SynthSense

Team

- Craig Hiller
- Adithya Murali
- Frank Lu
- Tomás Vega
- Krishna Parashar

Questions and What We Learned

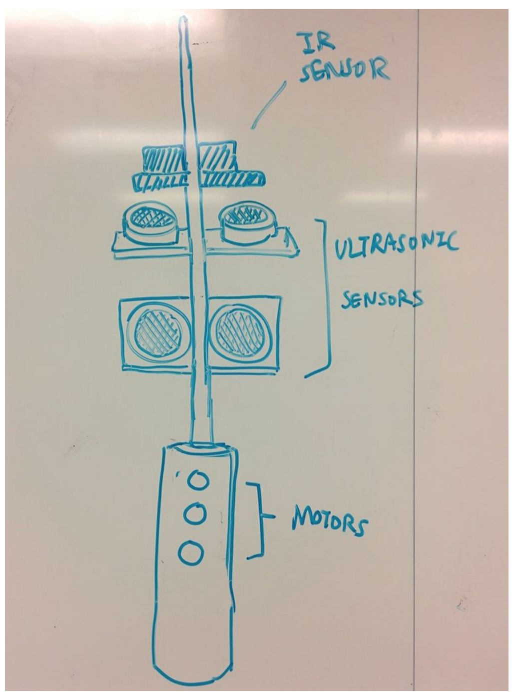
1. What is the most effective way to detect dropoff?
    - The two ways we were considering for detecting dropoff involved using either an IR or an ultrasonic distance sensor. We concluded that the ultrasonic sensor would give a false positive when passing through narrow openings such as doors, but the IR sensor would not have this problem as it has a narrower beam.
2. Can we connect multiple ultrasonic sensors at different angles to detect obstacles at different levels?
    - Yes! We had two different ultrasonic sensors and the IR sensor connected and were able to detect the objects at different levels. Part of the unknown that we addressed here was how to mount the sensors, which we solved. The solution is shown later in the pictures.
3. Can we get reasonable haptic feedback with the two types of vibration motors?
    - Again, yes. We used both small eccentric rotating mass motors and coin vibration motors, and both of them gave us the vibrations we desired, and they can be run off of the IO pins on the various controllers that we have, which was an added benefit.
4. It is possible to have vibration motors give a sense of direction on the wrist?
    - To tackle this, we built a very lo-fi prototype of the navigation portion of our project, and had all of the vibration motors go off in sequence, the result was a clockwise rotating feeling around the wrist, as we desired.
5. Can we get directions to a location by speaking into a phone?
    - We needed to figure out if there was a usable speech recognition API that we could use on the phone, and if it is possible to use the strings returned from that to get directions from the current location to that place. This turned out to be possible thanks to sample code from Nuance and their SpeechKit.

6. Can we easily power our devices?
    - We learned that we need to have a decent power supply for the obstacle avoidance system, on a small battery when we tried to run the motors and sensors, we didn't have enough power so we experienced some unexpected behavior. This was fixed by using USB for the power, so this is still under investigation.

Look and Feel Prototypes

For this deadline, we really wanted to tackle the technical challenges that were ahead of us. But we also wanted to think more about the "ideal" product should look like, independent of if we could build it at the current time. This is what our current thoughts for the best version of this project look like:

