Thesis Project Portfolio

Visually Assistive Hat: A Wearable Device for the Visually Impaired

(Technical Report)

Sociotechnical Factors Contributing to the Inequalities in Visual Impairments Across Genders

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Mary DeSimone

Spring, 2022

Department of Electrical and Computer Engineering

Table of Contents

Sociotechnical Synthesis

Visual impairment, including blindness or simply any form of vision degradation, affects many people at some point in their life, making it a widespread issue. This portfolio details the process and results of focusing on blindness and visual impairments, and improvements that can be made in the field of eyecare. The technical portion of this project contained the creation of a new wearable technology for those suffering from visual impairments, in order to provide feedback to users about unseen obstructions. It utilizes an array of sensors, motors, and speakers in order to provide tangible feedback to users about their surroundings. The full documentation and detail of the creation and testing of this device are included in the portfolio for the visually assistive hat. For the science, technology, and society (STS) research topic, the results aim to show an answer to the following question: what leads to women being more likely to suffer from visual impairments, such as cataracts and blindness, than men? These two topics and projects are closely linked together, as they aim to provide insight and solutions into the field eye care and the disparities within it.

For the technical portion of this portfolio, this project focused on creating a hat that provides tactile and auditory feedback to blind and visually impaired individuals based on obstruction detection. This was done by embedding light detection and ranging (LiDAR) sensors into the hat and connecting them to a central microcontroller (MCU) board to process current surroundings. The device gathers information regarding a user's surroundings from the front, sides, back, and any incline changes. Then, using the information provided by the LiDAR sensors, vibrating direct current (DC) motors were programmed to vibrate whenever their respective sensor detects an object and increases the vibration frequency as the object gets closer to the individual. Additionally, small piezo speakers will be mounted to the side of the cap and

connected to the MCU to provide auditory feedback for users who may prefer to have auditory feedback. Lastly, the cap has a sensor that provides feedback whenever the user approaches steps or some type of change in surface elevation. The technical work involved in this portfolio ultimately aimed to mitigate issues found in alternative forms of visual assistants by creating a lightweight device the user can place on their head and not worry about holding. This project's design provides the user with a fuller picture and awareness of their surroundings by monitoring obstructions from the user's side or behind. The combined use of LiDAR and ultrasonic sensors help create a more effective and powerful obstacle detection system, as opposed to the use of video cameras or simply ultrasonic sensors alone.

The STS research topic for this portfolio is centered around the discrepancies between genders within the field of visual degradation. Blindness and vision loss is a problem that affects millions of people around the world, and something that most people are likely to experience to varying degrees. As the world continues to age and average lifespans increase, visual impairments will only increase in frequency. Unfortunately, studies have shown that blindness is more common in women, specifically those over 50, than in men, and yet women are less likely to receive care for their eye problems. This portion of the portfolio aims to determine what leads to women being more likely to suffer from visual impairments, such as cataracts and blindness, than men. Official journals, governmental and educational papers, studies, and reports will be used to gather information about the current state of visual impairments across genders. This research is analyzed using the wicked problem framing technique to be able to assemble a complete breakdown of the problems surrounding women's lack of access to eyecare, as well as providing an in-depth review of the inequalities across genders. The results of this paper provide findings to the field of STS in order to address the root causes involving access to eyecare, as

well as influence policy for global lawmakers to add additional welfare programs or financial solutions to alleviate eyecare access concerns.

Overall, this portfolio aims to combine two topics I am particularly passionate about, both blindness and women's social issues and health. The technical portion of this design is a hat created to provide visually impaired individuals access to their surroundings in a hands-free way, in order to provide a safe way for them to navigate their surroundings. The research paper aims to fully understand what sociotechnical factors play into women being more likely to be affected by visual impairments than men. The benefit of working on these two projects at the same time was plentiful, because through the research for the STS portion of the paper knowledge was gained on the background of visual impairments and it helped to influence the design and build of the hat.