GLASSES FOR THE BLIND

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1. Introduction

1.1 Objective

There are many groups of people in the world today who are faced with accessibility issues every day in their lives. According to the World Health Organization (WHO), 285 million people in the world are visually impaired of whom 39 million are blind. [1] For blind people in particular, unfamiliar obstacles in their path present a hazard for which accidents and injuries can occur. In a study carried out by the University of California, Santa Cruz, 86% of accidents occur outdoors due to branches, poles, and signs which are closer to head level. [2]

For this project, the goal will be to mitigate accidents occurring outdoors due to unfamiliar obstacles at head level for blind people. The design will implement a glasses sensor subsystem which will house a 3D ultrasonic sensor and a feedback subsystem which will provide greater understanding of the world to blind users. Our product will map the space where the user is facing onto a 2D grid to determine if obstructions above the waist level are present in certain zones of the grid. It will then communicate with a haptic feedback device that will use actuators in a grid to let users know within which grid block in front of them the object has been detected.

1.2 Background

Currently, blind people will often use white canes as a mobility tool to get a better understanding of the world around them. This tool can be effective for providing feedback about obstacles at the ground level. However, obstacles above waist level such as tree branches often go unnoticed. Technology-assisted white canes which have been developed by companies such as BAWA and WeWALK are able to provide additional feedback for these potential hazards above waist level, and a project done by Team 18 in Spring 2019, OptiCane, was a variation of these technological canes which used LIDAR and a vibration bracelet to provide blind users with information about their environment. [3][4] However, these technological canes tend to provide superfluous features and only use imprecise vibrations for feedback.

The design proposed in this document will be a fundamentally different solution. Instead of providing a technology-assisted white cane, a supplementary wearable system to white canes will be created. This system is designed with the goal of providing blind users a more accurate and tangible picture of what obstructions lie in their path ahead and will consist of a glasses sensor system and an arm sleeve feedback system.

1.3 Physical Design

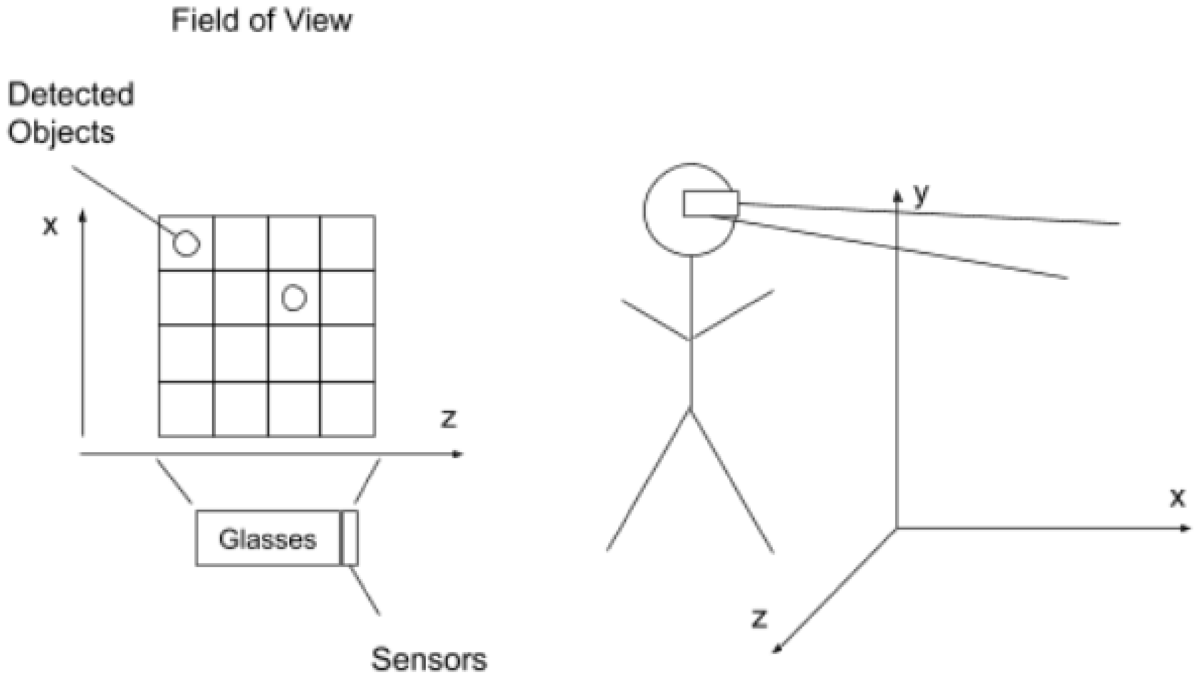

Figure 1. Visual Representation of the Glasses Module

The 3D Ultrasonic sensor in the glasses will return the coordinates of obstacles detected and map them to the corresponding space in the xz grid. This information will then be sent to the feedback subsystem which will be a 2D grid of vibration motors. When an object is detected in the grid space, the same grid will vibrate on the user's arm, effectively mapping the space in front of the blind person into a tangible 2D grid to provide greater understanding of the obstacles in front of them. Here, the y coordinate is not considered, as this design is to be used in conjunction with white canes. White canes can detect hazards below the waist, so this design only needs to focus on those above the waist. The accuracy from this design will allow users to see objects approaching as they move closer on the grid and will be able to evade them when they get close.