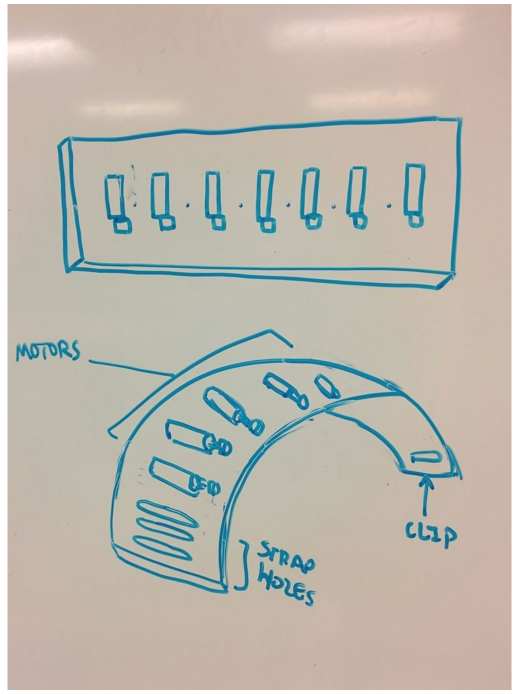
Obstacle Avoidance



We wanted a design that separated the sensors from the handle to avoid having the user accidently block them. This then has all of the haptic feedback motors in their own ergonomic enclosure, so that is all the user has to concern . This image is very much not drawn to scale, the cane is much longer than any of the devices we are adding.

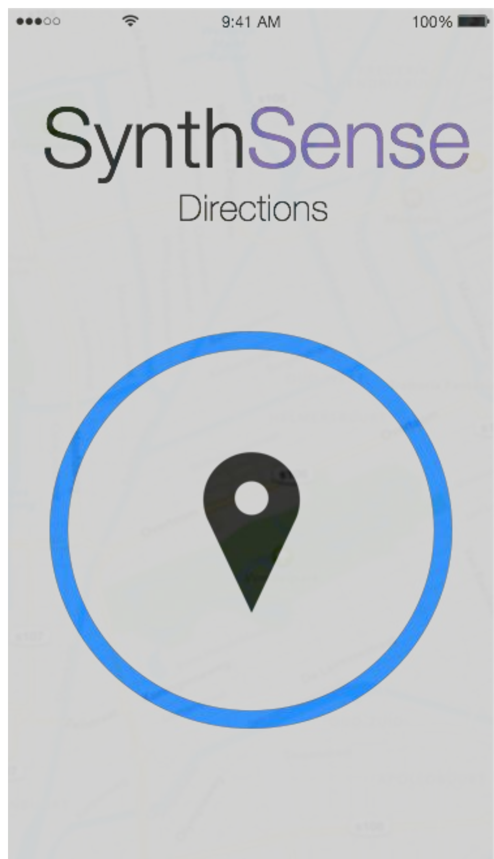
Navigation

The navigation bracelet is the part of the project that is worn on the user to provide feedback about which way to turn/walk to reach a destination. We want it to be controlled through bluetooth to a phone that provides the turn-by-turn instructions. On the bracelet itself, we wanted a minimalistic design, with only the motors and a clasp visible. In future versions, we want to hide the motors so they don't get caught in anything, but we haven't figured out a tradeoff between how this is constructed and how it would look. The clasp we're thinking should be a standard watch-type strap with a pin and holes or a magnetic enclosure. Further testing is required to settle on a design on that front.



Controlling App

To create a "look-and-feel" prototype for this app, we had to consider who our use base is. Namely, blind people. Since they cannot see, this prototype needs to be very simple to use provide audio feedback instead of visual. While our prototype does have an appealing visual aspect to non-visually impaired people, the main functionality is controlled by tapping anywhere in the middle of the screen. When this happens, the device will say "Say your destination address". After the user has spoken the address, the speech-recognized version is read back. The user can then confirm if this is correct by saying "Yes" or "No" after being prompted. If the user confirms the address, the app will then send haptic instructions to the navigation wristband for the turn-by-turn directions. The data sent can be augmented by sensor readings from within the phone. A mockup of the main screen of our controlling app is shown to the right.

