Introduction

In the United States, more than 34 million people are visually impaired, many of whom are afflicted with hyperopia or presbyopia. Because such conditions cause close-by objects to appear unclear, these individuals have difficulty reading conventional watch faces. In a society that runs on strict schedules, not having the ability to know the time can be detrimental.

Engineering Problem

Many conventional watches do not enable the visually impaired to easily obtain accurate time data information.

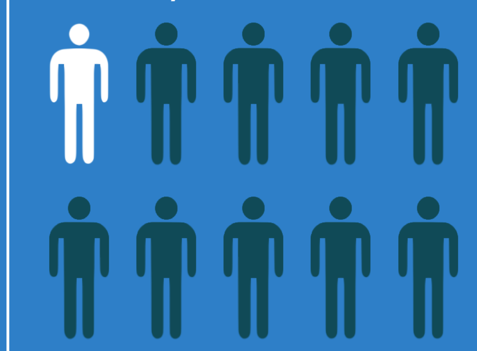
Engineering Goal

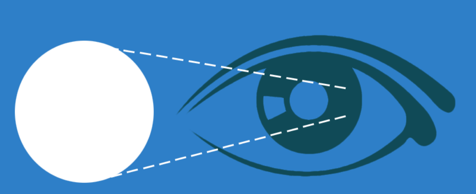
The goal was to engineer a watch that enables the visually impaired to easily acquire accurate time information.

Background Information

Visual Impairment in the United States

One in Every Ten



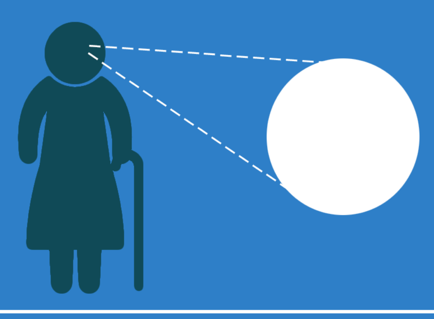


Hyperopia

Caused when the eye is too short, or the cornea is not curved enough and the image is focused behind the retina. People can see objects farther away from their eyes more easily than objects close to them. However, objects may appear blurry at all distances.

Presbyopia

When a person ages, the lens inside his or her eye becomes less flexible, which can cause the image to be poorly focused upon the retina.



Sensing

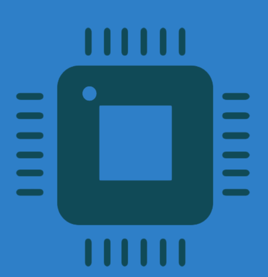
The results of a recent study showed that the wrist is one of the most sensitive areas of the body.

The experiment was set up in a stimulating environment and showed that vibrations are successful in conveying information in any environment.

Exteroceptive sensing: includes the ability to feel pain and thermal differences, along with tactile sensing (dynamic and static sensing).

Technology and Hardware

The main hardware pieces include Arduino based modules and vibrating cell motors.



Arduino

An open source project that makes user-friendly micro controller boards and software. The software, the Arduino IDE, uses a simplified version of C++.

Cell Motors

Includes two copper coils on an unbalanced weight. When electricity is passed through the motor, these coils become magnets, and their strong, contrasting magnetic fields push against one another, causing this system to steadily spin and vibrate.

Procedure

Testing

1. Each participant wore the watch on his or her wrist
2. A certain time was set on the watch, and each volunteer pressed the button
3. The watch vibrated a certain number of pulses correlating to the set time, and each participant verbally relayed the perceived time to the tester
4. The responses were recorded using Excel

Patterns

Pattern 1: When the user pressed the button, the watch would vibrate the hours, pause, then vibrate the minutes. A short duration vibration represented each hour and each minute.

Pattern 2: On the first press of the button, the user would feel one short vibration for each hour. Then, on the second press of the button, the user would feel one vibration for each minute.

Pattern 3: On the first press of the button the watch would vibrate for the hours, and on the second press of the button, the watch would vibrate for the minutes. These counts were in sets of ten, where ten minutes or ten hours were represented with a longer duration vibration.

Example: 11:24 a.m.

