NORTHEASTERN UNIVERSITY
Department of Electrical and Computer Engineering

Ultra-Infrastructure for the Visually Impaired: A Network of Medium Range Information for Explorers

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Abstract

Our capstone project joins Northeastern's Enabling Engineering club and Professor Mona Minkara to help those with visual impairments. Our goal is to create alternative infrastructure to communicate medium range navigation and geographic information Through this collaboration we aim to simplify navigation and identification for those with trouble and have designed a cane attachment to facilitate.

Through extensive research we have concluded that a combination of RFID and bluetooth will allow this to come to fruition. The design incorporates an RFID reader and bluetooth receiver to act as the main 'identifiers' and RFID tags and bluetooth beacons to act as methods of information dissemination. By leveraging the advancements made in these respective radio wave fields we will be able to handle the retrieval of both static and dynamic information with your cane from a range up to 50 feet. Using the same bluetooth chip, we will be able to output the information auditorily via a paired bluetooth device or the built in audio-jack. Extra functionality will be available with a companion application such as history or setting modification. We aim to test this project on Northeastern's campus by the end of Spring 2021.

Introduction

According to the World Health Organization (WHO), as of 2019 there are "at least 2.2 billion people [who] have a vision impairment or blindness" [1] and of that, almost 200,000 are considered completely blind [2]. Currently, the visually impaired can successfully navigate their environments using physical tools such as canes and seeing eye dogs, or use their limited vision to see obstacles. Existing GPS tools like Google Maps are widely used to travel through a city, and Voice-Over tools on cell phones make the directions very accessible to people who cannot see their screen. However, there are many intermediate markers that the sighted use to navigate an environment which you cannot feel with a cane or determine using a map application.

To help understand the goal of this project, consider spending a spontaneous afternoon exploring a new or your own city. Something as simple as walking down the street can provide so much information. You could find a bus stop, read the route number, then search on your phone to see all of the next stops. Chalkboards outside local restaurants advertise specials, and reading the pub's menu plastered on the window decides where you dine. Even infrastructure as simple as street numbers help determine your exact location when Google Maps fails to due to spotty cell service. For the visually impaired, there is no existing infrastructure to communicate this information to them.

In order to provide medium range navigation information, we aim to create a small device that affixes onto standard canes and automatically reads easy to find markers with locally stored information. The attachment will then translate this information into a Voice-Over message. An optional phone application can use the tag info to determine a user's precise location and supplement existing navigation apps. In order to meet the many use cases we will design two types of markers: less expensive stickers that communicate small amounts of static information, and a more expensive beacon that can send dynamic information further.

Since the brunt of the technology exists on our cane attachment, the markers will be significantly cheaper. Any city or institution can easily buy hundreds of markers, and a business can choose to invest in a few to make their stores accessible at a low cost. Additionally, since our marker-reading device is removable, users can remove it if they worry about damaging it, and transfer it to a new cane, making it a one-time purchase. The versatility of the static and dynamic markers serve many purposes, and all of the information is local and unreliant on good cell service.

Ultimately these markers serve to communicate the information that sighted people get from infrastructure every day. They provide information as simple as the gate number at an airport or the aisle in the grocery store. Museums can use markers to provide information about a piece of art when the user walks by instead of searching for a braille plaque. Train stations can broadcast train schedules to the cane and restaurants can advertise their specials. Tourist attractions can make informational signs more accessible by adding a marker. Endless use cases can be handled by this one system, and we hope that by providing markers at a low cost, it will be adopted by many cities, institutions, and independent businesses. By providing this medium range information, we hope it will improve day-to-day navigation, as well as empower the visually impaired to independently explore new places without having to set a route or plan in advance.

Related Work

As visual impairment has been an issue for humans throughout history, there are many tools and resources developed for the visually impaired use to avoid obstacles as well as travel through environments that provide minimal infrastructure for the sighted. One of the most recognizable tools is the white-tipped cane, although it is estimated that only about two to eight percent of blind people use a white-tipped cane. These canes offer independence in navigating by detecting physical obstacles. While this information is necessary it is rudimentary. Since the cane is constantly making contact with the ground and other physical objects, the tip gets worn down and requires that the cane be replaced approximately every three to four months. These types of cane can be purchased for about $25, which makes it one of the cheapest options currently on the market.

Many visually impaired people instead rely on seeing-eye dogs or sighted guides. Seeing-eye dogs, like canes, can lead a visually impaired person but do not provide detailed information about the venue. It is estimated about two percent of the visually impaired population use seeing-eye dogs. Sighted guides can be very useful at both navigating and providing intelligent information, but they are not widely available.

While a cane or a dog can physically get someone to a place, it cannot provide specific information about where they are. Historically, the visually impaired have been able to determine where they are using braille markers. Due to their physical nature, braille markers are relatively reliable since they don't rely on cell-phone data or have a battery life. However they cannot be updated easily and it can be difficult and unsanitary to search for braille plaques.. Additionally, since the invention of smartphones, the National Federation of the Blind states there has been a significant decrease in Braille readers and estimates only about ten percent of blind people can read it.