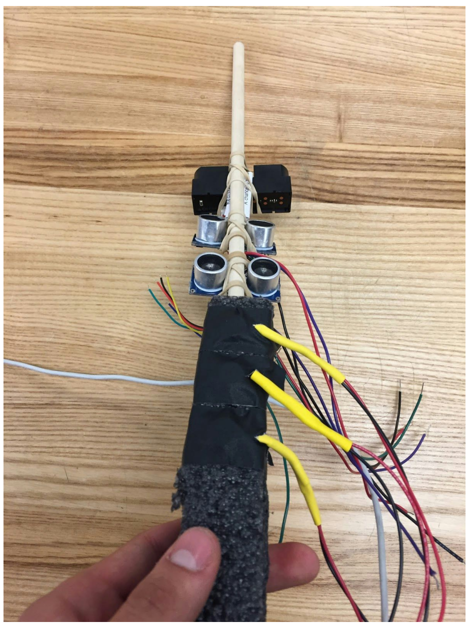


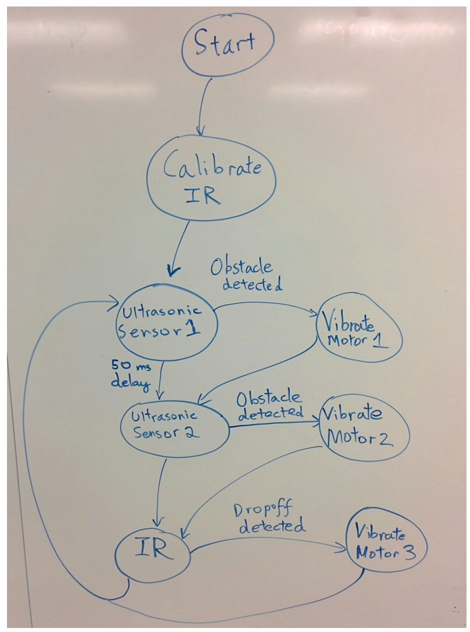
.

Look and Feel Prototypes

The following prototypes are what we were actually able to build! They were built with the focus of tackling our main technical questions, and for the most part were a good platform to do that. These platforms let us test a bunch of different questions we had without having to build a new device for each test, so this prototyping stage was incredibly valuable. We did have our challenges, discussed later. But for now, this is what we built.