Legend		
|	=	Short vibration
■	=	Long vibration

	Pattern 1	Pattern 2	Pattern 3
Hour	|||||||||||	|||||||||||	■|
Minute	||||||||||||||||||||||||	||||||||||||||||||||||||	■■||||
Total Vibrations	35	35	8

Table 1. This table shows the number of vibrations that the user would have to count in order to understand the time of 11:24 a.m.

Results

Data From Watch Testing

	Pattern #	1		2		3	
Participant	Test #	Test Time	Relayed	Test Time	Relayed	Test Time	Relayed
1	1	6:23	6:20	10:31	10:23	6:46	6:46
5581	2	4:12	4:10	11:10	11:11	5:16	5:16
	3	2:04	2:04	7:14	7:15	9:25	9:25

Figure 1. This table is an example of the raw data that was collected during testing.

On average, the group of participants who were older than 18 had a larger time deviation for every test.

Averages Total (min)		
Pattern	Average	STDEV
1	13.90	53.13
2	14.18	40.18
3	0.31	1.42

Figure 2. This table shows the average time deviation and standard deviation for each pattern.

Materials

Hardware:

- Clock module, vibration motor, Bluetooth module, button
- Arduino pro mini microcontroller
- Wires and connections
- PLA, ABS, and TPU plastic
- Qidi Tech 3D printer

Software:

- Google Sketchup
- Android Studio
- Arduino IDE
- MakerBot Desktop

All images, charts, and graphs created by researcher unless otherwise stated.

Final Designs

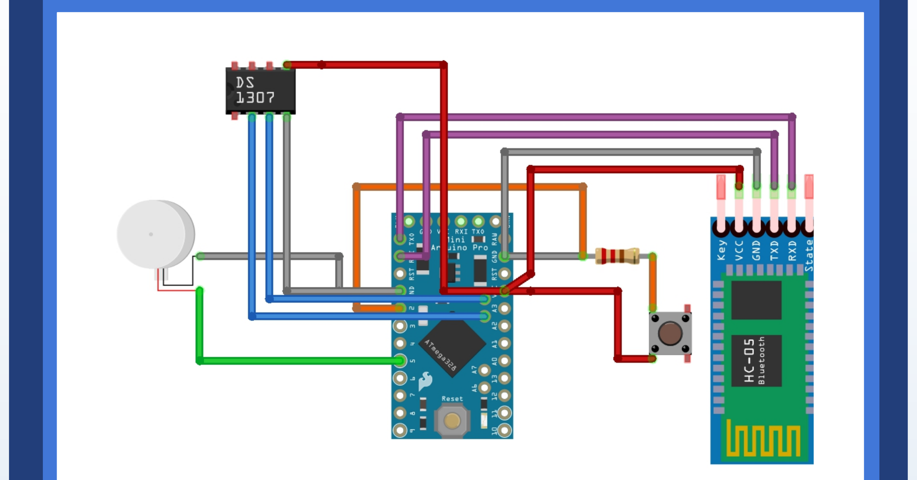


Figure 3. This is the hardware of this device, showing all of the wiring and connections to the board from the modules.

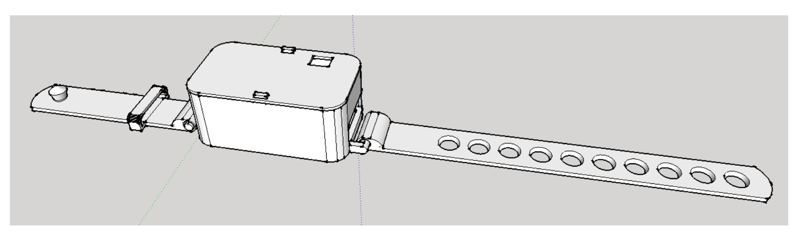


Figure 4. Prototype 16: This model is a recent prototype designed on Google Sketchup.

