Designing and Building Low-Cost Wearable Proximity Sensor
(Technical Topic)

Analysis of Social Implications and Stigma with Disability Aids and Devices
(STS Topic)

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Joshua R. Arabit

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Technical Project Team Members: Bill Zhang, Jazlene Guevarra, Renée Mitchell

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signature _____

Approved _____ Date _____
Kathryn A. Neeley, Associate Professor of STS, Department of Engineering and Society

Approved _____ Date _____
Harry C. Powell Jr., Professor, Department of Electrical and Computer Engineering

Introduction

The ability to see and process the images within our environment is invaluable. Vision is one of the most important human senses in regards to processing information and gaining a better understanding of the natural world. As of a report conducted by the World Health Organization (WHO), approximately "314 million people worldwide suffer from visual impairment" and out of the 314 million, 45 million are blind (Meshram, Patil, & Shu, 2019 p.449). People with visual impairments (VI) face multifaceted challenges ranging from difficulties in reading to general entertainment. Within this range of challenges, the idea of mobility and travel plays a major role in the well-being and quality of life for an individual with VI. The ability to move from one place to another, without the assistance of another individual, gives a sense of independence and facilitates habits for success within society. In order to overcome some of the limitations of VI and its effects on a person's mobility, people with VI implement the use of white canes and guide dogs. Although these devices and techniques solve some of the problems involving collision avoidance, most of these solutions either require an immense amount of time, money, or concentration in order for the aid to be an effective tool. Additionally, implementing these current VI aids in daily life brings about the internal struggle of choosing to make their VI visible to the public due to the fear of social implications that are associated with VI (Wong, 2018). As a result, people with VI tend to favor end-to-end transportation or call for outside assistance in order to travel to different destinations.

In an attempt to improve the quality of life and social independence for people with VI my capstone team will be designing and building a prototype Low-Cost Wearable Proximity Sensor in order to solve the challenges where previous devices and techniques fall short. The device will improve guidance capabilities to people with VI by using an array of sensors,

feedback motors, and embedded microchips as well as keeping a subtle form factor to alleviate the uncertainty of social stigma. In addition to the construction of a working assistive device, I will be researching and analyzing the domain of social stigma regarding the use of disability aids and its relation to people with VI and other disabilities in order to gain a better understanding and knowledge regarding this sociotechnical problem.

Technical Topic: Designing and Building Low-Cost Wearable Proximity Sensor

In today's technological driven society, the domain of disability aid and devices regarding VI still lags behind with outdated techniques and solutions. The white cane and guide dogs serve as the primary solutions in aiding with mobility for people with VI. Although guide dogs are helpful in providing feedback to the user, this solution proves to be very costly due to the amount of time and resources being spent in order to train a guide dog, as well as the needed attention from the owner of the dog. The white cane, on the other hand, is an inexpensive device that can provide feedback to the user through physical sensations of objects that are in near proximity. Although the white cane is inexpensive and easy to use, a recent study conducted by members of the Institute of Electrical and Electronics Engineers (IEEE) shows that "93.21% of [interview participants] confirmed that a white cane did not provide information about the surrounding environment" but rather only gave information about objects in the knee-high level plane of the user (Meshram, Patil, & Shu, 2019 p.450). In addition to the lack of spatial information from the white cane, the device requires constant conscious effort from the user to deduce the type of objects in near proximity. This means that users would have to constantly spend the effort to think about where they are and the space around them. Therefore, the white cane falls short in being an effective way to provide mobility to people with VI because of its

inability to provide overall spatial awareness and requiring the user to be constantly auditing the feedback from the cane.

In response to the issues of the white cane, my capstone team and I have identified the use of wireless sensor, haptic vibration motors, and embedded micro-controllers as a way to design a proximity sensor that allows people with VI to navigate a room without the fear of collision with nearby objects. We found that people with VI tend to prefer devices that are sensor based in order to remove the idea of waving a physical object and devices that give tactile or auditory feedback to the user when an object is detected (Cuturi, Aggius-Vella, Campus, Parmiggiani, & Gori, 2016). From our research we have decided to design an easy to use, wearable device that will act as a proximity sensor for people with VI.

