<Name> - Team C

TODOs

- [ ] **Find a name**

Problem Space

- [x] ~~Specify solution/problem (crosswalk focus)~~

Intervention

- [ ] Call Gordon, identify main pain points

Feature List

- [ ] More details on how it works (fill in details for our two new features we're focusing on)

Architecture

- [x] ~~Adapt devices and description in architecture design~~

Timeline

- [x] ~~Add milestones~~

Questions Gordon

- Is crossing a street a burden for you?
- How dou you currently cross a street? Which external help do you use?
- If yes, could you think of a solution that would helo you to overcome it?
- Do you know any software in this space?
- What steps do you have to take to cross a crosswalk or traffic light?
- Would it help you to know the distance from one side to the other of the crossing?
-

Problem Space

What is the problem you're addressing?

The problem we are addressing is that blind people cannot walk independently and safely without external help, especially when crossing crosswalks. While external help like white canes or guide dogs are helpful for general navigation, they are not infallible and can lead to some errors. In fact, according to this source around 7%-13% have an accident at least once a month that often require medical attention. This is further compounded by the inherent dangers that the visually impaired face when it comes to crossing a crosswalk. To further illustrate this, we can first break down the steps a visually impaired person would have to take as follows:

1. Detecting and identifying the street
2. Aligning self to cross
3. Identifying when they can cross
4. Maintaining crossing alignment

Most, if not all of these steps are not fully aided by the tools currently available to the visually impaired. Furthermore, the common techniques used by the visually impaired can be prone to errors due to factors such as incorrect or missing information (source)

This changes walking habits and reduces confidence of being an independent traveler. In our project, we want to create a system that improves the safety for visually impaired travelers crossing a crosswalk, and thus make them more independent and reduce potential harm.

Who is the target population/user?

The main target population/user would be blind/visually impaired people who are unable to see/have difficulty seeing what is in front of them without the use of tools (such as a white cane). More than 1.3 Million people in the US are legally blind and around 8 Million people have a visual disability (source). In particular, we are focusing on young blind/visually impaired people that live in in cities. This is because since we are focusing on crosswalks, cities will be where the more dangerous crosswalks will be. Furthermore, in comparison to the general public, blind people are over represented in cities (source).

Why is it important?

Still, current infrastructure is not fully accommodating of blind people. Take tactile paving for example. Although it's common in many countries around the world, there is no good standard for tactile paving (source). In fact, there are even documented cases in which the paving leads people into obstacles such as trees or ledges, making it outright dangerous instead of helpful (source). This can be extra dangerous with crosswalks, where detecting the street and aligning oneself with the street can have an error happen due to the incorrect info from the tactile paving. Furthermore, over 60% of blind people travel more than 5 times a week outside one's own residence where they require support. On top of that, almost half of the blind travelers travel an unfamiliar route which requires good systems to make them feel comfortable, safe and independent.

What previous work has been done in this space? Where did it succeed? Where did it fail?

Stanford researchers created an improved version of the white cane that has sensors attached to it that allow the cane to “self-navigate” (video). It works by using similar sensors to the ones used in self-driving vehicles to detect when obstacles are in front of the user, and adjusts itself accordingly via a spinning wheel mechanism. When the wheel spins, the user feels a “tug” that tells them how to move in order to avoid the obstacle. It succeeded in a way, that with 5 minutes of training, blind people increased their walking speed by 38%. Another aid for blind people was made by a Korean researcher to aid in crossing traffic crosswalks. It works by scanning for a pedestrian signal light and determining when it shows the walk signal. The device succeeded in that it had a 96.2% color interpreting accuracy, however overall it only managed to get a 74.4% overall accuracy, showing room for improvement (source). Finally, this article outline many apps made with the visually impaired in mind (source). However, upon checking the apps all of them no longer seemed to be supported. Thus, these works for some reason or another showcase a potential avenue of exploration: allowing for safer crossing of crosswalks. The Stanford study doesn’t help in this regard as it only augments what the white cane can already do in detecting obstacles, and thus doesn’t help with dangerous tasks that don’t involve obstacles such as crossing a crosswalk. The Korean study, while similar, is narrower in scope in that it only works with crosswalks with a pedestrian signal, thus limiting the crosswalks it can support. Finally, the discontinued apps showcase the need for further improvement in supporting the visually impaired.

Intervention

How do you plan to address the problem/part of the problem?