With technological advancement, there have been some new tools and resources created in the form of "smart canes". While these canes work to provide both navigation and general information, they tend to be expensive and rely on cell phone data meaning they are not always available to use.

The main smart cane on the market currently is the WeWalk [7]. The cane uses advanced sensors to provide improved feedback to users from the cane. This includes ultrasonic sensing, haptic feedback, bus API stats, GPS, and clockwise navigation. This cane is extremely technologically advanced and provides the user with feedback they would not receive with a traditional cane. Using a touchpad on the cane, the user will swipe to select menu options such as "Navigation", "Find my Phone" "Where Am I" and "Obstacle Detection". The cane is connected to an app that allows for customizability. This application does restrict the user as the cane must always be used with the app. Another restriction is the twenty-hour battery life of the cane or the battery life of the smartphone. The price of this cane is $450, which is extremely pricey especially as users have to replace the cane often due to typical wear and tear. The cane comes with its own navigation feature, although that tends to be redundant since users must carry a smartphone anyways. Users have also mentioned the speaker can sometimes be difficult to hear, especially in crowded areas like city streets. Because of the added technology, the canes tend to have bigger handles and are heavier than traditional canes, making it more difficult for some users.

At the Ebenezer School and Home for the Visually Impaired in Hong Kong [8], researchers developed a smart cane that uses physical RFID markers that tell a phone precisely where the user is. The cane accounts for lack of GPS precision and gives useful directions and information such as “The elevators are to your right, you are currently on the sixth floor”. The product has been developed specifically and only for use at the school, and uses map and navigation data stored in the cloud to navigate. Since the data is not stored locally, a smartphone and data are still required for use. As this product is currently only designed for the Ebenezer School, it is not on the market for widespread use.

Another class of solutions for helping navigation involve using a smartphone’s hardware with certain apps meant to solve a similar issue to ours. While these solutions approach the problem in a completely different manner, our solution addresses the shortcomings of these software issues and provides a robust method of communication.

Google / Apple Maps is the most obvious example of this. These apps contain a ton of features for navigation, location recommendation, and even some social media features that allow users to leave reviews of certain locations. Due to the scale of these applications, they also include many features addressing accessibility - including constant voice communication, cardinal directions, and accessible transit listing options. The main drawbacks of this approach involve the limitations of a GPS-based navigation system. Most obviously, the difficulties of maintaining a stable connection within an urban canyon (a dense city where cell connection is limited). Additionally, these apps are dependent on the hardware running them, meaning that both cost and battery life of the phone impacts the user’s ability to navigate.

Blindsquare [3] is another phone application, but entirely meant for the visually impaired rather than accessibility features. This app uses the APIs of navigation services, social media pages, local business information, transit services, etc. and streamlines the information to the user through voice assisted actions. In addition to using 3rd party API’s Blindsquare also sells beacons to universities and public places to provide more precise information. While the app is free and smart in it’s utilization of multiple sources for a single flow of information, it shares the same drawbacks as any other software using the phone’s cellular services for navigation. The introduction of the beacon is a smart idea for more precise location data, but it’s not a main component of their product.

Aira [4] takes a unique approach to navigation, and offers a subscription service which connects the visually impaired using camera-glasses to live support teams who tell the users what they see in the live feed. Aira has a 24/7 support crew that is always available to be called and can be accessed quickly through their mobile application. The service is $100/month for 120 minutes, or $200 for 300 minutes depending on the plan. The hardware is necessary as well, which has a battery life of its own. This solution can be quick and easy as long as you can get a representative on the line, but it shares the issues which come along with being tethered to a mobile device.

A final technology that many cities already implement to help the visually impaired is the addition of uniquely textured surfaces easily recognizable by the touch of a cane. The most common example is the yellow lines protruding near the ends of train platforms in Boston. Many schools for the blind and hospitals also have these surfaces built in for assisted use. These are great safety features, and are a simpe, robust solution to helping the visually impaired; however, it is a costly and large system and needs to be planned into construction developments, which is not ideal for a short-term implementation. Our proposed solution would be simple to add into any existing infrastructure in a city (ex. Traffic cones, poles, restaurant signs).

Design Specification

Overview

The cane attachment provides a modular solution for users: it can be removed and reattached at any time. While using the attachment, the user is provided with a means of both passively and actively gaining rich information about their immediate surroundings, as the attachment works in conjunction with easily found markers placed in the real world. Our system will include a cane attachment for receiving information and translating it to the user, a network of static tags and dynamic beacons to store the local information, and an optional phone application to use tag data with other internet-dependent navigation tools. To meet the diverse needs of the medium range navigational information, we will develop a cheaper static tag and a more expensive dynamic beacon.

Static Sticker

A flat, weather proof sticker that can be placed anywhere and will cost only a few dollars. This durable sticker can be placed on any location and stores about a sentence or two of information without any maintenance. It will passively hold this local information, requiring no external power, and can be read from up to 1.5m away. Potential use cases are street names and numbers, room numbers in a school, or the name of a painting in a museum.

