SonicSight

A Wearable Detection System for Waist-Up Protection of Visually Impaired Individuals

Abid Ahmad, Lea Manglicmot, Richard Ngai

ENGL21007 – R

Mr. Thomas Barber

The City College of New York

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Abstract

Blind people are highly susceptible to head and torso injuries due to the limited scope of the white cane. While there are existing technologies that aim to address this problem, they cause mobility complications to the user and is unaffordable. As such, ConThrive has devised the SonicSight – an electronic travel aid that is wearable, lightweight, and cost-effective. A pair of glasses that employ two ultrasonic sensors, SonicSight gives it user a field of detection wider than the average human eye-sight. Once an object is in range, the device will vary the amplitude of its auditory or haptic cue depending on how far or close the object is. This proposal is separated into two phases: the prototyping phase and the commercial phase. First, ConThrive will need a substantial amount of time testing and analyzing prototypes for this project. After this phase, the company aims to distribute 2,000 units throughout the state of New York. For this project, ConThrive plans to invest $300,000 and seek state grant since this project will assist hundreds of thousands of individuals across the state.

Introduction

Vision is an integral tool for human beings to function in the society. After this fact, for a long time, visually impaired people has not been able to practice the same rights and responsibilities like others with functional vision. While variants of the cane, a primary mobility aid, have been used for thousands of years, it was not until World War I when the modern white cane has come to existence [1]. Since then, visually impaired people have less reliance on other people; the white cane has become a symbol of their independence and confidence [1].

Visual impairment has two types: legally blind and blind. Being legally blind means that the person has a central vision acuity of 20/200. Practically, this means that the legally blind person can only see up to 20 feet, whereas a person with normal vision can see up to 200 feet [2].

On the other hand, being blind simply means that the person has no vision at all [2]. For the purpose of simplicity, in this proposal, the two types of visual impairment are combined into the umbrella term, “blind.”

While the white cane has been a celebrated tool for blind people, it still does not provide sufficient information about the environment if order for its user to navigate a path safely. The white cane assists in avoidance of obstacles only with height ranges from the waist and down. This conveys that blind people are highly susceptible to head and torso injuries, where the vital organs are located. In a survey interview with 300 blind respondents, 88% have experienced head-level accidents with a frequency ranging from once in a year to more than once in a month [3]. Outdoor accidents account for 86% of the head-level accidents, which are caused by tree branches, poles and signs, and construction equipment [3]. While majority of the head-level accidents happen outdoors, blind people are not completely safe indoors either. Staircases, wall shelves and cabinets left afar are the typical causes of head-level injuries indoors [3]. Ultimately, regardless of where it happens, head-level accidents can have medical consequences, like dental treatment for broken teeth, stitches, and plastic surgery [3].

Technological modifications have been made on the white cane in order to address head-level accidents. For instance, UltraCane, which has been available in the market in 2011, has two ultrasonic beams for sensing the environment [4]. One of the beams is pointed straight ahead to detect waist-level and lower torso-level obstacles, while the other beam is pointed at an angle upwards to detect upper torso-level and head-level obstacles [4]. When it detects an obstacle, UltraCane sends vibrations in order to alert the user. Another modified version of the white cane is the EyeCane which has two narrow infrared sensors; like UltraCane’s ultrasonic sensors, one of EyeCane’s sensors is pointed straight ahead while the other one is pointed at an angle upwards

[5]. In addition to haptic cues, EyeCane sends audio cues to the user when an obstacle from waist-level and up is detected [5]. The proximity between the user and obstacle can also be estimated because the closer the user gets to the obstacle, the higher the frequency of the vibrations are [5].

While advantageous, the technological alterations made on the white cane have negative consequences. First, according to a survey comparing different mobility aids for blind people, none of the upgraded white canes have been widely accepted by the targeted population because of its unaffordability, with an average cost of $700 [6]. Second, both canes require long period of training before initial use; the additional cues coming from the haptic and audio actuator require additional cognitive process, which makes a significant gap between detection time and reaction time inevitable, especially without training [5]. Lastly, and the most essential consequence of the upgraded white cane is its addition to the neuromusculoskeletal problem a regular white cane already has [7]; a significant amount of weight is added to the white cane due to the additional components and placement of robust encasement on the components [8]. The manipulation of a regular white cane relies almost completely on the repetitive movement of the wrist and shoulder of an individual while the remaining of the upper body is sustained [7]. Consequently, the added weight on a modified cane strains the wrist and shoulder more, therefore, worsens the neuromusculoskeletal problem related to the regular cane.

In order to address the waist-up accidents of blind people and the issues with its present solutions, our company has come up with an electronic secondary travel aid – the SonicSight. The approval of this project proposal will allow us to distribute SonicSight to the blind population in New York City through the market and through partnership with organizations, like American Foundation for the Blind and VISIONS.