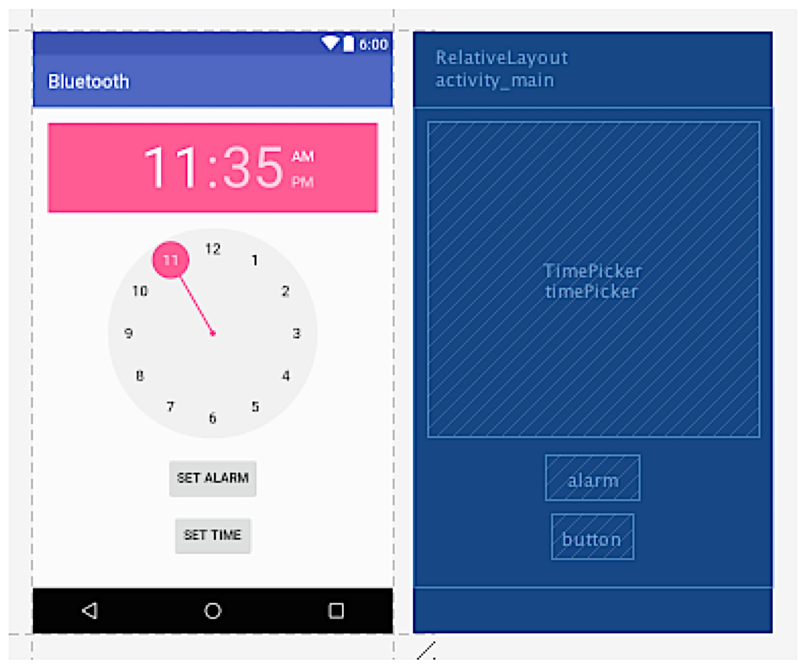
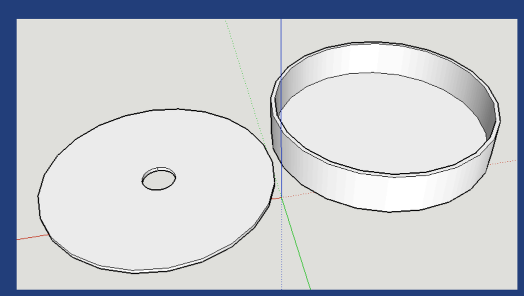


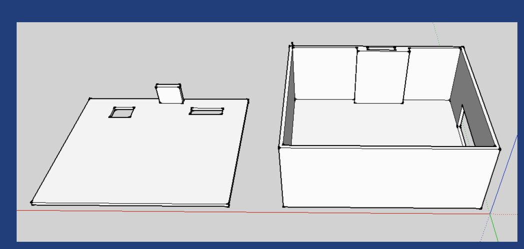
Figure 5. On the left: this is the user interface of the Android app. On the right: the blueprint for the app.

Prototypes

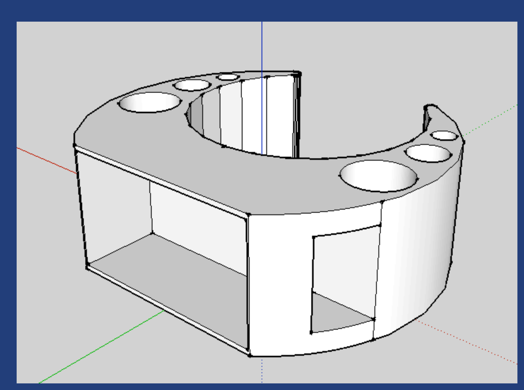
Prototype #2



Prototype #7



Prototype #12



Prototype #18

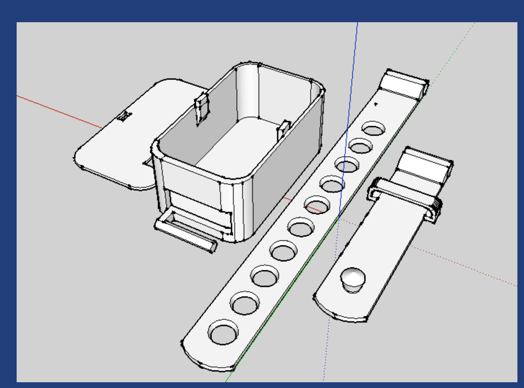


Figure 6. This shows the progression of prototypes for the casing of the watch device.

