American Sign Language Convenience Soundboard

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Abstract

In order to improve communication between Deaf, mute, and nonverbal children, the engineers plan to design, prototype, and test a device that can produce sound from the press of a button. This device is paired with a customizable app where the voice line output can be changed along with speech-to-text to allow back and forth conversation. The product must be easily accessible and convenient to carry around. A conversation conducted using our product must be 40% faster than a conversation on paper in order for us to deem it successful. The buttons have to sense when it's being pressed 100% of the time, and the engineers also plan on making it cheap for the user as well as developing an app that is user friendly and does not take up much storage space. Through testing, the engineers found that this device is at least 40% more efficient along with general positive feedback. 67% of people also said they would use the device over the most common way to communicate which is pen and paper. With the continuation of this project, the device would be made smaller along with being able to be accessible on the wrist.

Contents

Introduction

During the span of a year, engineers were tasked to solve a complex, justifiably problem. The engineers have to come up with a unique question that they think is a real problem that needs to be solved. They will then go through the engineering process to design, build, test, modify and report a prototype that they think will solve the problem. With the goal of making an impact, the engineers want to help provide smoother communication between the hearing and the hard of hearing. In order to do this, the engineers plan to have an app communicate with a wristwatch device which can play customizable sound. In this process they will learn crucial skills such as communication, planning, iterations, and other engineering skills. Additionally, they will also learn hard skills such as CAD, 3D Printing, coding, assembly, and more to aid them in their process to build the prototype. Through this experience, the engineers hope to grow and learn more about real world problems and how engineering is used to solve them.

Background

More than 70 million people around the world use sign language as their main method of communication, but less than 1% of abled people knows sign language. Because of this, deaf and mute people encounter many inconveniences around communication daily. Some previously patented inventions include Patent US8428643B2 which is a system that translates sign language and text processing images. This program is powerful, but it is just an algorithm. Patent US10580213B2 is a sensory eyewear that can translate sign language and present it to the user which is a good idea, but it is just an idea and not an actual product. This idea is powerful but it is also too big for normal people and is mostly for stores and businesses. Patent US8504350B2 is a camera system that translates text into other languages which would be helpful for our project. This project is different from other patented results as it is a wearable device along with software for optimal customization for customers. The engineers did their own survey of twenty deaf kids at a Deaf School. The engineers found that 95% of respondents said they do not know American Sign Language, 95% said a device for ASL would be useful, 60% said an app would be useful, 50% said hardware would be useful, and most people would pay around 0-10 dollars for a solution to this problem. Through this process, the engineers discovered that this communication problem is prevalent along with realizing that previous patents do not cover the criteria constraints for the specific market the engineers of this project chose. This product is designed to target kids who do not have technology along with other deaf people and mute people who can not communicate through speaking. The criteria set for this project includes create an app that will take in phrases and sentences for a soundboard, ensure that 90% of the sound is recognized and transferred to text, ensure that the button has proper pressure recognition 100% of the time, app is easy to navigate with simple design for convenience and takes up only 10mb. The constraints set for this product includes the device has to be small enough to be portable and easily accessible, the device has to be cheap and accessible to all incomes, it cannot invade a person's privacy, be wearable on the wrist, has to be adjustable to fit any wrists, comfortable to wear and easy to use, utilize 3d printing and create a cost effective product (under $30). Finally, the researchers created a solution statement: Design, prototype, and test a device that can produce sound from the press of a button which is customizable by app, and receive sound then produce text as well.

Materials

Below is the list of materials the engineers used to construct the prototype:

- 3D Print: PLA
- Power Bank
- Raspberry Pi
- Colored Buttons
- Wires
- Speaker

Below is the list of materials needed for future production of a smaller product:

- Leather Strap
- 3D Print: PLA
- Microbattery
- Speaker
- Micro-controller
- Colored Buttons
- Wires

In addition to hardware materials, the engineers used a variety of softwares to help them construct the prototype. Below is a list of softwares used to code the app and prototype