Plan of Work

SonicSight is a pair of eyeglasses integrated with two ultrasonic distance sensors for detection of obstacles from the waist-level up of the user. The ultrasonic sensors will be placed on the endpieces of the eyeglasses. Each sensor will have 75° of vision such that the user will have a total effective field of vision of 150°; a human with normal vision has a field of vision of 130° [9], which makes SonicSight's field of vision more accommodating to the user. The frontal depth of the sensors will be two meters, while the lateral depth will be approximately 10 meters. These magnitudes of depth are essential to ensure that any obstacle right in front of the user will be easily detected and give ample time for the user to execute a proper motion to avoid the obstacle.

In order to control the depth of detection of the ultrasonic sensors, we will use Arduino Uno as a microcontroller. In addition to this, we will use this microcontroller in order to process the input from the ultrasonic sensors and turn it into haptic cues or audio cues. As shown in Figure 1, once the Arduino Uno knows how far away an object is, it varies the loudness of piezo buzzers located on the glasses. We are using two eccentric DC vibration motors, that will vibrate at the same time as the buzzer, and work similarly. The closer an object is to a person, the louder and faster a buzzer/vibration motor will sound. The location of the buzzer/vibration motor on the glasses will tell the blind person where the obstacle is located. For example, if a blind person is approaching a tree branch on their left side, the buzzer/vibration motor on the left will sound. We have a master on and off switch and a vibration switch so that the user can choose whether to have a vibration alert as well as a sound alert. This is because we felt it might be uncomfortable to have vibrating glasses. 9V Battery Chargers will be sold alongside the product, so that the glasses can charge. However, we are not creating these chargers. The batteries are not proprietary, and as such consumers can use the glasses with any 9V rechargeable batteries. Also, as indicated in Table II, the battery contributes significantly to the weight of the device, which is why ConThrive aims to replace it with a lighter one during the refinement of the device.

Figure 1. Flow of Information in SonicSight

TABLE I. Dimensions and Weight of SonicSight Components

Component	Quantity per unit	Dimensions(mm)		Weight (g)
Ultrasonic sensor	2	Length	15.52	4.23
		Width	22.36	
		Height	20	
piezo buzzer	2	Diameter	11.9	0.7
		Height	6.53	
Eccentric vibration motor	2	Diameter	4	0.3
		Height	3.7	
mini breadboard	2	Length	1.8	13.1
		Width	1.4	
		Height	0.4	
9V battery	2	Length	26.5	43.09
		Width	17.5	
		Height	48.5	
Switch	2	Length	6.2	0.1
		Width	6.2	
		Height	2.5	

Timeline

The following details of the timeline is summarized in Figure 2.

<u>December 2018: Brainstorming</u>

We are considering the different visual needs of blind people, and accounting for any situation that they might require the use of our glasses. For example, we elected not to use lidar because it is too expensive and infrared because it does not work well in rainy weather. Furthermore, we will consider concerns from a blind person about issues that they have with just using a cane.

<u>January-February 2019: Design of Prototype</u>

Using our initial idea, we will flesh out the dimensions, materials, and cost of creation. We will make Standard Triangle Language (STL) files using SolidWorks to print three-dimensional parts of the initial prototype.

<u>May 2019: Building of First Prototype</u>

We will 3D print a pair of glasses. We also must test its structural integrity and make sure it can hold up to any weather condition.

<u>June 2019 - July 2020: Beta Testing</u>

We will conduct a study in the field, giving a random group of blind people our product and observing them for a year. We will then survey their responses to judge what concerns they have, if any, and how we can fix them.

<u>August– December 2020: Further Iterations and Beta Testing</u>

We will consider different alternatives to the initial prototype, such has having different sizes of glasses for different head sizes and consider the feedback from the beta-testing. We will start mass producing these glasses.

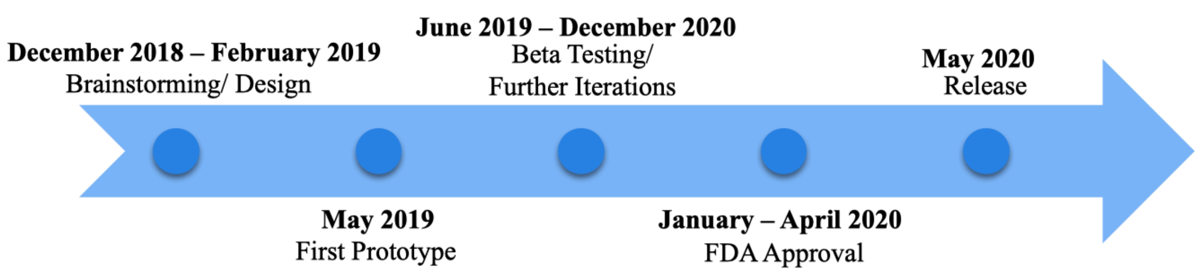
January– August 2021: FDA Approval

The FDA needs to approve our product for use as medical equipment so that insurance will be able to pay for some of the cost. This will take several steps: “Establishment registration, Medical Device Listing, Premarket Notification 510(k), unless exempt, or Premarket Approval (PMA), Investigational Device Exemption (IDE) for clinical studies, Quality System (QS) regulation, Labeling requirements, and Medical Device Reporting (MDR)” [10].

