Distance Information for the Blind

Group 14 Photonics 2

Duc-Quy Nguyen Photonic Science & Engineering
Alex Radelescu Electrical Engineering
Austin Singh Photonic Science & Engineering
Hunter Tanchin Computer Engineering

Project Narrative

Everyday we rely on our vision to give us information about our surroundings. Sight is one of the most important senses when it comes to providing awareness of the dangers around us whether it be wet floors, uneven sidewalks, and cars driving by. Without reliable eyes, it would be very difficult to walk freely and safely anywhere. A majority of us can wake up everyday and never have to worry about bumping into a tree on our way to work, but this is not the case for everybody. According to a study conducted by the World Health Organization in 2017, 39 million people around the world suffer from blindness. http://www.who.int/blindness/GLOBALDATAFINALforweb.pdf Blind people who have to walk to work face a challenge everyday. Vision is a privilege we often take for granted.

Cities were designed by people with vision for people with vision. While we cannot necessarily implement large changes to cities to make them more accessible and safe for people who are vision impaired, we can develop an aid to better help them navigate their surroundings. The reason why we chose to do this project is because we do not believe blindness should create barriers preventing people from living a purposeful life. The advancement of technology should be leveraged today so that people who are blind can integrate seamlessly into our society. We want to empower blind people to be able to move with confidence regardless of their surroundings whether it be walking downtown or exploring in a forest.

The conventional walking cane is a powerful tool for blind people, providing instantaneous tactile feedback that provides information regarding the user's immediate whereabouts. This allows for a blind person to determine where it is safe for them to plant their feet and move forward, as well as detect objects, walls, and elevation changes as they approach. The challenge with the walking cane is the limited range to detect potential obstacle hazards and relay this information back to the user. Standard white canes range in size generally between 110 cm -150 cm. Past this range, the white cane does not provide environmental information to the user whatsoever, and the user is left with only their other senses and the potential assistance from others to guide their way.

As such, the solution we propose is a device that would provide additional ranged information to a blind user. This device would both extend the obstacle and hazard detection at a distance for the user as well as provide information regarding potential obstacles at mid-to-head height that the current white cane entirely lacks. Such a device will allow for the user to better plan their path and avoid obstacles, such as walls, tree branches, bars, and counters. This solution would be packaged inside another common accessory for the blind; dark eyeglasses. As such, the device would allow for users to keep a familiar, useful tool in the form of the white cane while also gathering more environmental information to use as a supplement to the tactile information gained from the cane. Additionally, our head-mounted design leverages the sophisticated and natural motions of the user's head and neck to scan their environment and direct the use of the device.

While there are a few aids that have been developed for the blind, mostly in the form of modified white canes that provide additional sensory information, they are prohibitively expensive for your average person. Additionally, adding features and changing the natural responses of a tool that a user is already familiar and adept with may prove difficult for them to adapt to and reduce the overall effectiveness of the device during the learning period. By producing an optically based solution that is head-mounted, we hope to provide a solution that is both cost-effective and serves as a supplementary information gathering and navigation planning tool for the blind.

Requirements Specifications & Constraints

Detection Distance	2 m - 10 m
Electronics Speed	Fast enough to provide timely feedback to the user.
Connectivity	Effective connectivity in close proximity given power, form factor, and price constraints.
Laser Wavelength (ƛ)	1310 nm or 1550 nm
Laser Output Power (P_{out})	~ 1 mW
Operational Input	Intuitive and simple interfacing for any interaction with a visually impaired user.
Small	Eyeglasses-sized
Weight	< 1 kg
Operation Time	1-8 hours

The most salient constraint of this project is certainly the size of our system. If we are to adapt it to a standard sized pair of eyeglasses the packaging for our PCB and optical system has to be very compact and placed strategically in locations around the glasses. As the front of the glasses are not used for vision, it is possible we can place certain components, such as light detectors or emitters, on the lenses themselves, and run power and computation on a satchel attached by wire to the glasses themselves. Below are considerations

1. Printed Circuit Board

Per design requirement specifications, we shall design a custom Printed Circuit Board, have it manufactured by a third party, and assemble the necessary components onto it to provide our device with all of the functionality required, per the requirements stated elsewhere in this document. Designed with an appropriate software program, the Printed Circuit Board shall provide a platform to electrically network together all of the below components.

1a. Physical Requirements

Under financial restrictions, the Printed Circuit Board shall be manufactured with the following requirements:

I. The Printed Circuit Board shall be durable enough to withstand shock from daily wear and tear by a visually-impaired individual for a reasonably long time – comparable or almost comparable with other current market devices designed to withstand similar physical conditions.
II. The Printed Circuit Board shall provide mounting locations - holes, pads, etc. - sufficient for all of the components designed to be placed on the board itself.
III. The Printed Circuit Board shall be sized large enough for all of the components designed to be placed on the board itself, as well as shaped sufficiently in a form-factor that allows our device to encase the majority, if not the entirety, of the board itself.
IV. The Printed Circuit Board shall contain enough layers to reasonably allow for the balance of cost, the device's spatial constraints and trace locations.