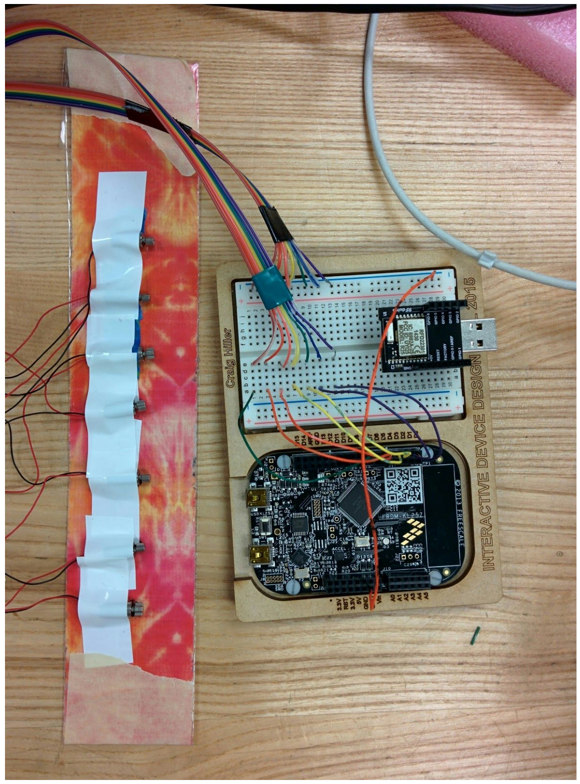
Obstacle Avoidance





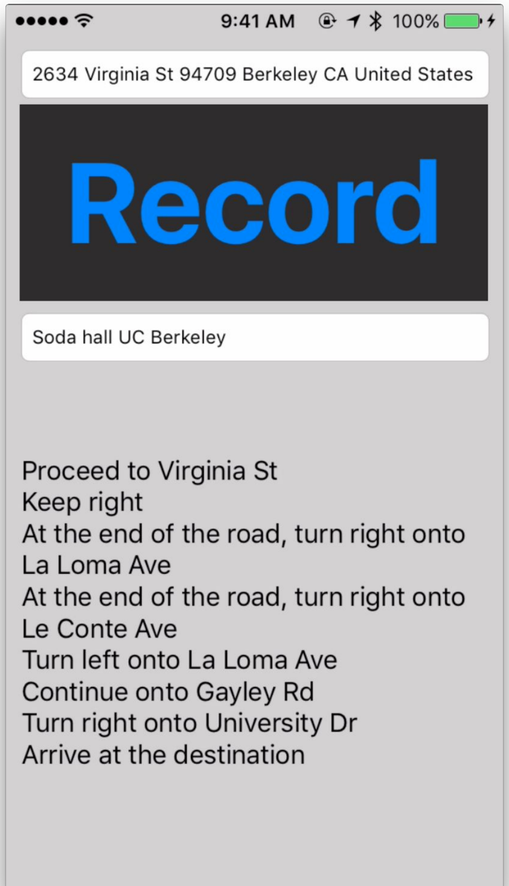
The augmented white cane prototype is constructed from black foam and a short dowell. We didn't want to invest significant time/resources into designing a proper handle or buying a white cane. Using these materials, we were able to iterate quickly on what worked and what didn't, such as positioning the ultrasonic sensors. Since we secured them with rubber bands, they were easy to adjust. To keep the angles, we just had to put an appropriate sized stopped behind them. The dowell fit nicely between the sensors so it was easy to attach. The black foam as a handle provided a decently comfortable solution that was easy to resize/remake. We easily taped the coin vibrators onto here and we could check if the positioning felt good in a human hand. Also pictured is the state machine that powers the measurements/feedback in the cane.

Navigation



With this prototype, we really wanted to see if the motors could be controlled from a microcontroller and if by doing so we could get a decent sense of motion on the wrist. To start this, we first needed to make a wristband. Since we wanted something quickly, this is made from a couple strips of duct tape covered in packing tape. Instead of a complicated clasp mechanism, a piece of masking tape (the white tape on the ends of the band in the picture) was used. Next, we obviously needed the motors, we decided to put on seven since it allows for three on each side of the wrist and one in the center, which may be useful later. These were taped on in roughly equal spacing across the band, leaving extra room at the ends to allow the band to close. This current version has a mess of wires, but in future versions we hope to clean this up and keep it more self-contained. It would be useful to add H-bridges to this circuit as well so that we can reverse the direction of the motors. This would improve the resolution of the vibrational pattern and thus, provide a more distinct sensation. With this prototype we were able to test different numbers of motors, and get a glimpse as to how this system could feel on a user's wrist. A demo of the band is here: https://youtu.be/f-9pZ1GHJiE