The way in which we want to address the problem and improve safety for the visually impaired is by providing ~~assistance in facing the crosswalk and~~ assistance in actually crossing it. ~~To provide assistance in facing the crosswalk we would use the sensors from the Galaxy Smartwatch (such as the compass and GPS) to guide the user in where they should face to align themself with it. This would help in the first two steps of what a visually impaired person takes for street crossing (detecting and identifying the street as well as facing themself towards it).~~ To provide assistance in actually crossing the street we would attach direction sound microphones to the white cane to measure the incoming traffic. Furthermore, sensors from the smartwatch (such as the compass and GPS again) would be used to alert the user if they are veering off course. This would help with the other two steps (determining when it is safe to cross and maintaining the crossing alignment).

Why do you think it will help give your problem space (related work, target population, etc.)?

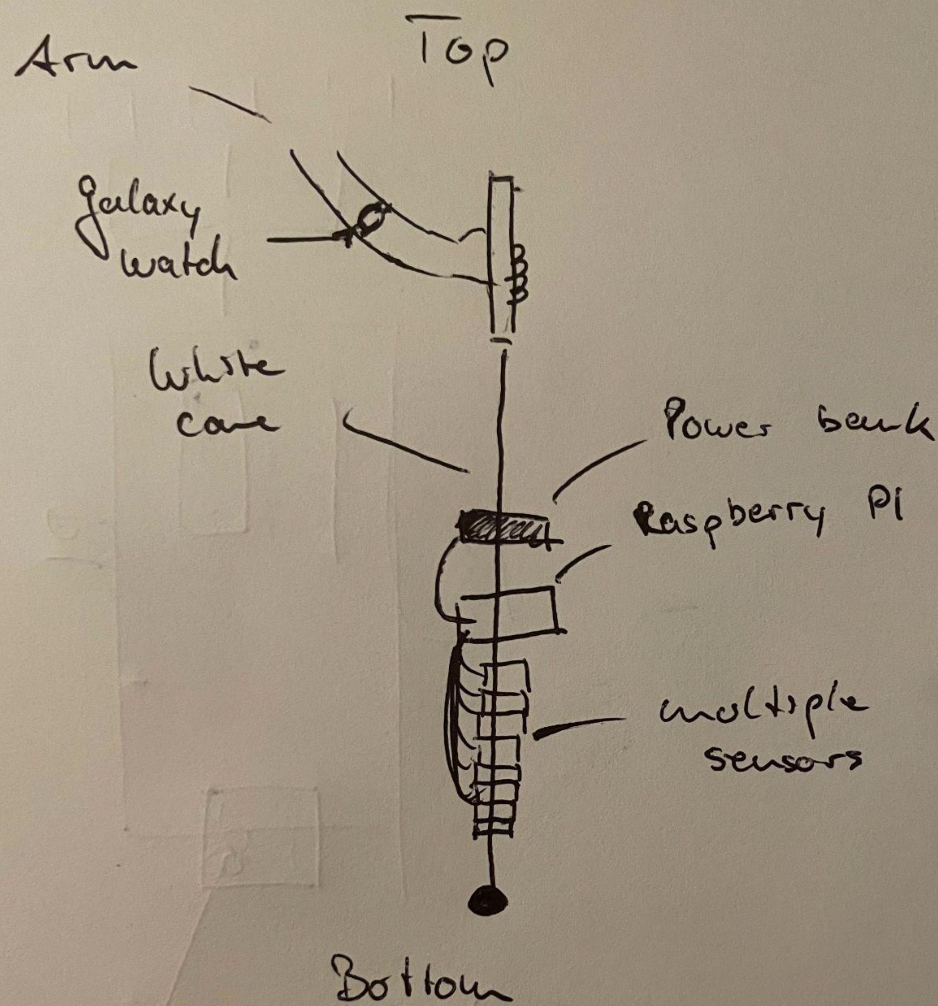
Our solution is ideal for our target audience as it provides aid on one of the most dangerous tasks a visually impaired person in a city might face. Furthermore, as mentioned in the problem space, this is an aspect that hasn't seen much focus in the past. While some studies, like the Korean study with the traffic crossings, partially tackle this issue, it has a reliance on a feature not present on all crosswalks. Thus, our solution would be more widely applicable than previous works for a dangerous situation to our target audience.

This solution is going to be ideal for most of the target population as it is very convenient and does not require the visually impaired pedestrians to change a lot about their behavior or hinder them in any way. As seen in the project of the Stanford University, within 5 minutes, the walking speed of visually impaired increased by 38%. This turns out to be a great success and boosts the confidence of visually impaired.

Give us your vision of what your intervention/solution will do and how it will do it. Walk us through what using it will be and feel like. Add pictures and drawings if helpful. Convince us that this is the right solution to your problem.