1b. Electrical Traces

In consideration of the layout of the Printed Circuit Board tracing, it shall be manufactured with the following requirements:

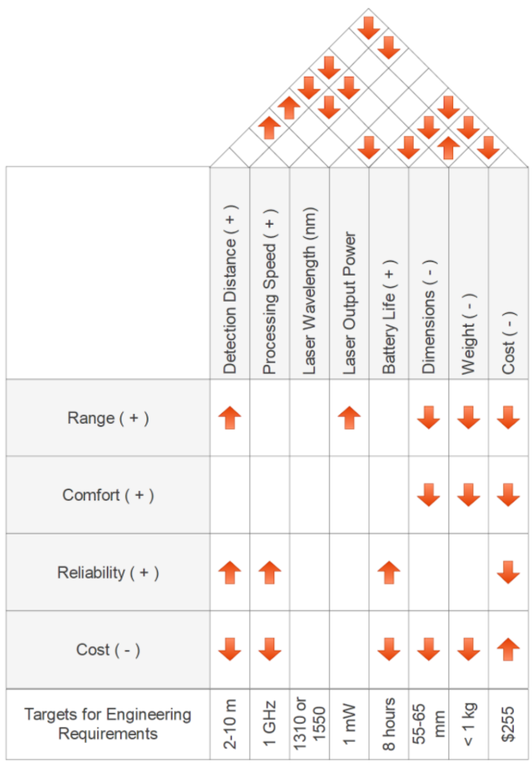
I. First, the Printed Circuit Board shall be designed for the presence of a main controller unit which shall communicate with and control all of the input/output features of the device.
II. In order for the device to be powered, the Printed Circuit Board shall provide electrical conduits for power from the main battery to the rest over the board via DC-DC converters. They shall be sufficiently wide for ample power distribution and sufficiently spaced so as to avoid any short-circuiting.
III. For the optics, the Printed Circuit Board shall provide electrical conduits for connecting the sensors providing feedback to the Main Controller Unit (MCU). The board shall contain analog-to-digital converters with minimal loss of information quality.
IV. To provide feedback to the user, the Printed Circuit Board shall provide electrical conduits for disseminating instructions to the analog peripherals of the device which will give the user feedback as described elsewhere. They shall be sufficiently wide for ample data distribution and sufficiently spaced so as to avoid any short-circuiting.
V. Additional traces and GPIO pins shall be provided on the the Printed Circuit Board to allow access for user input such as buttons, switches, etc. per the device requirements.

Software Requirements

In order for the electronics to communicate effectively, software must be designed to run on the Main Controller Unit to integrate all of the components with the given requirements:

I. The software shall effectively read in the signals received by the sensors on the device and convert them from analog to digital signals.
II. Given a user input, the software shall activate the proper functionality of the device (e.g. turning on the device via a switch will start the program sequence).
III. For any output feedback (audible, haptic etc.), the software should be able to manipulate the hardware provided by converting digital signal into analog output.
IV. Care should be taken to provide sufficient documentation, allowing those who are not the author to read and understand the code's functionality and flow.