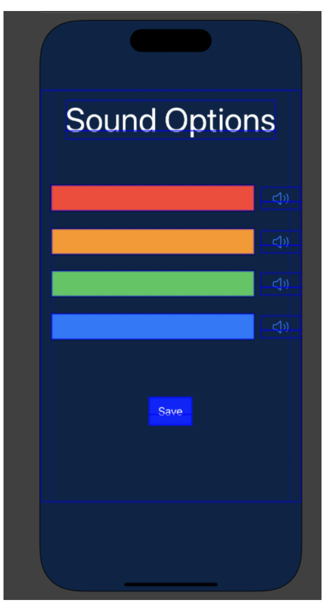
- XCode
- Swift
- Python
- Onshape

Procedure

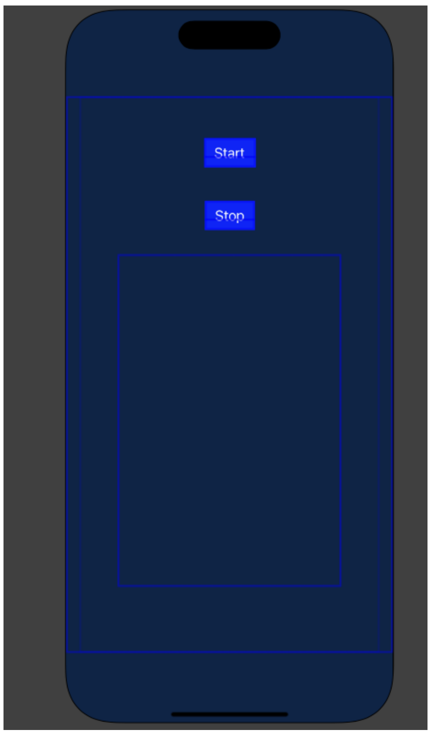
App development

The engineers decided to use Swift programming language and utilize the Xcode programming environment. To learn about Swift, the engineers took a course from Codecademy. Through this process, a lot of syntax was learned about Swift along with how programming works in the Xcode environment. There are two distinct ways to make an app on Xcode which are Storyboard and SwiftUI. To decide on which one to use, the engineers decided to make a tic-tac toe game on both options. Storyboard was decided on as it is more user friendly for a more easier coding experience. The first task was to make the sound changing option.

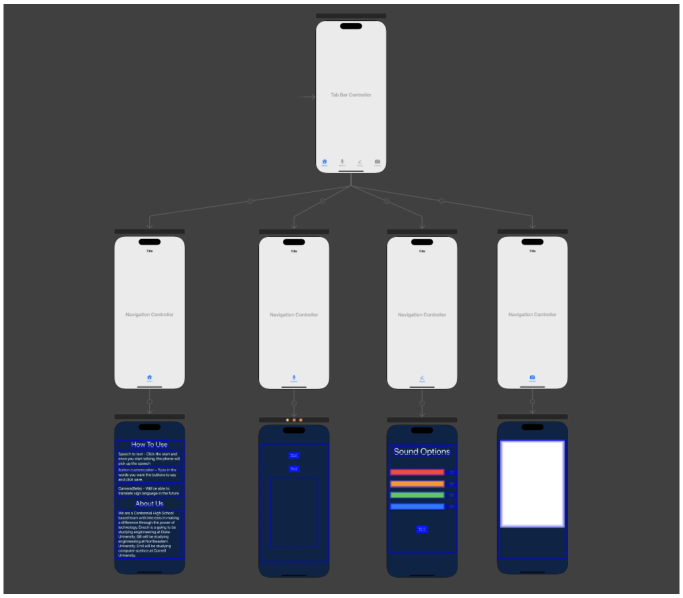
To do this, the engineers had to decide between UITextfields and buttons. UITextfields were ultimately chosen for the customizability as well as ability to save in the app. In order to save the UITextfields, defaults were implemented into the code. The next part of the app is speech to text recognition. Different colors are implemented which will be color coordinated with the device.



Thorough research was done and different ideas were generated on how to do this. Apple's SFSpeechRecognizer was used and it internally converts the speech to text which is then displayed continuously as long as the start button is pressed. SFSpeechRecognizer has a transcribe method which is utilized and internally continuously uses the microphone. This needs permission in the IOS target properties.



The bottom of the app has navigation which utilizes UITabView. A camera is added to simulate the ASL translator described later in the paper, but it is currently not able to perform ASL recognition. The camera is just a UIView with the UIImagePicker library. An About Us tab is also provided. The UITabView contains a TabBar Controller, Navigation Controller, and a View Controller.

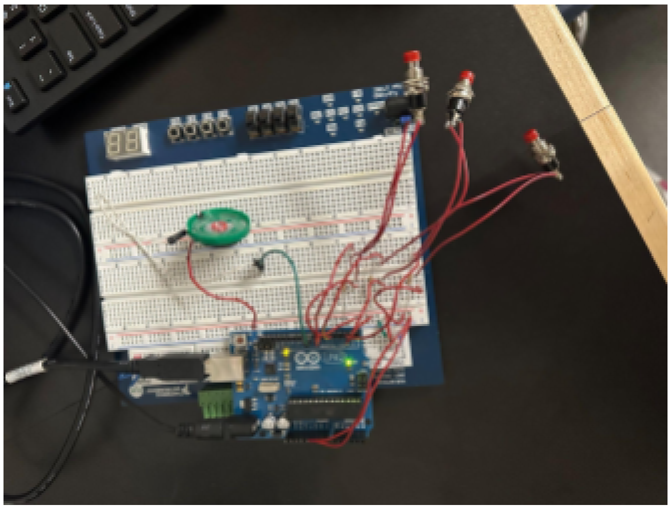


Many things were learned through this app development stage. Swift language was learned as well as Xcode and its IDE format was also learned. Many libraries were investigated and Xcode's storyboard language was also learned. This will help the engineers in future endeavors pertaining to app development for IOS.