Data Analysis

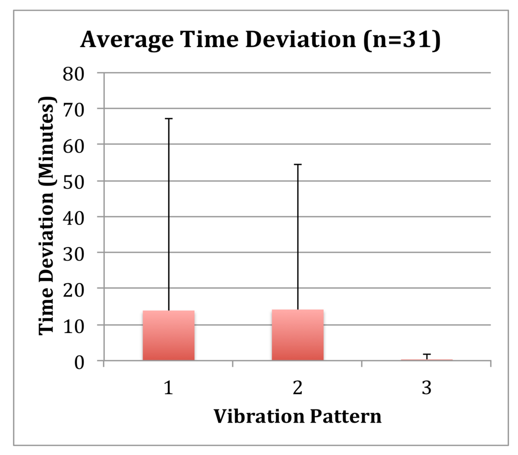


Figure 7. This graph shows the average time deviation for each vibration pattern and error bars that represent standard deviation.

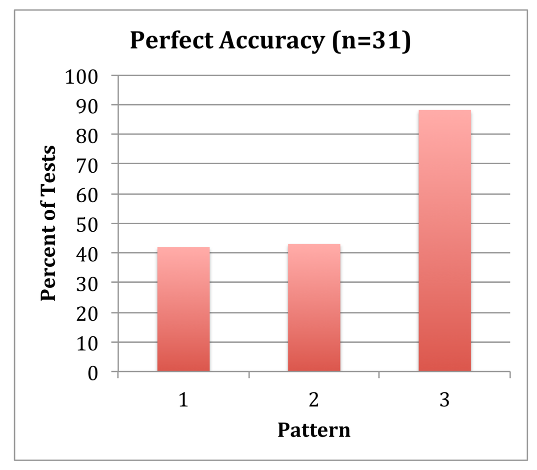


Figure 8. This graph shows the percentage of tests that were perfectly accurate.

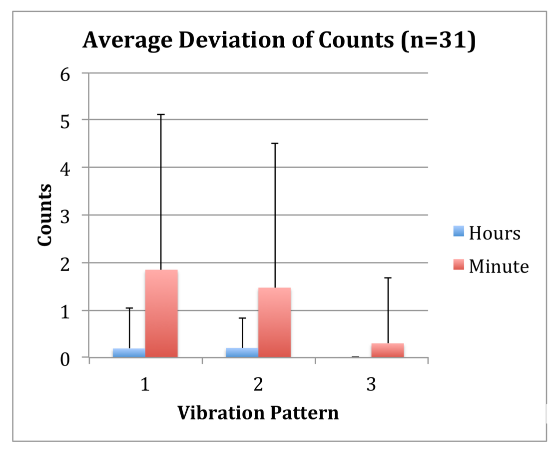


Figure 9. This graph shows participants' average time deviation, in hours and minutes, for each vibration pattern. The error bars represent standard deviation.

An ANOVA test was used to determine if these averages were **significantly different (p = 0.027)**.

Similar devices on the market are accurate within 5 minutes. The vibration pattern selected for the final prototype was **significantly more accurate than those of commercially available devices (p = 0.0001).**

The **current prototype costs $7.00**. Because of its low cost, this device can be accessible to people who cannot afford more expensive alternates.

Conclusion

There is always a demand for creating inexpensive and more available technology for those in need. People all over the world suffer with visual impairments, ranging in severity from mildly impaired to completely blind. These people could benefit from a vibrating watch to accurately tell the time. This engineered prototype is accurate to 0.3 minutes (19 seconds) and only costs $7.00 to produce. Further tests and expansions to this device can make a difference in many people's lives.

Ongoing Work

Patients in medical facilities can wear this device. The patient's caretaker can set times for medication to be taken by that patient. When this time comes, a light on the device will turn red. From the Android application, the caretaker can select "Medicine Taken," and the light will turn back to green.

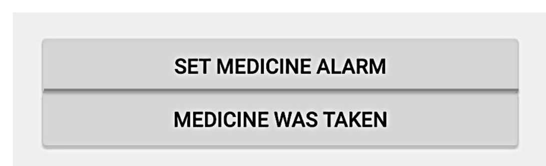


Figure 8. This is the user interface of the medical application. The user can add patients to the list and change each device independently of the other devices.