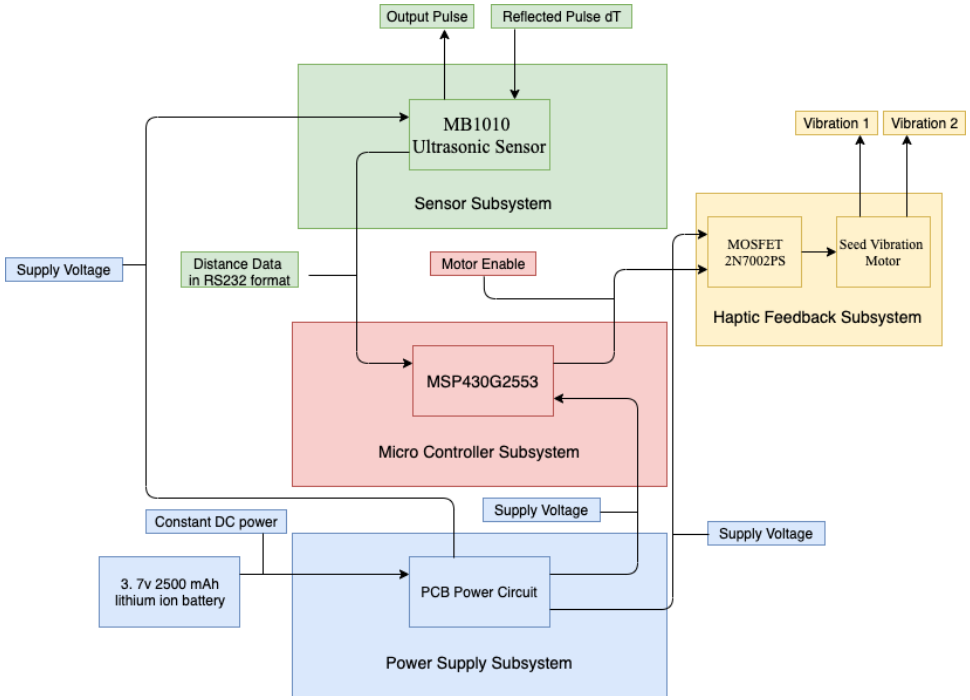

Figure 1: System Diagram of the Wearable Proximity Sensor showing how each subsystem integrates with each other (Created by author 2019).

As shown in the figure above, the device being designed and prototyped by my capstone group will incorporate all the essential components that improves upon the experience when using a

white cane. The device constantly measures distance data with an ultrasonic sensor and sends said data to an embedded micro-controller. This micro-controller reads the data from the sensor and runs an algorithm that determines if the device has to notify the user of an object. If the micro-controller determines that it needs to notify the user, the device activates a haptic vibration motor which provides tactile feedback thus letting the user know of a nearby object. The device and final technical report will be finished by the end of the Fall 2019 semester. The project will be finished within a group of four people and advised by Professor Harry Powell. Renée will be in charge of the printed circuit board design, I will be in charge of system integration and assist with the circuit design, Jazlene will be in charge of the test plan and overall device design, and William will be in charge of the software and algorithm design.

STS Topic: Analysis of Social Implications and Stigma with Disability Aids and Devices

In the discussion about the use of the white cane as a solution for being a cost-effective way to provide mobility and safety for people with VI, the cane itself is often rejected by users due to the social stigma that stems from the use of the cane. The white cane acts as a "symbolic indicator that a person is blind" and due to this idea, people with VI "resist cane use in order to 'pass' as 'normal' and avoid being stigmatized" (Hersh, 2015 p.104). This stigmatization from society leads to significant internal conflict within people with VI regarding using a cane or a similar device in public. In a recent study conducted by the Department of Environmental Medicine & Public Health, participants "recalls being passed over for employment opportunities because their impairment was visible during job interviews, with one informant describing an interview experience in which she was asked to explain how she could travel independently" (Wong, 2018 p.89).

Table 2
Barriers to the use of the long cane reported by the participants.

Barrier	Number of responses	Percentage of responses
Social stigma associated with using a cane	89	30.8
Can use a sighted guide	67	23.2
Can use residual vision	47	16.3
Do not know the cane technique	33	11.4
Cane training was not recommended	12	4.2
Mobility not limited	10	3.5
Afraid of losing job	7	2.4
Pressure from family	6	2.1
Hope for new other treatment	5	1.7
Safety	4	1.4
Fear it will affect chance for marriage	3	1.0
Age	2	0.7
Mobility not a problem	2	0.7
Lack of time	1	0.4
Problem only in daylight	1	0.4

Note: The participants could check more than one barrier.

Figure 2: Results from a questionnaire from 200 participants in South India who have some degree of VI. The results show that the primary barrier from the long cane use is the social stigma associated with using a cane. (Christy & Nirmalan, 2006 p.117)

The problem with social stigma regarding visual aids and device does not stop within American society. Within South Indian society, the long cane or a white cane also symbolizes blindness and the disabilities that are connected to it. The fear of being stigmatized with the use of the long cane in India is a magnitude greater because of the way social and cultural norms dictate the acceptance of an induvial into society. As a result of social stigma regarding visual aids and devices, as seen in global societies, people with VI tend to reject the use of these devices even though it can prove beneficial in granting them access to mobility and spatial awareness.

In response to the problem of social stigma being a barrier to acceptability of visual aids, I will strive for a better understanding of the social technical system that encompasses the domain of VI, visual aids, and society. The primary topics and artifacts to focus on in order to gain a well-rounded knowledge base, are the primary causes of social stigma regarding technology use, techniques that reduce this social bias, and previous research which proposes some possible solutions to increase acceptance of visual aids. In addition to having a

comprehensive understanding of the problem domain, I will incorporate the STS framework of Social Construction of Technology (SCOT) in order to understand how society can be the primary actor that shapes the design and use of visual aids. Gaining a better understanding of social stigma and VI, as well as implementing the SCOT framework will lead to a better comprehensive research of the topic and new knowledge being created.

Conclusion

In an attempt to solve some of the problems that previous visual mobility aids fall short on, such as lack of user feedback and ease of use, my capstone group will be designing and prototyping a cost-effective wearable proximity sensor. The creation of our embedded device will hopefully improve the user experience for people with VI, as well as increasing the chance of the device being accepted into the social community of VI. In addition to the proximity sensor, my STS research will study and develop a strong understanding of how social stigmatization of visual aids and other disability devices affect the acceptance of said devices into the hands of users. The STS research will also focus on the SCOT framework in order to show how visual aid design and technology is shaped through the social context of people with VI and how they interact with other parts of society. If both of these projects are correctly and successfully implemented, the combination of the two will result in a greater understanding of visual aids, such as the technology and design choices that are used when creating a device and how society shapes these choices.

Word Count: 1,701

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