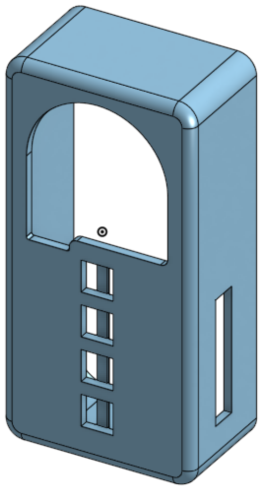
[VIDEO ABOUT APP]

Hardware

Hardware had many many iterations. Initially, a small arduino microcontroller was used to test button press and recognition. Buttons were placed on a breadboard as well as the microcontroller. LED lights lit up upon the press of a button to test this. The next step was to get a speaker and test text to speech on the microcontroller. This step had many lessons learned including how to code on the arduino IDE, circuitry, and electrical engineering ideas. Overall, this step did not work as the speaker did not produce enough sound, and the text to speech takes too much time.



After that, the engineers decided to use a Raspberry Pi as it is readily available to them. This Raspberry Pi has wifi capabilities which allows the engineers to connect to the web if necessary. In order to detect button presses, the engineers utilize python and the RPIO library. An event_detection method is used to detect button presses. To have text to speech, research is done and it is decided that Google has a good user friendly API to use. This is installed through the terminal and the OS python library is utilized to access the Google Text to Speech API. This Raspberry Pi needs a battery, so the engineers decided to use a power bank. There were many interactions on the box, but this is the design that ended up working the best.



Buttons were placed in the four small squares and the powerbank is attached to the Raspberry Pi through floss.

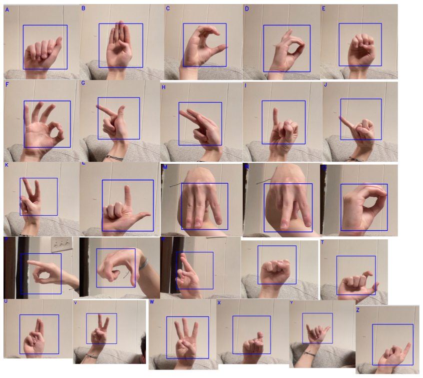
Integration of App and Device

In order for the app to communicate with the physical device, a multitude of ideas were generated. Many ideas were tried including MQTT, Socketserver, websocket, and HTTP web server. MQTT and Socketserver are not compatible with the Xcode version the engineers are using. Websocket is difficult to implement in python. The web server is easily implementable in python and integratable in the app. A web server is built on the Raspberry Pi button detection python class. It is running on port 8080. A GET request is sent every time the “save” is clicked on the app. The web server receives this request and is processed as the information contains a lot of random characters.

VIDEO ABOUT INTEGRATION

Sign Language

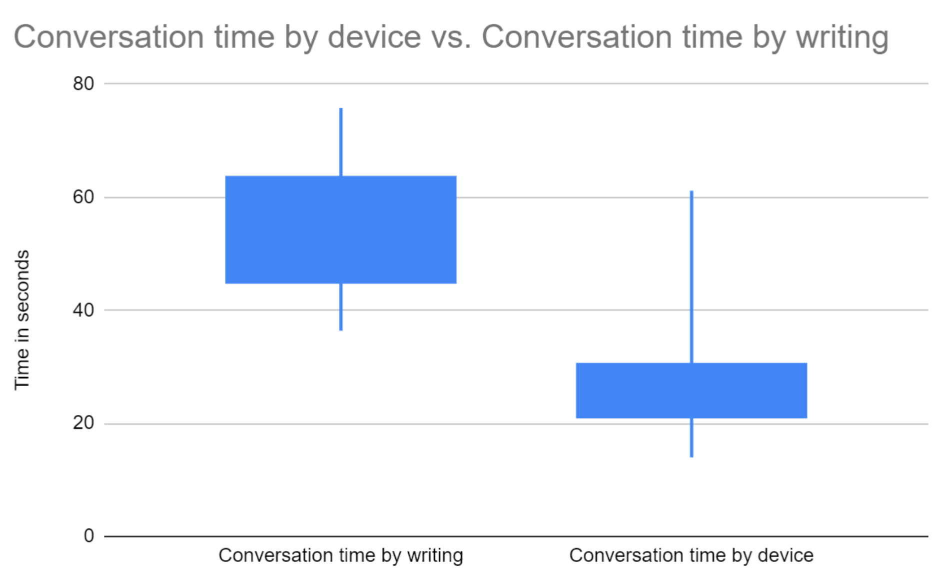
A sign language converter to english text is a lofty goal for the engineers. Research into image recognition is done by watching youtube videos and reading papers. Number recognition is the closest to ASL recognition, and the engineers implemented a neural network. This is then processed using a Kaggle dataset of 28000 images of ASL. After about 10 hours of training through 10 epochs, the neural network was trained to an accuracy of up to 98%. OpenCV was then used to have the live camera feed, but because of all the movement and also the similarities between the letters, the live camera is not that accurate. The engineers learned about neural networks, train/test data, OpenCV library, and much more.