1.4 High Level Requirements

- The sensor will be able to detect obstacles when users are walking on sidewalks outdoors that appear within a 4x4m space in front of the user.
- The haptic feedback will be able to provide the users with detailed and non-intrusive information about obstacles in the space in front of them through a wearable armband.
- The device must be able to last the larger part of the day, at least 12 hours

2. Design

2.1 Block Diagram

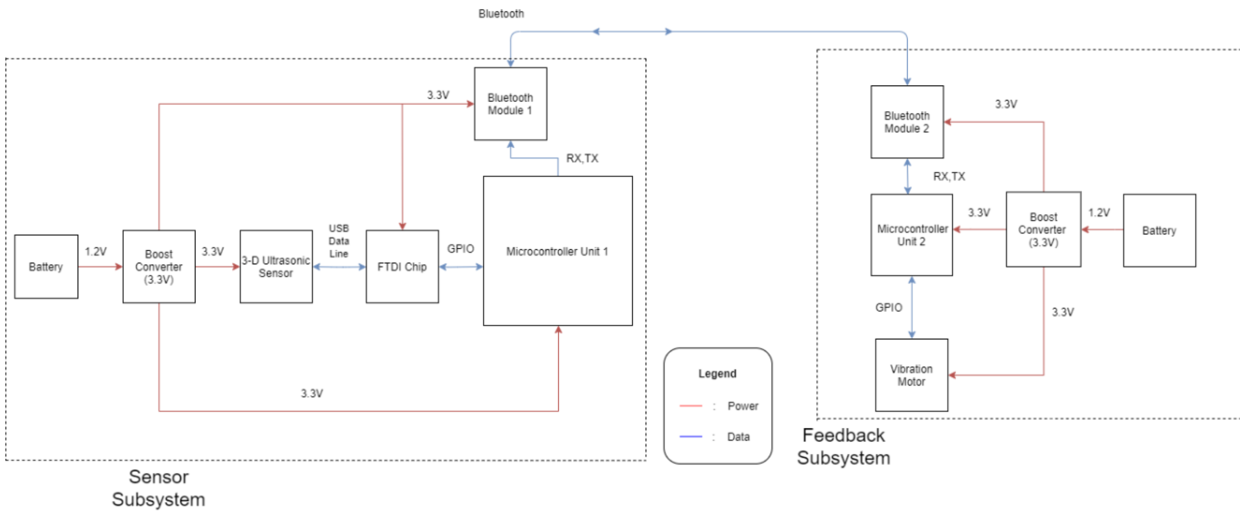

Figure 2: Block Diagram of Glasses for the Blind

Our block diagram has 2 subsystems. The first subsystem is the sensor subsystem. This subsystem houses a 3-D ultrasonic sensor that maps obstacles in the outside world. Data from the 3-D ultrasonic sensor is communicated over USB B to an FTDI Chip, which converts that USB signal to an input into the microcontroller. The microcontroller then sends that information to the feedback subsystem via the Bluetooth module. The feedback subsystem is responsible for controlling the vibration motors that will help our users determine where the obstacles are located as explained in the “Physical Design” section.

2.2 Functional Overview

Battery

We will be using rechargeable AAA batteries to power both the Sensor Subsystem and the Feedback Subsystem. These batteries will be put in parallel and have a total capacity of 1800 mAh. This component relates to the high-level requirements in that we need to be able to power the project.

Boost Converter

The boost converter will step up the voltage of the batteries from 1.2 V to 3.3 V. We need this component, because the rest of the circuit components are in the range of 3.3 V to power up. This component is used mainly for the 3rd high level requirement. By using a boost converter, we can double the power storage, because we do not need to put the batteries in series to make the power source up to 3 V.

3-D Ultrasonic Sensor

This 3D ultrasonic sensor will be able to use ultrasonic waves to detect what is in front of the sensor and outputs the 3D coordinates of the objects. We need this sensor for the 1st high level requirement, because this sensor will be used for detection. [5]

FTDI Chip

Converts USB data signals to microcontroller inputs. We need this component in order to relay the data from the sensors to the microcontroller, which is needed for the project to work. This component is related to the second high-level requirement, because we need the Sensor Subsystem to communicate the correct data to the Feedback System.