House of Quality



Block Diagrams

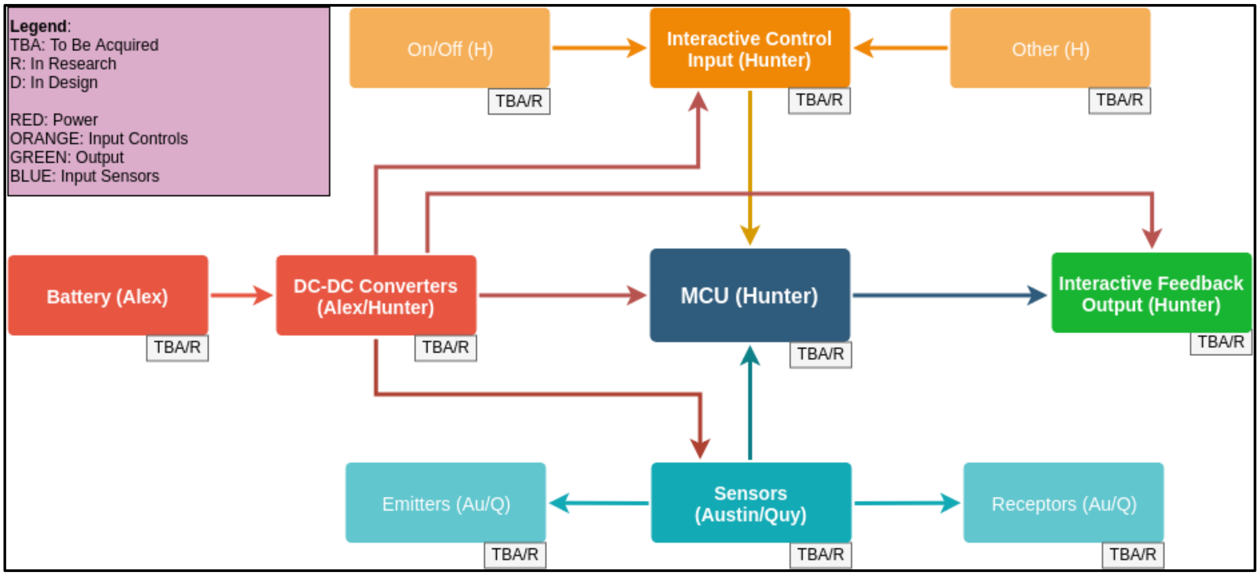


Figure 1: Printed Circuit Board Block Diagram

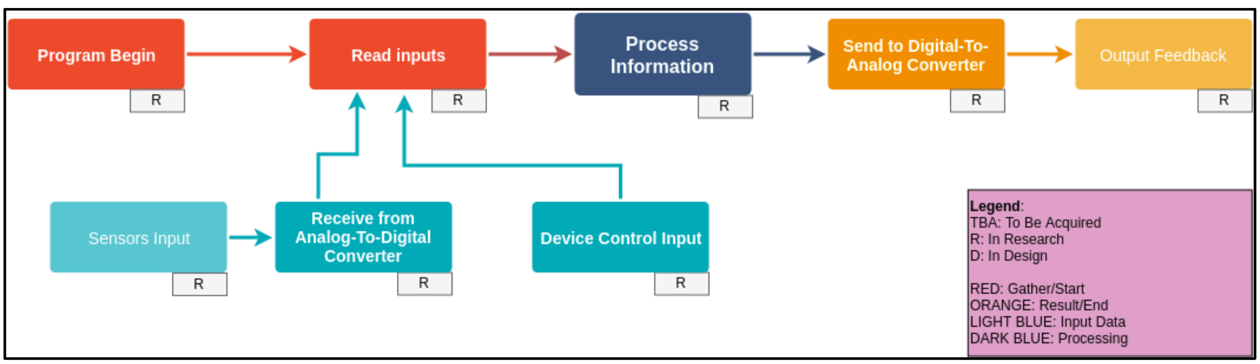


Figure 2: Software Flow Block Diagram

Budget and Financing

The team plans to seek funding from potentially the Office of Diversity and Inclusion at UCF, Student Accessibility Services at UCF, Florida Division of Blind Services, and Student Government Association at UCF. We are currently in dialog with these organizations.

Item #	Part	Cost
1	Printed Circuit Board	$ 43.00
2	PCB Components	$ 40.00
3	Main Controller Unit	$ 12.00

4	Rechargeable Battery Bank	$ 20.00
5	NIR Laser Diode	$ 80.00
6	NIR Photodiode	$ 60.00
7	Miscellaneous Optics	$ TBD
8	Optomechanics	$ TBD
9	Device Housing	$ 30.00
Total		**$ 285**

Initial Project Milestones

Senior Design 1		
Item	**Duration**	**Dates**
Brainstorming/Project Identification	3½ Weeks	August 20th 2018 - September 10th 2018
Initial Project and Group Identification Document	1 week	September 10th 2018 - September 14th 2018
Updated Initial Project Documentation	2 weeks	September 15th 2018- September 28th 2018
Initial Device and Product Research with Florida Division of Blind Services	4 weeks	September 21st 2018 - October 19th 2018
Initial Designs and Seek Funding	2 weeks	October 5th 2018 - October 19th 2018

60 Page Draft	2 weeks	October 19^{th} 2018 - November 2^{nd} 2018
Design Drafts / Breadboarding	2 ½ weeks	November 2^{nd} 2018 - November 16^{th} 2018
100 Page Draft	2 ½ weeks	November 2^{nd} 2018 - November 16^{th} 2018
Final Draft	2 ½ weeks	November 17^{th} 2018 - December 3^{rd} 2018
Begin to Order Project Parts	1 week	December 4^{th} 2018- December 11^{th} 2018
Senior Design 2		
Prototype Construction	4 weeks	January 4^{th} 2019 - February 1^{st} 2019
Testing and Redesign	4 weeks	February 2^{nd} 2019 - March 1^{st} 2019
Final Prototype	4 weeks	March 1^{st} 2019 - April 1^{st} 2019
Peer Presentation	3 weeks	April 2019
Final Report	5 weeks	May 2019
Final Presentation	5 weeks	May 2019