September 2021- February 2022: Release to Commercial Market

Finally, we will cooperate with large biomedical companies and medical equipment suppliers to bring our product to consumers. This way, our product will reach the most people. Blind people will be able to receive our product either from a doctor prescribing the device, buying directly from our company or from third party suppliers.

Figure 2. Timeline of Work



Budget

As shown in Table II, an initial investment of $300,000 will be made towards the development of the product in the first year. Preliminary costs will be directed towards the building and testing of the prototype. In order to ensure accuracy of the product, parts for the device will be bought individually rather than in bulk for this phase; any error in one component will not be in other similar components. In this manner, financial losses will be minimized if the products used in the prototype are found to be inefficient. Initial projections have shown that an individual prototype should cost approximately $150. For the beta-testing phase, five trials will be conducted, and five prototypes will be created for each trial to determine the most effective variants of the product. A three-dimensional printer will also be required in order to make affordable eyeglasses for the prototypes. As such, an allocation of $10,000 should be sufficient to refine the product before it is released to the market.

TABLE II. Expected expenses for prototyping, testing, and production of SonicSight

	Materials	Quantity	Cost	
PHASE I	3D Printer	1	$	2500.00
	Piezo buzzer	25	$	33.75
	electric wires	5	$	65.15
	switch	25	$	12.94
	breadboard	25	$	138.25
	9V rechargeable battery	25	$	159.64
	resistors	100	$	337.75
	eccentric vibration motor	25	$	77.96
	ultrasonic sensor	50	$	1123.00
	Preliminary advertising	N/A	$	4000.00
PHASE II	SonicSight	2000	$	300000.00
	SonicSight for sponsors	100	$	30000.00
Total			**$**	**338,648.44**

In the first year of the product's release, the company aims to sell a total of 2,000 units to its consumers. Each unit will be sold for $400, which is a much lower price than products similar to SonicSight. In addition, ConThrive will distribute this product to non-profit organizations such as VISIONS, Lighthouse Guild, and The American Foundation for The Blind for a reduced cost of $200 per unit in exchange for their promotion and marketing of the product. This is the most cost-effective method of advertising, allowing most of the budget to be allocated towards the manufacturing of the product. Finally, ConThrive will be seeking a $100,000 grant from the state of New York in order to further the initiative of an affordable and lightweight product that acts as a tool for more efficient gathering of information for the blind population.

Qualifications

Each member in our team has significant experience and relative background in order to execute this project proposal successfully:

1. Richard Ngai, COO: He was a Mechanical Product Design Engineer at Boston Dynamics for several years, until he became COO of Conthrive. He finished his master's degree in Mechanical Engineering from the City College of New York. He has several years of experience with robotics, having worked on Arduino, Raspberry Pi and is an expert in computer programming using Python and Java. He previously worked on creating a computer vision enhanced checkers playing robot.
2. Abid Ahmad, CFO: He holds a master's degree in Business Administration from Yale University. He also spearheaded research on Strategy and Innovation in the area of finance in the University of Oxford. He was a financial analyst for ConThrive for 2 years before becoming the CFO of the company.
3. Lea Manglicmot, CEO: She earned her bachelor's degree in Electrical Engineering and Business from the City College of New York. She also holds a doctorate in Biomedical Engineering from Columbia University. Before founding ConThrive, she was a consultant in Harlem Biospace for five years, working alongside with biomedical executives and start-up biotech companies.

In addition to our individual qualifications, ConThrive has had previous projects that are also focused on prevention of serious accidents and medical consequences. For instance, DusTector is a real-time, real-space particulate matter detector integrated to a wristband. DusTector uses infrared light to measure the concentration of particulate matter in the location of the user and gives an audio cue when the concentration is above the recommended amount for the user. The device aims to prevent complications in individuals with respiratory and/or cardiovascular disorders. Another device that ConThrive had released in the market is the OptiPuncture, which also uses infrared light to read the layers of tissue underneath a patient's skin. The information gathered from the infrared light is then converted into a three-dimensional projection so that whoever is performing a venipuncture would not miss the patient's vein and not puncture through the vein. OptiPuncture aims to prevent hematoma formation and nerve damage that may result from an unsuccessful venipuncture.

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