Dynamic Beacon

The more expensive tag, this beacon will require a power source and maintenance, but a larger range and amount of information. The longer-range beacons provide interactive, dynamic information that can be updated at any time. Depending on the use case, the owner of a beacon can store information in the way that they see fit, using a mobile application specifically for beacon owners. A multi-tiered representation of information allows the user to quickly get a summary of the beacon nearby, and can navigate through a menu of options to hear more. The beacon can broadcast its information for up to 200m and the information on the beacons can be robust and changed at any time. In order to maintain information on this beacon, we will provide an application to the owner of the beacon for changing the data. Potential use cases are broadcasting the train schedule in a train station, or the day's specials at a restaurant.

Cane Attachment

The cane attachment will snap onto any existing cane and can be removed without additional tools at any time. The device will be waterproof and durable, so the user does not have to continue to replace the device. For user experience and feedback, the attachment will have a haptic motor to cause a vibration for notifications and a button to get user feedback. On- cane audio will be handled in three different ways, giving the user an option to use whichever is most convenient for them. The attachment will include a speaker, for outloud broadcasting, as well as an audio jack to connect wired headphones. The third option will be to Bluetooth connect wireless headphones to the cane .

As the user walks down the street the cane-attachment will be constantly scanning for tags. When a tag is found, the information is read off the tag and processed by a Text-to-Voice module. The user is notified by a haptic vibration and the information will be 'read-aloud'
There will be two modes the user can select from, Intentional or Explore More. In Intentional Mode, the user has to opt in to hearing the message read from the tag by pressing a button after a notification. Explore mode will automatically read out the information it reads from tags. When reading the Static Stickers, the information can be handled by a singular audio message.
Since the Dynamic Beacons provide multi-tiered information, the user can navigate through each option and its corresponding data with button presses on the device, or choose to do nothing after hearing the initial message.

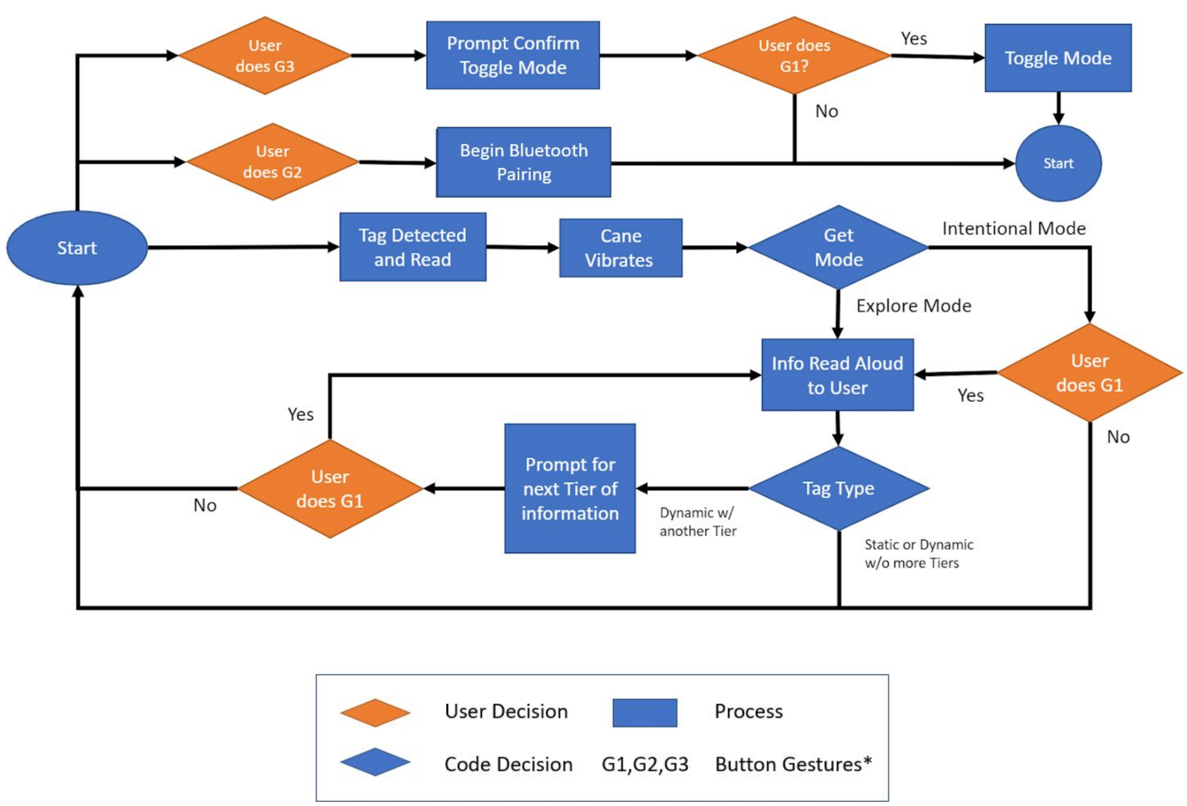
Additionally, our cane attachment will provide information on cardinal direction, as a useful feature when trying to navigate a city. When a user points the cane in a direction and does the 'Compass Gesture' using the button, the cardinal direction and the degree.