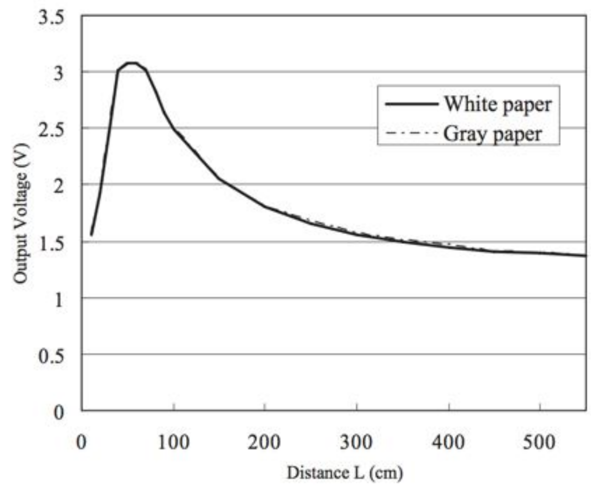
Controlling App



As a first pass on the controlling app, we modified sample code from Nuance's SpeechKit. This allowed us to pretty quickly get speech recognition up and running. From there, we determined the user's current location and then through the geocoder and a directions request determine how to get to the address that the user spoke. The app will repeat the recognized text as voice and directions will be shown on screen. Since this is a prototype for the team, we wanted a quick visual way to see all of this information without dealing with all of the nuances required to be accessible to the visually impaired. Most notably, we don't have a voice confirmation for the address, and the design is not particularly blind friendly. This prototype did confirm to us that we will be able to get instructions by voice though, which is really what we wanted to address. Here is a short demo: https://youtu.be/0xVNsfzi9LA unfortunatley, the sound generated from the phone was not captured in the recording.

Challenges

Sensors



- Mapping IR sensor to a linear affine function and measure the bias to calculate correct drop off distance.
- IR sensor is very sensitive to outside light, and we plan on putting a filter, but it might affect the reading.
- We need to ensure that the placement of the IR sensor and how the user uses the cane will allow the sensor to correctly output the readings within the operating range.

Power

- Given that our device is somewhat a wearable, we need to figure out how to maximize the battery capacity and form of the device, while minimizing the size to still fit a white cane.
- We're having issues powering the sensors after attempting to boost up the 3.7V to 5V battery output with a boost converter, so we're sticking with USB power for now.

Design

- Given the cylindrical nature of the device, we need to design a custom PCB that will fit all the components. Also considering usability, the sensors can be easily broken if exposed. We need to therefore design two enclosures, one for the power components and motors, the other one for the sensors.

Non-blocking Haptic feedback

- Whenever an obstacle is detected, we would like the vibration motor to vibrate (for 3 seconds) but the ultrasound sensor continues to measure readings. Essentially, we could have a separate thread to run the motor. Alternatively, we could start the motor and measure the time stamp. At the beginning of each loop, we verify if the time for the motor vibration has exceeded and turn it off correspondingly.

Reflection

Overall, we had a pretty successful first prototyping round. We learned a lot from what we built, especially with regards to the feasibility of the whole thing. Some of the highlights of what we learned are: how to provide haptic feedback to the user based off of combined readings from multiple sensors without blocking the processor, that a series of vibrating motors can accurately give a sense of motion and direction, and how to use speech recognition in an iOS app. Basically, we learned the answers to the questions we proposed at the beginning of P3.

Most of the challenges that we faced are listed in the previous section, but one more that arose was team availability and communication. We learned that even if we start early, if we only have a subset of the team working at a time, it is difficult for the others to get back up to speed on the progress that was made. This is something, outside the realm of technical problems, that we will work on improving this week.

One of the main concerns that was brought up from this stage was being able to power everything. We ran into problems with external batteries since they couldn't supply enough current to power the boards, sensors, and motors at the same time. In the coming weeks, we will need to address these power concerns and figure out a reliable way to power our devices without being connected via USB at all times.

While most of the designs haven't changed much since we met with the potential users in P2, we became more aware of the nuances of the design. For example, with the navigation band we need to be able to close it in a way that is simple, intuitive enough to be done without visual cues, and secure enough to not fall off while moving throughout the day.

Our designs and implementations still have a fair amount to go before they resemble any sort of non-research useable interactive device. Specifically, we have many different power sources, wires going everywhere, and a slew of different microcontrollers for each part of the project. One of the main things we want to do in the coming weeks is to integrate the three parts of this project together. At the moment each one is separate and not talking each other, which was fine when we wanted to see if everything would work, but now we want to see if everything can work harmoniously. Once we have a link between the three devices, it may be useful to go back to the people we interviewed and get their feedback on the system. By keeping the system modular, we would be able to reuse large parts of the code even if we end up needing to redesign our project.

Presentation

[SynthSense Prototype Presentation]

Code

Obstacle Avoidance :https://github.com/adithyamurali/SynthSense

Navigation band: https://developer.mbed.org/users/chiller/code/NavBandProto/

Controlling App: https://github.com/craighiller/speechDirections