Results

After the completion of our prototype, we took the prototype to the test. To get the most comprehensive results, we collected both quantitative and qualitative data, which are presented in the following pages. We conducted the following test to determine the success of our product:

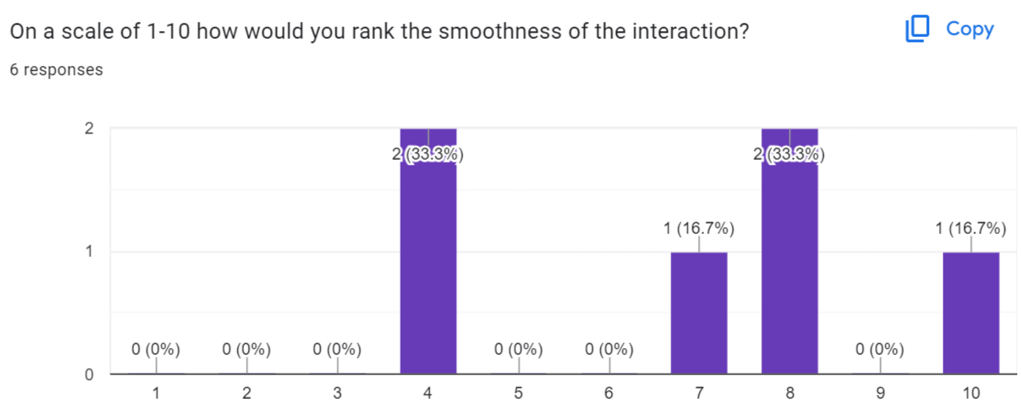
1. Have subject conduct a 4 exchange conversation by writing on paper and time it
2. Have subject conduct a 4 exchange conversation using soundboard and time it
3. Ask subject to change 3 outputs on the app to “good morning”, “help”, and “where is the restroom” and time how long it takes for them to figure out
4. Compare the times of testing with prototype with them using a piece of paper
5. Ask subjects about comfortableness as well as additional comments using a premade survey.

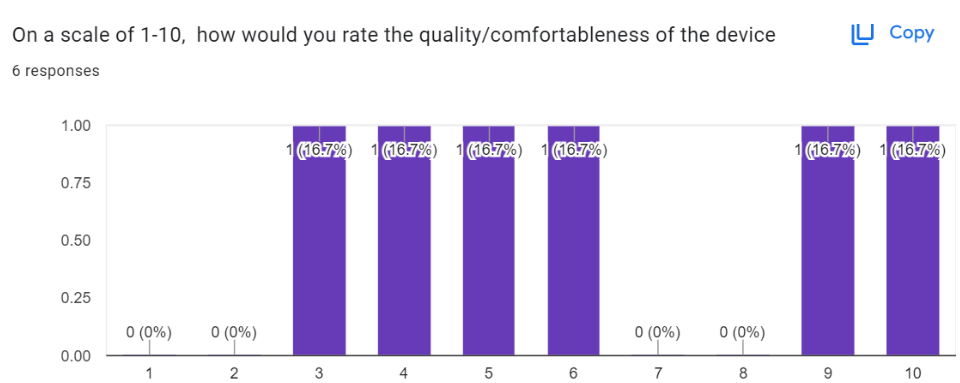


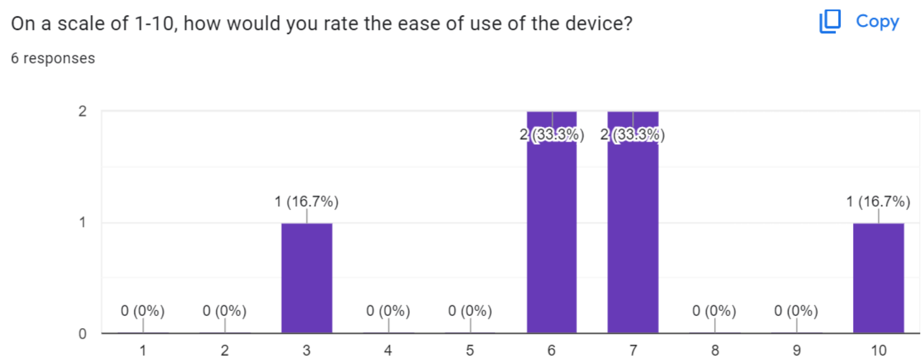
It is important to note that our sample size was 6, collected *not randomly* from willing participants from our community