We envision the solution to require three core devices: a Raspberry Pi computer, directional microphones and wearable Galaxy smartwatch. We want to attach the microphones to a white cane facing either side of it to detect the frequency of soundwaves produced by approaching cars. The raspberry PI is processing the frequency signals and calculates if it is in excess of a certain threshold.If the consensus comes to the conclusion that there is an approaching car, a notification will be sent to the galaxy watch that the user is wearing.We also want to let the user know if he/she is not walking straight by using the galaxy watches magnetometer to track their alignment and then correct their course if they are veering via different vibration frequencies to indicate different messages. One vibration: going too much to the left, two vibrations: going too much to the right.

In addition to crossing the street we also want to use navigational street level data scraped from the google API, in conjunction with the galaxy watches GPS sensor to instruct the user to rotate or turn to face the crosswalk if they are not facing it. This actuation will be achieved by audio instructions from the galaxy watch.



Top
Arm
Galaxy watch
White cane
Power bank
Raspberry PI
multiple sensors
Bottom

Consider that you will be demoing this at the end of the quarter. How will you demonstrate your intervention?

We will show the functionality of our system by having one of us use the cane apparatus with the watch to cross a nearby crosswalk.

Feature List

Give us a breakdown of the features you intend to implement with your system, what it will do, why it exists, and an example of how someone might use it (a storyboard). You may find drawings useful here to describe user interactions and interfaces.

Crossing a street/crosswalk

- Detect incoming cars/safety to walk
    - Directional sensors and PI
    - The directional microphones are measuring the noise of the incoming traffic. When it detects that traffic has settled down to a noise level that corresponds to stopped/no cars, it'll alert the user that it is safe to walk.
        - Why it exists
            - To alert the user if there are any oncoming vehicles, on the crosswalk they intend to cross
        - Use Case
            - If a visually impaired person attempted to cross the street, they would stick their cane out and the microphones coupled with the pi integrated into the cane would discern if there was an oncoming vehicle. Then this information would be actuated by a voice command through the alexa app on the watch.
- Walking straight
    - GPS and compass
    - Using the built in GPS and gyroscope of the watch, it can provide feedback to the user when it detects the user veering off from the path.
    - This feature will alert the user if they are veering off a straight path while walking, the alert will be a vibration(s),which the user can choose to ignore.
        - Why it exists
            - To let the user know they are deviating from their path if their intention is not to do so.
        - Use Case

            - As a blind person, I want to cross streets without going sideways so that I safely and quickly arrive on the other side of the street
            - A blind pedestrian attempting to cross an intersection needs to walk straight to reach the other side without entering the intersection. The watch will alert the user if they are deviating from the direction they were initially facing when crossing, thus making sure they are aware if they are off track.

- Length of crosswalk
    - Satellite
    - By marking the length of the road, the amazon echo can give the user updates on how much of the crossing is left (ie “there is 1 meter left”)
        - Why it exists:
            - To give direct feedback to the user on how much they have left to cross when needed
        - Use case:
            - A visually impaired/blind person may not know how much of the street is left, which is a problem normally due to [ask Gordon]

Face the user towards the street

- Detect when near street
    - GPS
- Give feedback to have user face direction to cross
    - Compass

Devices

What devices will you need to implement your intervention? You can use devices that we covered in class, but you are welcome to go beyond those in class if you have access to them. How do you plan to power the devices?

1) Alexa Echo
2) Raspberry Pi
3) Directional microphone

   a) https://www.youtube.com/watch?v=Yx2R3xtGRsg&ab_channel=TESRCo.%2CLTD
4) Galaxy Watch 4

Architecture

Are you using a network?

Yes, we will set up a TCP server on the PI and Galaxy Watch that allows sending of notifications from the PI and Galaxy Watch to the Amazon Echo. We will use WebSockets to use the established connection and send out notifications.

Where is your server? What devices are clients?

The server will be hosted on our raspberry PI and Galaxy Watch. The PI, Galaxy watch and our Amazon Echo serve as clients. The PI is connected to the directional microphone sensors, calculates velocity and proximity and decides whether there is a moving object of concern around the user. As soon as a message is sent over the TCP connection, the Amazon Echo will process this signal through its VoiceFlow synchronization algorithm to forward to its voice output system.