Companion Application

The cane works as intended without the need for a smartphone. If the user chooses to pair their smartphone with their cane, further features can be used with the smartphone to enhance the overall user experience. Whenever stickers or beacons are encountered, in-app audio provides the option of listening to navigation software like Google Maps in addition to the cane audio, all from the same headphones. Additionally the user can opt to send the tag location to their navigation software, to update to a more precise location. The information from tags is cached and can be accessed through the companion app for the device and read at any time.

Design Overview

User Flow Diagram for Stand-alone Cane Attachment



* Specific button gestures will be determined later on in the design process

Conceptually this design has 2 sides, that which reads and that which is meant to be read. We have a modular attachment intended for canes (that which reads) and an RFID sticker or bluetooth node containing information (that which is meant to be read).

Less robust in nature, an Ultra-High Frequency RFID sticker only has one component: itself, and will be read wirelessly from a short distance using the modular attachment subsequently described. This is our static node and implies that the information written to the tag cannot be altered, certainly not in real time.

The more complex source of information is our dynamic tag, our Bluetooth Low Energy (BLE) node, which acts as a beacon for broadcasting information. These bluetooth nodes can hold larger amounts of information and can be changed by its owner in real time. The owner of a beacon interacts with its information using a mobile application designed specifically for beacon owners. This allows the user to quickly and easily update the content on their beacon with rich content of their choosing, and provides the owner with control over the order of each "tier" of information displayed to the user. For example a restaurant can display their name and a brief description of their cuisine first, hours next, followed by the day's specials. In this case, each tier can be toggled through using prompts in the user's audio interface: for example at a restaurant, the menu could consist of "menu, hours, specials." Each characteristic corresponding with each service will be more detailed information: the menu items, hours, or specials themselves. As the cane attachment pairs with the beacon, the user is presented with the first tier and prompted to press the button to access the next tier.

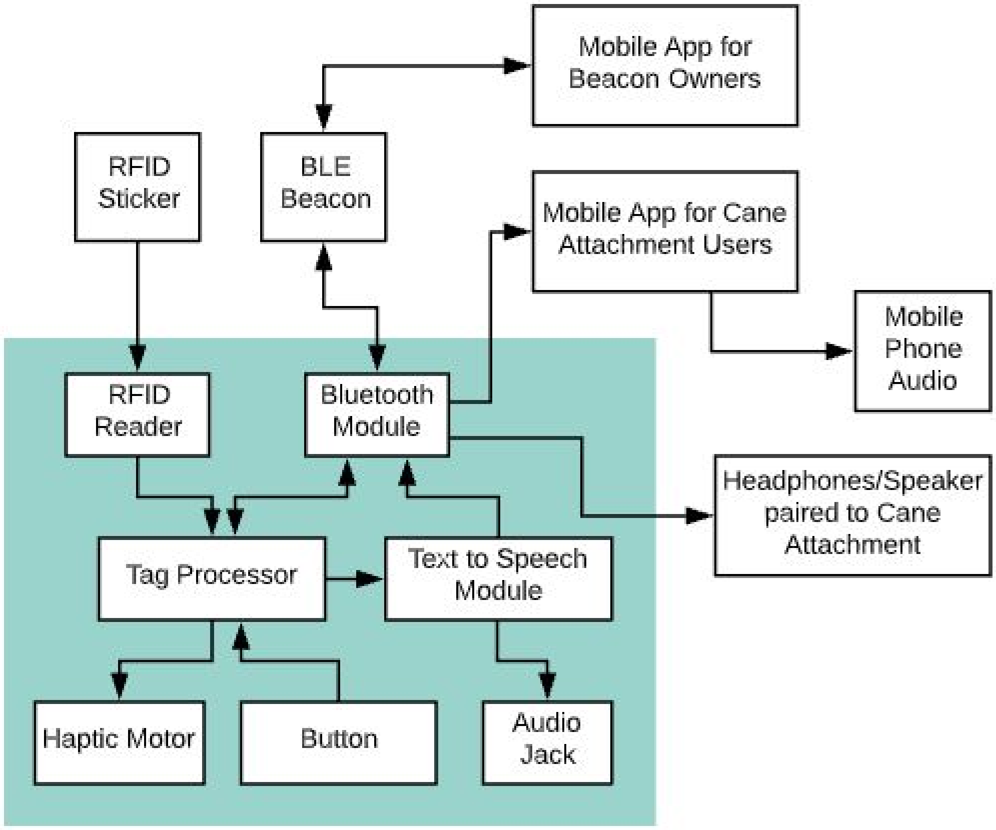
Step 1 of the reading process begins with the attached readers (RFID and Bluetooth) located at the top of the cane. In order to find new tags whenever you are within range, both readers will be continuously scanning at the most efficient intervals to ensure no "miss" of a nearby marker whilst managing battery usage. This information will then be transmitted to the internal processor that will locate and structure the proper response meant to be relayed to the user.