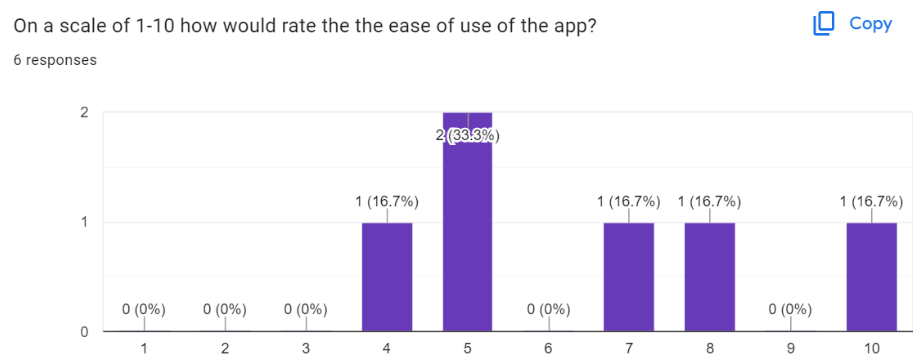
This graph displays the results of the first two tests. As we can see, the conversation time by device proves to be much shorter on average compared to conversation time by writing, which is currently the most popular method of contact between a Deaf/mute and abled person. Do keep in mind that this is a highly simplified, controlled simulation of a real world situation in which many things can go differently.

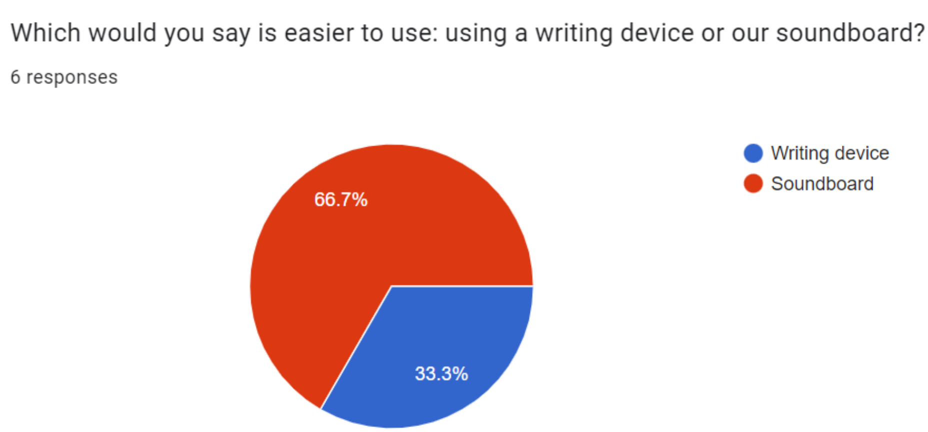
The results of our survey is also recorded below:











To sum up the results of the survey, most people found the device to be an improvement from writing with pen and paper, however, the comfortness of our device could be improved. The app received generally positive feedback. Some feedback the engineers received is: "You could definitely try to make the device more portable”, “The product is not held together well. Components are shaking inside the casing”.

Conclusion

In the process of designing an ASL sound board, the engineers have realized what the engineering process was all about. The engineers were tasked with a problem, and after several iterations, came up with a unique solution they believe solves the problem. After testing it in the real world, they have received input and will continue to modify their product. After the engineers complete their engineering process, they have learned various skills that are applicable to the real world. In terms of software development and hardware, they have learned how to use: Xcode and swift implementation,web server integration, machine learning, deep learning, Raspberry Pi, 3D printing, wireless communication, soldering, circuits, and more. On the communication side the engineers learned how to properly manage their time, communicate how much progress a person has made, iterating and redesigning prototypes, asking for professional help, getting survey results and documenting their work. In the future, the engineers hope to continue to utilize the skills they have learned from this project to their future goals and careers.