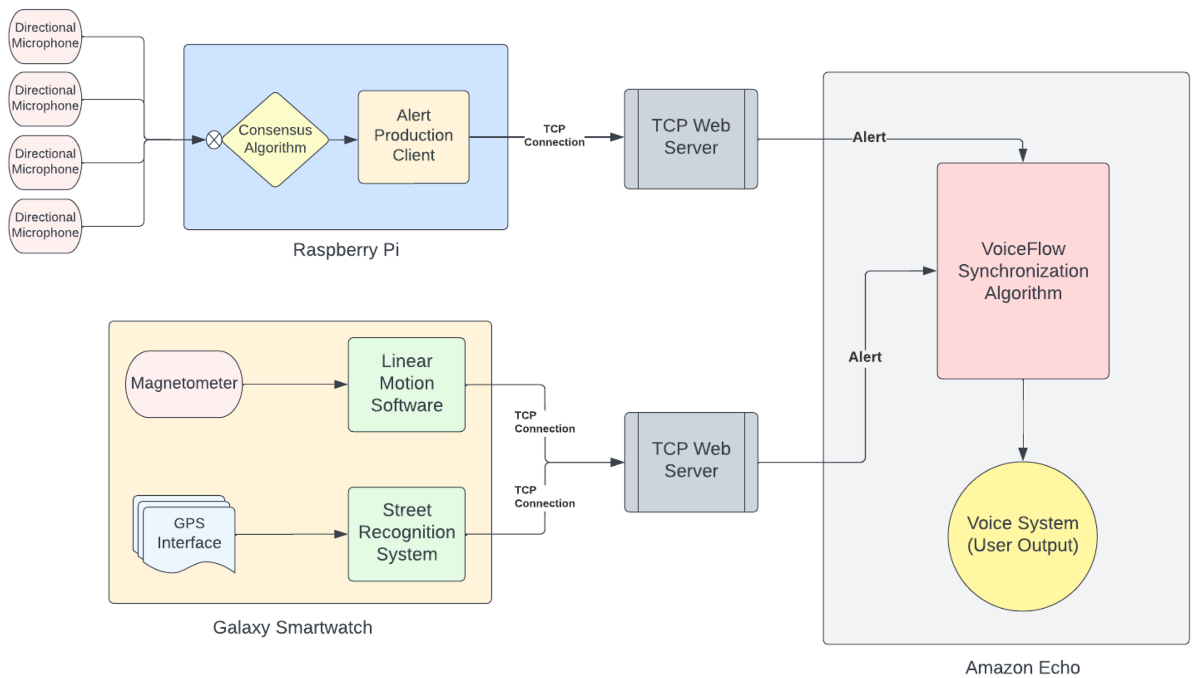
How is data stored?

We are using temporary data only and do not store any data on our servers or devices. As soon as the devices are turned off, the data is deleted.

Are you doing anything to protect user information?

For the current system, we are not planning to process or store individual information. However, we probably have to secure the tcp connection in the future to ensure the integrity of the system. Possible attacks could include the blocking of alarm messages which would not warn the blind person anymore or sending out false alarms.

Create a diagram or series of diagrams showing the flow of information through your system. Show how devices are connected and what protocols they use. Describe how information on each device is handled, whether it is saved, sent, or discarded. Give us a graphic of your system/network architecture. Don't forget to show the user where the data is relative to the user.



Our project dataflow is as follows:

Crossing a Street/Crosswalk Dataflow

Detect incoming cars/safety to walk Sub-Dataflow

Initially, four Directional Microphone Sensors will collect automobile velocity and proximity information about the user when crossing a street.

The automobile velocity and proximity information will be directed to our Raspberry Pi where our Raspberry Pi will run a consensus algorithm on the data collected by our Directional Microphone Sensors to accumulate the different velocity and proximity values across all Directional Microphone Sensors.

The Consensus Algorithm module will send its data to the Alert Production Client module which will classify whether there exists one or more automobiles of pressing velocity and/or proximity.

The Alert Production Client will then send its classification data to a TCP Web Server through a TCP connection to forward to the Amazon Echo, specifically to the VoiceFlow Synchronization Algorithm module.

Once the VoiceFlow Synchronization Algorithm module receives data from the Raspberry Pi signifying that there should be an alert raised to the user, the VoiceFlow

Synchronization Algorithm will send a signal to Amazon Echo's Voice System which will alert the user of a moving object.

Length of Crosswalk Sub-Dataflow

Initially, the Galaxy Watch GPS Interface will collect user location data and street layout data for the user.

The user location data and street layout data will be directed to the Street Recognition System module which will classify whether the user is approaching a street and/or crosswalk and send the data to a TCP Web Server through a TCP connection to forward to the Amazon Echo, specifically to the VoiceFlow Synchronization Algorithm module.