Step 2 handles communicating the information to the User, and is dependent on the two modes: Exploratory or Intentional. In Exploratory mode, any time information pertaining to the user's surroundings is processed by the cane, and directly output through the user's desired audio output. In Intentional mode, all beacons or stickers encountered alert the user with a haptic vibration. There is a multi-purpose button at the top of the cane with 3 purposes. 1.To toggle between Exploratory and Intentional mode. 2. to initiate Bluetooth pairing to the mobile app or headphones and 3. When in intentional mode, to make that 'intentional decision' to vocalize the information from the tag you have read. If you are in exploratory mode, the information sent to the user will be heard aloud from the audio output device immediately. If in Intentional mode, after having discovered a new tag, using haptic feedback there will be indication of a newly read tag and the option to listen to that data with a press of the button at the top of your cane.

The benefit of our modular attachment is its functionality devoid of another device, capable of autonomous object identification. However, we must admit the power a connected device can provide and thus have extended functionality available when paired to a mobile device via Bluetooth. The following outlined steps are only capable when successfully paired.

Step 3 is to send the information read from step 1 and use it with your device to gather additional feedback. Using a Bluetooth Radio we send the data to the connected device and access our app to retrieve more information on the marker and cache the data. The app will look-up the markers coordinates based on a unique marker ID and open Google Maps to identify some of what unmarked locations are around or simply begin directions beginning at that point.

Additionally, the device will include a power button. When the device is turned off by the power button, no tags are processed in the background and only when the user clicks the power button once does the device attempt to discover beacons/stickers.



Design Details

Major software and hardware components are outlined in the diagram above. Various interactions between each element in the chart occur to enable a fully self-contained system that can also be enhanced by a mobile application. The cane attachment itself does not rely on the mobile phone in any way, having a mobile phone simply increases the user's options and augments the experience.

Static Tag Reading

The static tags are a basic marker type that communicates minimal information to canes within 1 to 2 meters. The goal is to use ultra-high frequency RFID to communicate the information since UHF tags are inexpensive and can be bought for a few dollars.

The information will be stored on Confidex Print-On Metal tags and will operate on the global High Frequency (HF) 865-980 Mhz band [6]. This tag variety has lots of intrinsic benefits, some of which include being tested for extreme conditions and are weather-proof, power-wash proof, and safe from extreme heat. This also makes them optimal for placement on other metal surfaces and will last at least 1 year before having to be replaced.

Depending on the specific tag type we select, the max range can be as low as 1.5 meters and as high as 6 meters. The tags have up to 480bits user written memory [6]. This gives us enough space to use about 10 bytes for global information using enumerated codes, such as tag version, date placed, cardinal direction or tag type (street, mailbox, classroom) . The following 400 bits can be used to store an ASCII string up to 57 characters long for Street names, etc. As a bonus, these UHF tags are frequently used in traffic situations, so we know that the speed of a walking user passing the tag should not be an issue. Another benefit is that these tags are printable, so we can label them externally to help us debug.

The UHF RFID read/write device is considerably more expensive but can be used to write any information to the tags and read the information. Potential issues are range, balancing power consumption with detection rate, and determining how to initially write to the tags. To balance the potential battery issue, we aim for a 10% duty cycle. All RFID Read/Write chips considered can write to a tag in 80ms[5]. Determining how we write to the tags initially may be an issue as writing it into the user code does not make sense. Potential solutions are to create a separate Write-Only FW build so we can manually use the reader while connected to our laptops.

UHF readers have up to 16m range, but selecting the right UHF tag size will limit the range. For example, a Confidex Silverline Micro RFID tag can be read from at most 1.5m away, which limits the read range to our specification. If we discover we need a larger range, other similar RFID tags exist for us to test.

Dynamic Beacons

The bluetooth component of the cane attachment can be used to detect nearby "beacons," which store richer information than the static tags. The beacons themselves are composed of a Nordic nRF52 board or similar, which broadcasts data over Bluetooth Low Energy over a ~50 foot range. These beacons provide data which is read from the cane attachment itself, using a bluetooth chip built into the Raspberry Pi Zero W we plan to use. If multiple beacons are placed within range of each other, the signal strength of the BLE signal (which is always advertised by beacons) can be used to determine a user's proximity, so the right information is processed in the right place. The information stored on each dynamic marker can be updated at any time by the owner of the marker. In a mobile application specifically for beacon owners, the user determines the content and order of information advertised by their beacon. Using the Bluetooth radio on the nRF52, the beacon will temporarily stop broadcasting information and Bluetooth pair to the mobile app. Based on the user input to the application, the app will send an Advertised Name edit or a Tier edit. The tier edit will change the name of the tier in the menu as well as the information stored in that Tier.

User Interface

The user interface on the cane will consist of haptic vibrations to notify the user and a button to get their feedback. While implementing haptic feedback can be a very complex process, our product will only need one simple type of vibration, on or off. To implement this, we can buy a basic haptic motor or vibrating disk with two leads. We can attach these leads to our microcontroller, and determine in our firmware when to turn the motor on. Our biggest concern is designing a way to mount this motor such that the vibration can be felt however the user is holding the device. This will likely involve testing different housing materials, and likely building our housing so it holds the motor in place.