Appendix

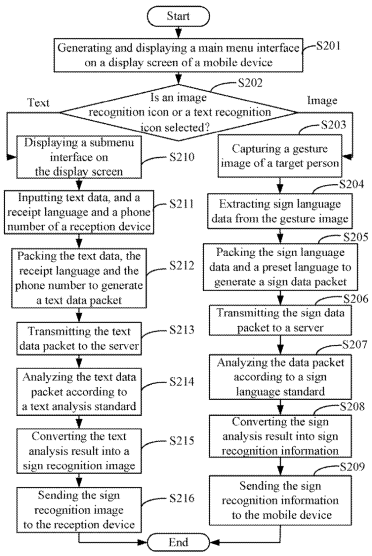
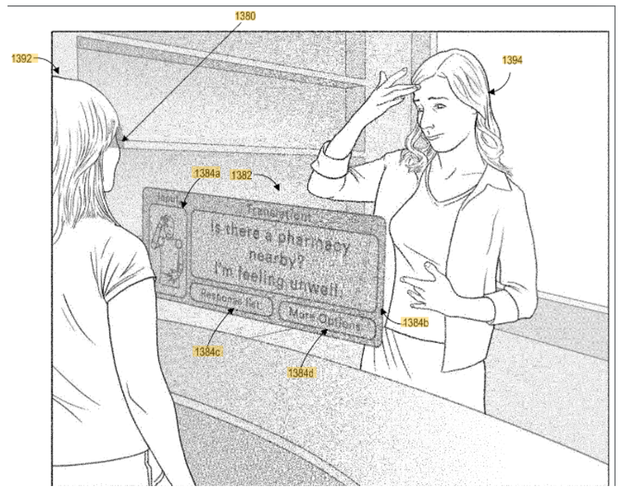
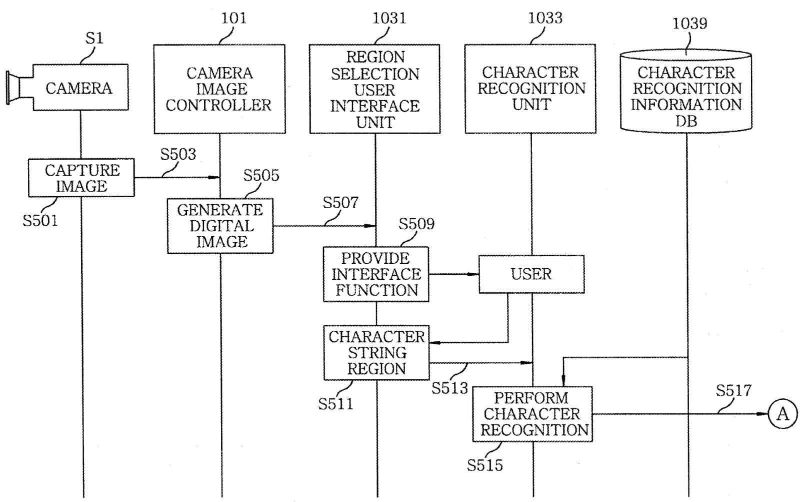
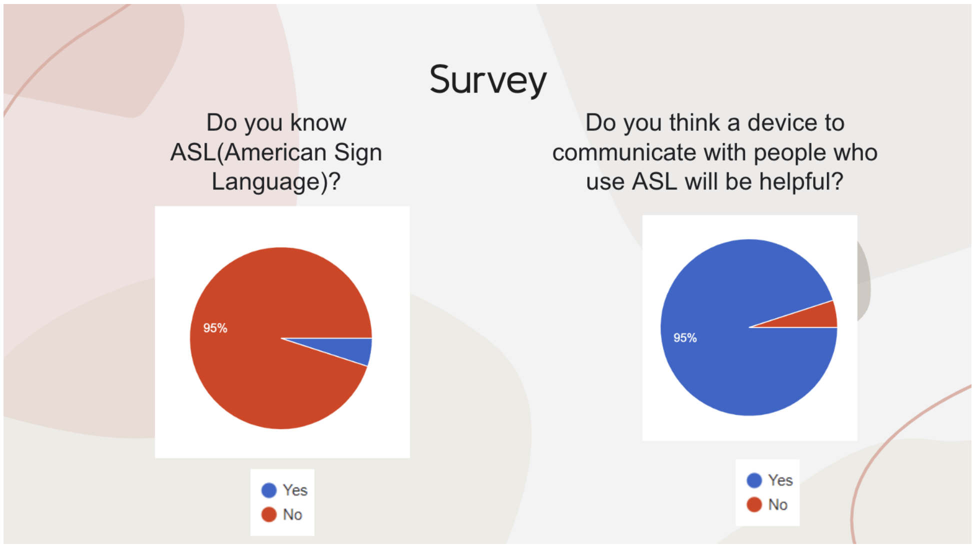
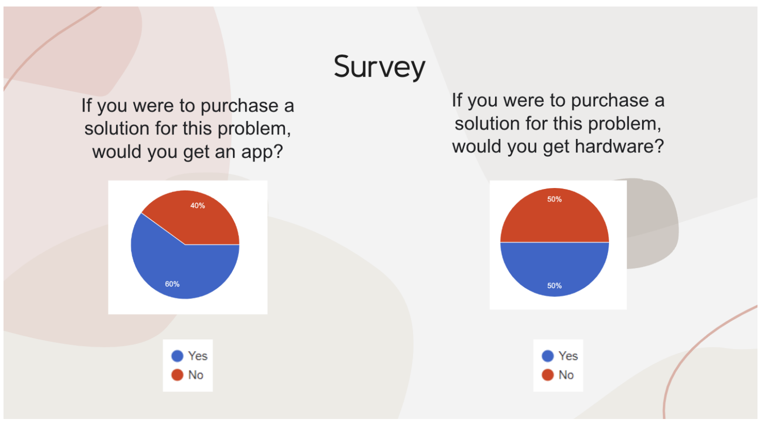


