic wristband, as well as a wireless chip, this device would send out high pitched sounds helping the wearer echolocate what is in front of them. This device would help countless people all over the world. Just in the United States, 7,675,600 adults have reported to be blind in 2016. These numbers are constantly changing, so using this invention, we have the ability to help at least 7,675,600 people.

One positive outcome of this invention that would benefit the blind, is that it would make activities and sports an option for the visually impaired. EyeEcho would help people with blindness navigate in a more efficient and simple way. With the ability to envision their surroundings, people who are blind can enjoy playing sports and other mobile activities. For example, someone who is blind, could now play basketball by echolocating the location of the hoop, as well as the basketball.

Another example of a positive consequence of our product, is that many children and students would benefit from our creation. As of 2016, 63,357 students are blind in the U.S. Students already face many challenges throughout school and childhood, but the difficulties would be much harder if a child could not see. These students would not be able to navigate easily throughout the large building, be able to locate where their equipment was, and where their classmates and teachers were located. Students might not feel comfortable asking for help or they might get to their classes late because they were trying to figure out their way to their destination. A solution that may come to mind is to get a staff to help the children navigate. However, a further investigation makes it clear that this choice is not very efficient. Many schools do not have enough teachers and staff members to help these students navigate. By using our creation, schools could help the students easily navigate through the crowds in the hallway as well as helping the student know the locations of other objects and peers. This creation would help students feel more independent, because they would now be able to navigate without needing to depend on others.

When discussing the side effects that we may encounter with Dr. Teng and Dr. Sohl-Dickstein, the topic of radiation came up. A reason that many might be hesitant about assistive technologies, such as ours, is due to radiation. However, we were informed that radiation should not be a concern in our product. Although a small amount of radiation may occur, there will not be any damage caused to the Primary Visual Cortex, or the rest of the brain. This information was very useful, because users' minds will be at ease when using our invention.

As stated previously, technology does have its flaws. A problem that we may occur while designing this invention is that it will be difficult to find the perfect frequency. This is due to the fact that if the frequency is too low, it can damage and be harmful to the wearer's ear. The frequency also needs to be above the range of what most animals, including humans, can hear, so others do not get disturbed while the product is in use.

We also may encounter health problems that we are not currently aware of. For example, there may be side effects of the brain-chip insertion. The neuroscientists discussed how the Primary Visual Cortex will naturally be repurposed if it is not put into use. Therefore, an insertion into the brain may cause unintended negative consequences.

By considering all positive and negative outcomes of this invention, we believe that the positive results that will come out of this creation are worth the negative effects. People who are visually impaired will have the opportunity to participate in sports, activities, as well as have similar experiences in school. Though there are negative consequences that may occur, there are also solutions to these problems. The first issue could simply be solved by testing multiple different frequencies to find the best one. The second, and last, issue could be solved by continuing to do more research, as well as testing on volunteers and animals. By finding solutions to these problems, we can successfully create an invention that will help the blind navigate with ease. We hope that EyeEcho will help millions of people and be the future of assistive technology.

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