User feedback will be handled using a single button. Similar to the haptic motor, we can use a two-lead system for the button and handle debouncing in the firmware. In order to have a smooth feel, we will attempt to build the button into the housing, and create a mechanical button with the two leads attached to the microcontroller. Power on-off will be handled the same with an additional button.

Text-to-Voice and Audio Routing

Given the advanced signal processing required to turn text into a voice, we intend to buy an existing text-to-voice chip. Small chips are available that take an ASCII input, and output the audio to an audio jack or speaker. Currently, we have been researching the Emic 2 Text-to-Speech chip. It has an audio jack and output for an 8 Ohm speaker, and requires a 9600 bps serial input. Using this type of product, we can easily expose the built in audio jack to the user for connecting headphones. However, if we additionally attach an 8 Ohm speaker, we must consider how to determine where the sound is routed to. The Emic 2 does not give an easy way of choosing the output via the serial input, so we may have to handle routing the audio by a switch circuit operated by the microcontroller.

Microcontroller

The microcontroller is the core of the device, which handles processing and caching the tags, interpreting user inputs, and operating as a state machine. We intend to write all our firmware in C and handle all on-cane code on a single microcontroller, with a built in Bluetooth chip.

Upon tag detection, the microcontroller receives the raw static tag data from the UHF RFID reader and raw dynamic marker data from the built-in Bluetooth module. In order to communicate with external sensors such as the RFID and any other sensors we may need, the microcontroller must have either a SPI bus or I2C bus based on the RFID reader we select. The microcontroller decodes the raw data from the tags into a string format, and temporarily caches the information about the tag to local memory.

This puts it in a state where depending on the mode the device has been set to (which is also stored by the microcontroller), it either immediately streams this data to the user or alerts the user by turning the haptic motor on over the GPIO pins. If the Android app is also in use and connected, then the microcontroller communicates all information about the tag with the app through a Bluetooth connection to the user's phone. If no mobile connection exists, the microcontroller routes the ASCII string to the text to voice module, for output over the audio jack or speaker. The text-to-voice chips we have researched require input over a 9600bps serial bus, so our microcontroller must be able to provide this information over a micro-USB.

Additionally, one of the most complex roles of the microcontroller will be maintaining all Bluetooth functionalities of the cane. It must balance constantly searching for any advertising Bluetooth beacons, and maintain a persistent Bluetooth connection to the user's mobile device if connected. This is feasible since the Bluetooth specification theoretically allows for up to 7 simultaneous connections. As a user encounters a beacon, they will by default get the name of the establishment which owns the beacon, in accordance with Bluetooth Low Energy protocol. This occurs through Bluetooth Low Energy's mechanism of advertising/discovery of "services" and "characteristics" which store various properties.

Battery

Given that our project needs to be portable, we will need to supply our microcontroller board with a reliable 5V power supply through a battery. Since major damage can be done to the entire system if exactly 5V is not supplied, we must provide some sort of power regulation system. Our ideal setup will include a 3.7V lithium ion battery, with over 1000mAh to meet battery life requirements, connected to the GPIO pins of the microcontroller via a charging and voltage regulating circuit. Many 3.7V Lithium Ion batteries are available for around $20 dollars, and we can buy an existing charging and regulating circuit for about the same cost. If we choose to use the Raspberry Pi Zero, there are existing portable power platforms we can purchase. In a worst case scenario, where the lithium ion battery circuit fails, we plan to buy a commercial power bank that will power the board over USB.