FIG. 4






Survey
Do you know ASL(American Sign Language)?
95%
Yes
No
Do you think a device to communicate with people who use ASL will be helpful?
95%
Yes
No


Survey
If you were to purchase a solution for this problem, would you get an app?
40%
60%
Yes
No
If you were to purchase a solution for this problem, would you get hardware?
50%
50%
Yes
No

Design Matrix

	Difficulty	Material Cost	Convenience	Durability	Reliability	total
Glove	3/10	2/5	4/10	4/5	8/15	21
App	2/10	5/5	8/10	3/5	7/15	25
Soundboard	7/10	3/5	7/10	3/5	12/15	32
Hand	7/10	2/5	3/10	3/5	12/15	24
Glasses	2/10	1/5	8/10	2/5	7/15	20

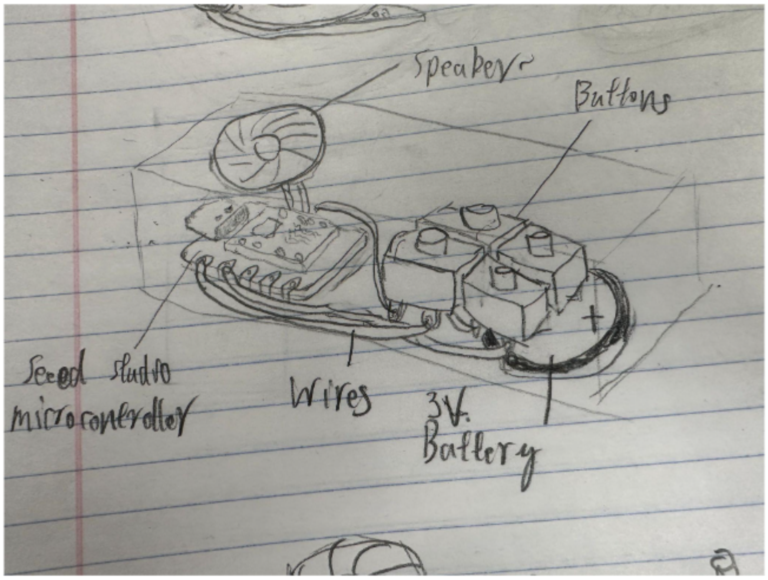
Materials/Cost

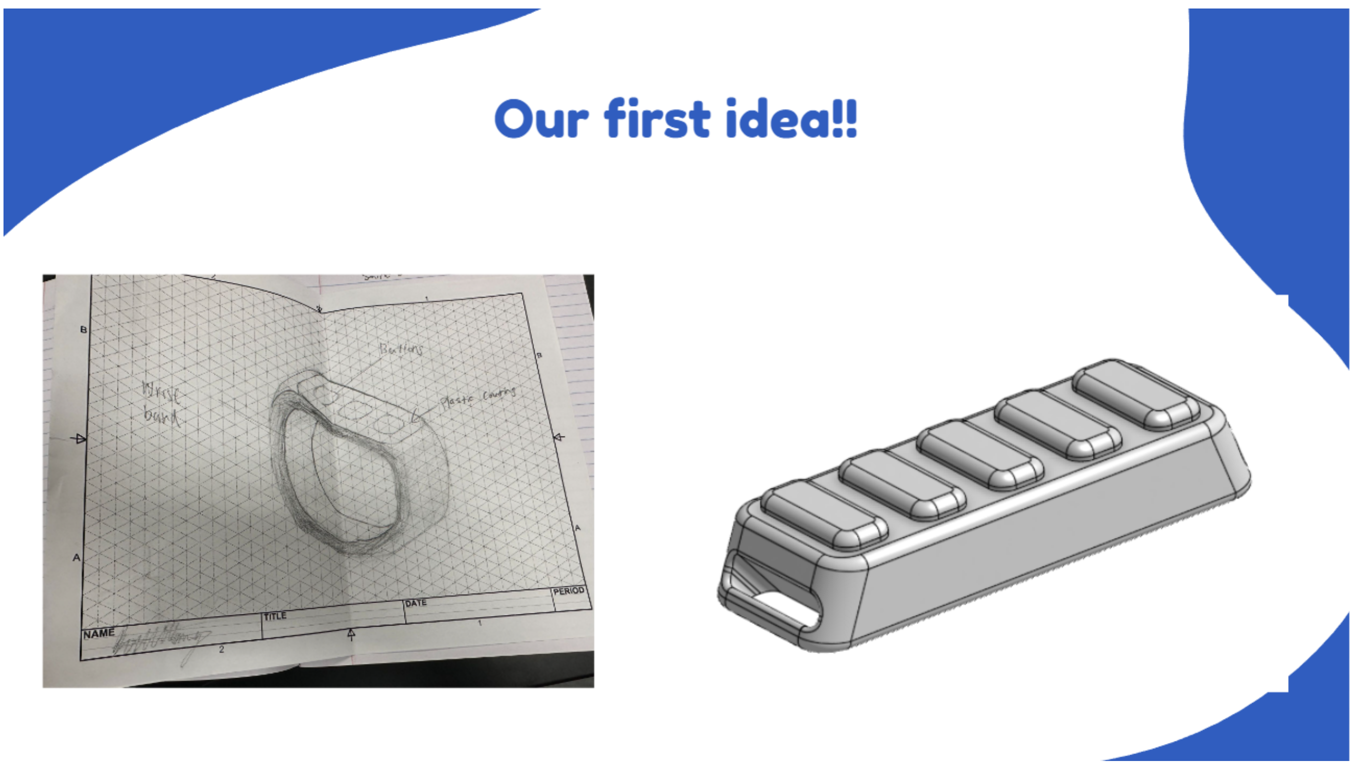
ITEM #	DESCRIPTION	UNIT COST	QTY/HR RATE	AMOUNT
B07QST4SCJ	Coin Cell Button Battery Holder Case (15PCS)	$11.99	1	$11.99
B08CN5YSQF	Seeed Studio XIAO SAMD21The Smallest Arduino Microcontroller Based on SAMD21,with Rich Interfaces, 100% Arduino IDE Compatible, desiged	$9.50	1	$9.50