Microcontroller 1 & 2

We will be using the ATMEGA328P-AU microcontroller, because we are more familiar with the IDE and a versatile voltage range to work on. Microcontroller 1 will be responsible for managing communication of the Ultrasonic sensor to our Bluetooth module. Microcontroller 2 is responsible for communicating with the Bluetooth module and turning on the vibration sensor. The microcontrollers are the brain of this project and are needed for the first two high level requirements, because both the feedback subsystem and the sensor subsystem need microcontrollers to work.

Bluetooth Module 1 & 2

Responsible for communication between each of our subsystems. We chose Bluetooth, because we find Wi-Fi more unreliable when outside. This component is used for the second high-level requirement as the Feedback Subsystem needs to be able to collect data from the Sensor Subsystem.

Vibration Motors

The vibration motors are responsible for communicating the direction and distance of an obstacle using vibrations. This component relates to the second high-level requirement, because this is the haptic portion of the Feedback System.

2.3 Block Requirements

Battery

We will be using rechargeable AAA batteries that will supply 1.2 V to our Sensor Subsystem and Feedback Subsystem.

Boost Converter

The converter must be able to take an input of 1.2 V and output 3.3 V.

3-D Ultrasonic Sensor

The 3-D ultrasonic sensor needs 3.3 V. This sensor must be able to detect objects that are in range.

FTDI Chip

The FTDI chip needs to be supplied 3.3 V. The chip needs to be able to transfer usb data at 480Mb/s. The chip must be able to correctly convert the data from USB to microcontroller inputs.

Microcontroller 1 & 2

The microcontrollers will need to be supplied 3.3 V. The microcontroller in the Sensor Subsystem must be able to process the data from the sensor. The microcontroller in the Feedback Subsystem must be able to output the correct haptic feedback information.

Bluetooth Module 1 & 2

The Bluetooth module will need to be supplied with 3.3 V. The module must correctly receive and transmit the correct information.

Vibration Motors

The vibration motors will need to be supplied with 3.3 V. The motors must be able to vibrate when triggered.

2.4 Risk Analysis

The block that poses the most risk is the 3-D Ultrasonic Sensor that is the core component of our project. If the ultrasonic sensor is unable to return coordinates of obstacles in front of the user in a grid pattern, the design will be unable to provide blind users with additional feedback to the obstructions in front of them. The sensor unit will need to have a high success rate to be considered viable for blind users to get useful feedback from the unit. If it is inconsistent, it may lead to users being injured by undetected obstacles.

3. Ethics and Safety

There are a few safety and ethics concerns that exist for our project. The first safety concern is the location of the PCB. Being an electrical device that will be worn on people, there is a chance that the PCB could fry, and users could harm themselves. In order to protect against this, we must ensure that there are adequate measures in place against electrostatic discharge. We plan to use proper grounding techniques. Making sure that traces do not run at the edge of the board and using two ground planes that we will stitch together with vias, so we have adequate grounding for our circuit. We also plan to use mechanical protections like a metal casing as additional ESD protection for both the user and device.

Another safety concern that we have is that transmission of direction information from our device occurs over Bluetooth, which is not the most secure. If someone with malicious intentions was able to hack the Bluetooth device, they could give users of the device false information and directions which could cause users harm. To make sure we adhere to ACM's General Ethics Principles 1.6 we plan to secure our Bluetooth network. We can add a pairing between each one of our subsystems by utilizing the BLE's security mode. This service level security will allow for authentication, encryption, and authorization of data to be sent between subsystems. [6]

Another safety concern that we have is device failure. Users of the cane rely on it to tell them information about their surroundings and if that provided information is incorrect then it could lead them to being injured. To protect from this, our product is intended for use with the white cane as our product detects obstacles above waist level while the cane focuses on the ground. This means that in case of product failure, the user will still have the cane for navigation. In addition, we will make sure that our device goes through intensive testing to make sure that it can consistently operate reliably.

4. References

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[2] R. Manduchi and S. Kurniawan, “Watch Your Head, Mind Your Step: Mobility-Related Accidents Experienced by People with Visual Impairment.” [Online]. Available: https://www.soe.ucsc.edu/sites/default/files/technical-reports/UCSC-SOE-10-24.pdf. [Accessed: 03-Apr-2020].

[3] WeWALK Smart Cane. [Online]. Available: https://wewalk.io/en/. [Accessed: 04-Apr-2020].

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[6] “The Code affirms an obligation of computing professionals to use their skills for the benefit of society.,” Code of Ethics. [Online]. Available: https://www.acm.org/code-of-ethics. [Accessed: 03-Apr-2020].