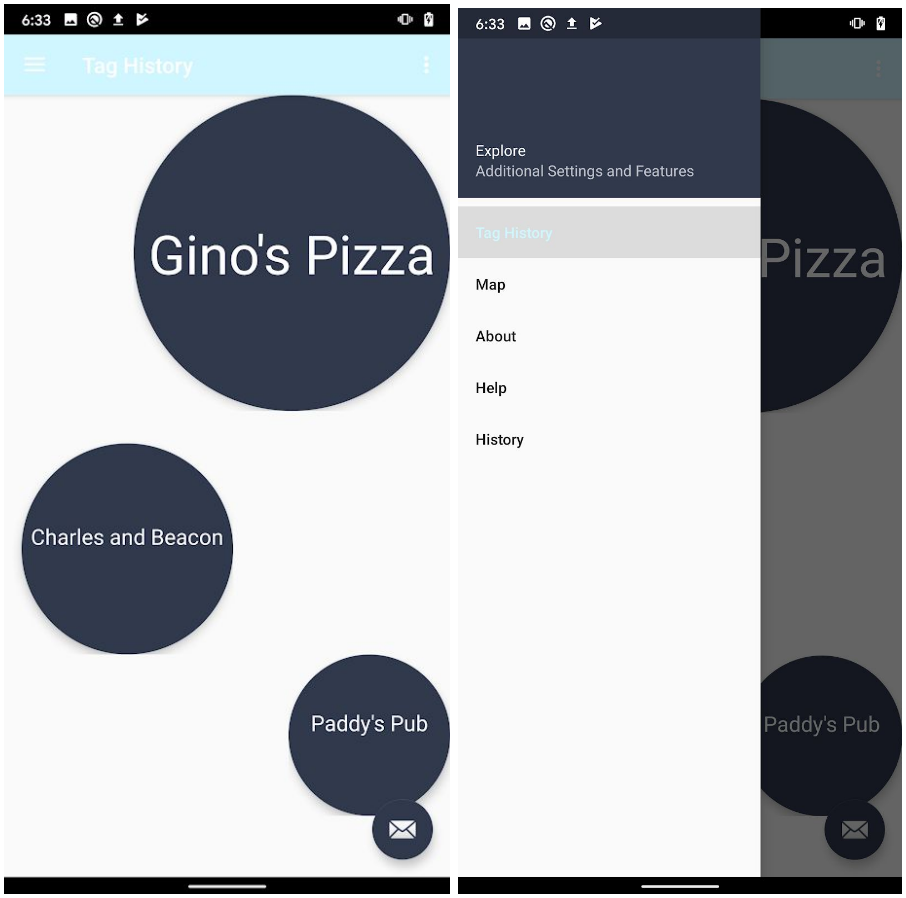
Housing

In the interest of user ergonomics and a pleasant aesthetic, we plan to encase the device in a 3D printed housing which will attach to the cane. We plan to use velcro straps to attach it securely to the cane in a modular way so that it can fit any cane. In order to ensure the device stays in place we will add rubber to the inside of the housing. The goal is for it to be resilient, water resistant, and easily adjustable, as well as look and feel modern and sleek.

Android App

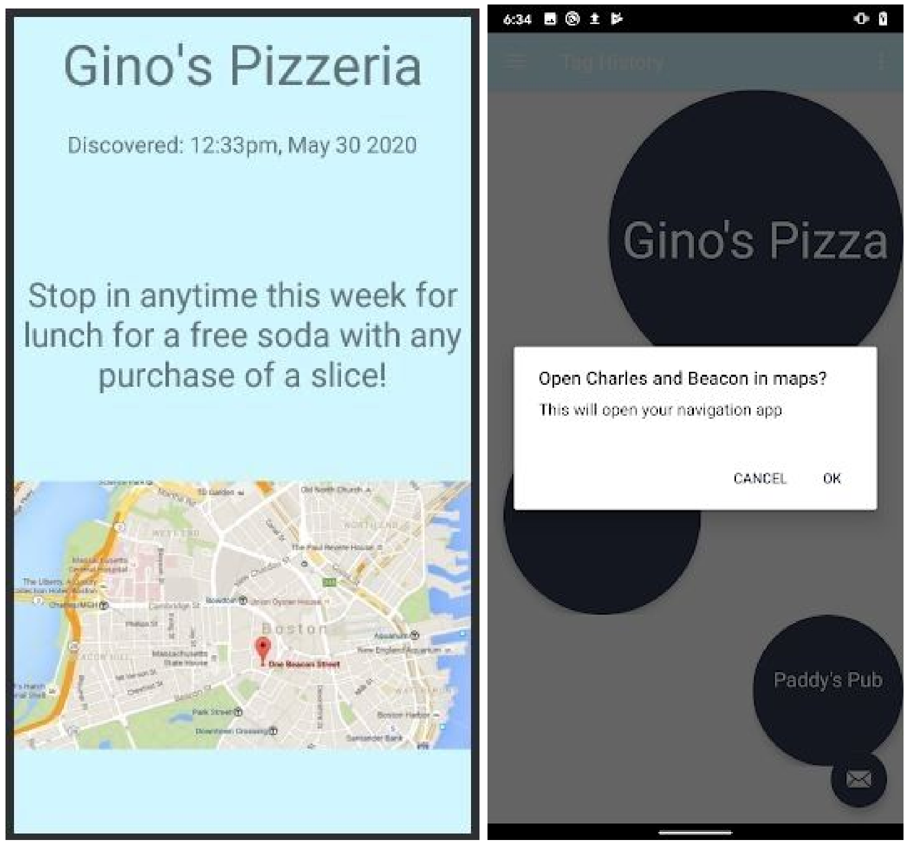
We also plan to have an optional Android app which can interface with the device. This will only extend the functionality of the device, it is important that this is not required to use our device. The app will be written natively using Kotlin, the popular mobile framework of Java. For web requests associated with transit APIs, we will be using Retrofit. The built in Android Bluetooth framework allows for a reactive app architecture, so the app will be using RxJava for graphical displays. The phone having access to better hardware and software capabilities is something we want to expand on the features of the main device. The encoded information will be key to decoding the information presented locally from the marker data.

This is an example of the main screen of the app, which will feature 3 buttons containing the information from the last 3 signals received. These include both the static passive tag info, as well as the dynamic information from beacons.