Once the VoiceFlow Synchronization Algorithm module receives data from the Street Recognition System module that there should be an alert raised to the user, the VoiceFlow Synchronization Algorithm will send a signal to Amazon Echo's Voice System which will alert the user how many meters is left to finish crossing the crosswalk.

<u>Walking Straight Dataflow</u>

Initially, the Galaxy Watch Magnetometer will collect linear motion alignment data for the user.

The linear motion alignment data will be directed to the Linear Motion Software module which will classify whether the user is walking in a linear trajectory or not and send the data to a TCP Web Server through a TCP connection to forward to the Amazon Echo, specifically to the VoiceFlow Synchronization Algorithm module

Once the VoiceFlow Synchronization Algorithm module receives data from the Linear Motion Software module that there should be an alert raised to the user, the VoiceFlow Synchronization Algorithm will send a signal to the Amazon Echo's Voice System which alert the user of his/her non-linear movement.

<u>Walking Towards a Street Dataflow</u>

Initially, the Galaxy Watch GPS Interface will collect user location data and street layout data for the user.

The user location data and street layout data will be directed to the Street Recognition System module which will classify whether the user is approaching a street and/or crosswalk and send the data to a TCP Web Server through a TCP connection to forward to the Amazon Echo, specifically to the VoiceFlow Synchronization Algorithm module.

Once the VoiceFlow Synchronization Algorithm module receives data from the Street Recognition System module that there should be an alert raised to the user, the VoiceFlow Synchronization Algorithm will send a signal to Amazon Echo's Voice System which will alert the user of an approaching crosswalk.

We will cover this topic in class on 11/1/22 and don't expect you to know what protocols to use where, but do your best, it's okay to be a little vague, but try to look up what protocols will be best for your purposes.

We believe a TCP connection between the Raspberry Pi, our Galaxy Smartwatch, and Amazon Echo would be the most efficient protocol to send and receive packet data between the two devices.

Timeline

You have 4-5 weeks. Give us a weekly breakdown of what features you intend to implement for that week. Keep in mind that the best plans are adaptable and give yourself some buffer room in case you fall behind schedule; have extra/bonus features planned if you find yourself with extra time. Distribute the work between your teammates. Don't forget to leave room for testing and make everything stable for the final demo.

Week:	Features:
By the end of **Week 6**	**If on schedule:** Conduct research on needs of visually impaired, including interview with potential user of device to identify user needs. **Milestone:** Understanding full range of requirements with a tangible list of pain points.
By the end of **Week 7**	**If on schedule:** Get audio representation of vehicle engine at various points(close/stationary, approaching slow, approaching fast) fon raspberry pi connected

	to microphone and develop sampling strategies **Milestone:** Having an effective model for detecting whether or not a car is approaching
By the end of **Week 8**	**If on schedule:** Test pi with microphones on a crosswalk under many conditions, and begin work on walking straight feature **Milestone:** Completing the car detection feature
By the end of **Week 9**	**If on schedule:** Develop strategies on how to utilize Galaxy Smartwatch sensors in order to determine if user is walking straight, as well as setting up the VoiceFlow Synchronization Algorithm to alert the user when they veer off course. **Milestone:** Completing walking straight feature (If **ahead of schedule**, can start implementing a potential facing the crosswalk before crossing feature)
By the end of **Week 10**	**If on schedule:** Polishing and testing the final product efficacy with potential to add improvements in order to prepare for the final project demo **Milestone:** Having a final working demo (If **behind schedule** at any point, then week 10 instead serves as a buffer for implementing any unimplemented features mentioned in the previous milestones)

https://srl.mcgill.ca/publications/2013-ICAD-WS.pdf

The study above implemented a GPS based speech guide,

https://www.eetimes.com/sensors-help-blind-people-on-road-crossings/

- Describes that street length actually matters - lets check with gordon https://www.visionofchildren.org/voc-blog/2018/7/13/smartphone-apps-for-the-blind-and-visually-impaired

- Ardiane GPS - not really in use

https://www.nytimes.com/2004/12/02/technology/circuits/street-smarts-a-device-to-help-the-blind-find.html#:~:text=The%20Mowat%20Sensor%20is%20a,audio%20panorama%20of%20his%20surroundings.

- Camera detection for crossings - not necessary if info is included on maps like London and Tokyo

https://www.researchgate.net/publication/309173663_Pedestrian_crossing_aid_device_for_the_visually_impaired

- Camera detection for traffic crossings, using the traffic signals to determine when a visually impaired person can cross

https://www.inclusivecitymaker.com/accessible-pedestrian-signals-guiding-sound-corridor/

- Detailing why sound corridors are good for city planning

Mfcc map, audio