B0787K2XWZ	Amazon Basics 4-Pack CR2032 Lithium Coin Cell Battery, 3 Volt, Long Lasting Power, Mercury-Free	$7.12	1	$7.12
B01EJI8UWI	Gikfun Round Micro Speaker Diameter 28mm 8Ohm 8R 2W for Arduino (Pack of 2pcs)	$7.88	1	$7.88

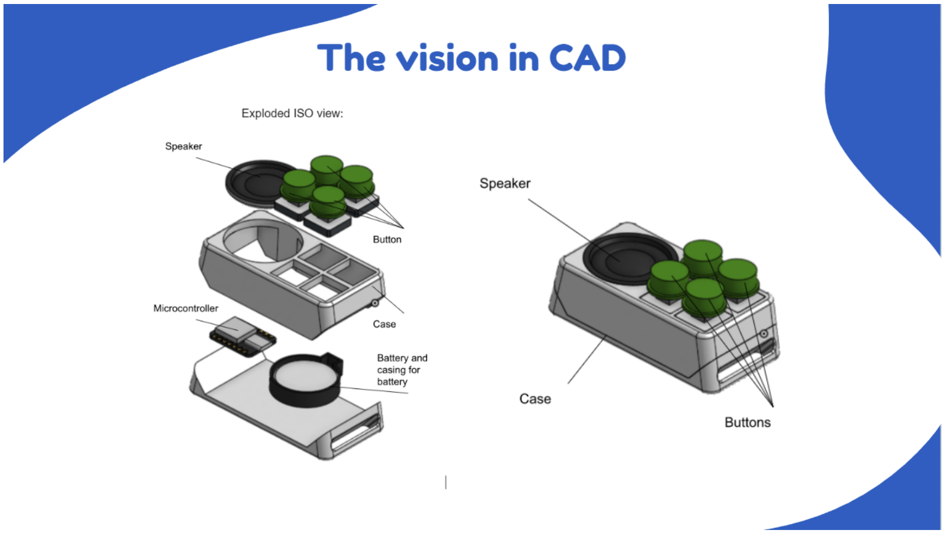
Other material not listed:
Leather band ($12)
Small microphone ($8)
Phone App (Free)

Everything Added equals **$50** and can create **4 units**. We plan to sell at $20 per unit which will make a **$7.5 profit**

ISO View


Speaker
Buttons
Seeed studio
microcontroller
Wires
3V.
Battery


Our first idea!!
Buttons
Wrist
band
plastic casing
NAME
TITLE
DATE
PERIOD


The vision in CAD
Exploded ISO view:
Speaker
Button
Case
Microcontroller
Battery and casing for battery
Speaker
Case
Buttons

Citations

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