Left - main screen, right - expanded navigation drawer

Once a user presses any of these tags, they are directed to a screen where they can find additional information. At a minimum, the tags will fill in enough information to display the name of the location, message, timestamp of passing, and coordinates on a map of the tag. Additionally, when the main tag buttons are held down, an intent will be sent from our app to open a mapping application (ex. Google Maps) and show the coordinate from the tag in relation to a better mapping software.



Left - Tag selected view, right - Tag long-hold view

The history will be displayed in a list on a seperate screen where the user can open any previously scanned tag and find the metadata associated with that tag. There will also be a settings screen to allow the user to change the volume level and haptics strength sent to the device, as well as a connecting screen for pairing.

The app will be designed with the specific intention of fitting Android's built in accessibility features for easy use. Android accessibility guidelines request that layouts be represented with large buttons and content wrappers that label areas of the screen. This is so that visually impaired users can drag their fingers along the screen and have specifically read content labels to provide the information relevant to the actions in that area. For example, the 3 bubbles on a white background provides a high-contrast, large area that can tell the user the meta-data being stored on the tag (or a shortened description of it). Our application design will also feature a side-navigation drawer, a popular design for additional screens in most modern applications. This is another feature that plugs into the Android visually-impaired tools as well, for the labels are easily read with the action-to-speech modules and allow for seamless navigation between screens.

Schedule

Timeline			Team Members					
BLOCK	WEEK	Goal	Daniel	Nicholas	Katherine	Neil	Nithila	Joshua
A	1 1/11/21	Create static and dynamic tags to test	Raspberry pi set up	Dynamic tag creation	Dynamic tag creation	Static tag creation	Static tag creation	Raspberry pi set up
	2 1/18/21	Reading Static Tags						
B	3 1/25/21	Reading Dynamic Tags	Read initial static tags with raspberry pi	Read initial dynamic tags with raspberry pi	Text to speech	Read initial static tags with raspberry pi	Read initial static tags with raspberry pi	Text to speech
	4 2/1/21	Turn it into Speech						
C	5 2/8/21	Microcontroller BLE	Local info write process to tags	Compass test and beacon manageme nt system	microcontr oller and button mapping	microcontrol ler and button mapping	Local info write process to tags	Compass test and beacon management system
	6 2/15/21	Uploading local information to static tags						
D	7 2/22/21	Standalone Reading	Android app	Android app	Haptics	Local cane cache	Haptics	Local cane cache
	8 3/1/21	Headphones vs. Phone						
E	9 3/8/21	Spring Break						
	10 3/15/21	Hardware design assembly	Wire everything up and test battery life w/ Mona and make changes	Wire everything up and test battery life w/ Mona and make changes	Wire everything up and test battery life w/ Mona and make changes	Wire everything up and test battery life w/ Mona and make changes	Wire everything up and test battery life w/ Mona and make changes	Wire everything up and test battery life w/ Mona and make changes
F	11 3/22/21	Revisit stretch Goals	Visual Features & Final Report	Visual Features & Final Report	Visual Features & Final Report	Visual Features & Final Report	Visual Features & Final Report	Visual Features & Final Report
	12 3/29/21	Final reports (written and oral)						
G	13 4/5/21	Test and practice	Testing and Validation	Testing and Validation	Testing and Validation	Testing and Validation	Testing and Validation	Testing and Validation
	14 4/12/21	Touch ups to everything						

Impact

The need to create a better environment for people of all abilities to navigate is clear. Cities must be the ones to update their infrastructure to accommodate for persons with disabilities, rather than lay the responsibility on the citizens. Our device's most powerful feature is the ability to communicate public signals through a means that is easy for anyone to use. In the past large signs have attracted people to locations, nowadays apps like Yelp attract people to locations. Who's to say that the future can't have bluetooth and UHF RFID guide us through a city for the first time.

Many of the existing solutions for helping the visually impaired navigate place the technical responsibility on the user - the opposite of how it should be. For example, smart canes need expensive sensors to tell the user what's physically there and require a smartphone to pair. Mobile mapping services also require a smartphone, plus a good enough GPS signal to maintain a real-time location. Cities have a notoriously bad reputation of keeping a reliable GPS service, especially in denser downtown sections. Our device eliminates both these needs, as all the information being streamed to the user is encoded in the signal itself. A cell phone is not needed, but can amplify the information using the hardware on the smartphone.

Stickers can be easily mass produced or sold on an individual basis - many apps currently exist to encode these tags already! Our device aims to be a cheaper, more reliable alternative to these other approaches. It can be easily attached to an existing cane (meaning a single device can be used across many different canes) to make it even easier to implement into the user's lifestyle.

We imagine college campuses adding in beacons and stickers to buildings and doorways, making it more accessible to students. Downtown urban areas with street corners labeled by our stickers for everyone to read, warning citizens about construction hazards with custom stickers on orange cones. Hospitals and medical facilities with all entryways labeled by UHF signals, and a suite of devices for all patients to use in the building. Bus stations with a static message of the bus schedule, or if the user has a cell phone, integration with transit APIs to provide real time alerts of the bus. A world where anyone can explore.

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