eyeAssist

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1. Introduction

1.1. Objective

People who are visually impaired often struggle with many issues that most of us take for granted. Mobility is an extremely important part of our lives; we depend on the ability to effectively navigate through any environment we are in every single day. People with visual impairments often have trouble navigating through their environment without some kind of assistance. Furthermore, reading any kind of text, whether that be a book or an important document, can be a difficult task. They may not be able to access audiobooks online, as those books must be pre-recorded before being sold to the public. This can be extremely frustrating and serve as a significant obstruction in their lives.

We would like to build wearable 'smart' glasses that can solve both these problems. Our solution is creating multi-purpose glasses that allow the visually impaired to navigate their home with ease, with the added benefit of reading text aloud to them in real-time.

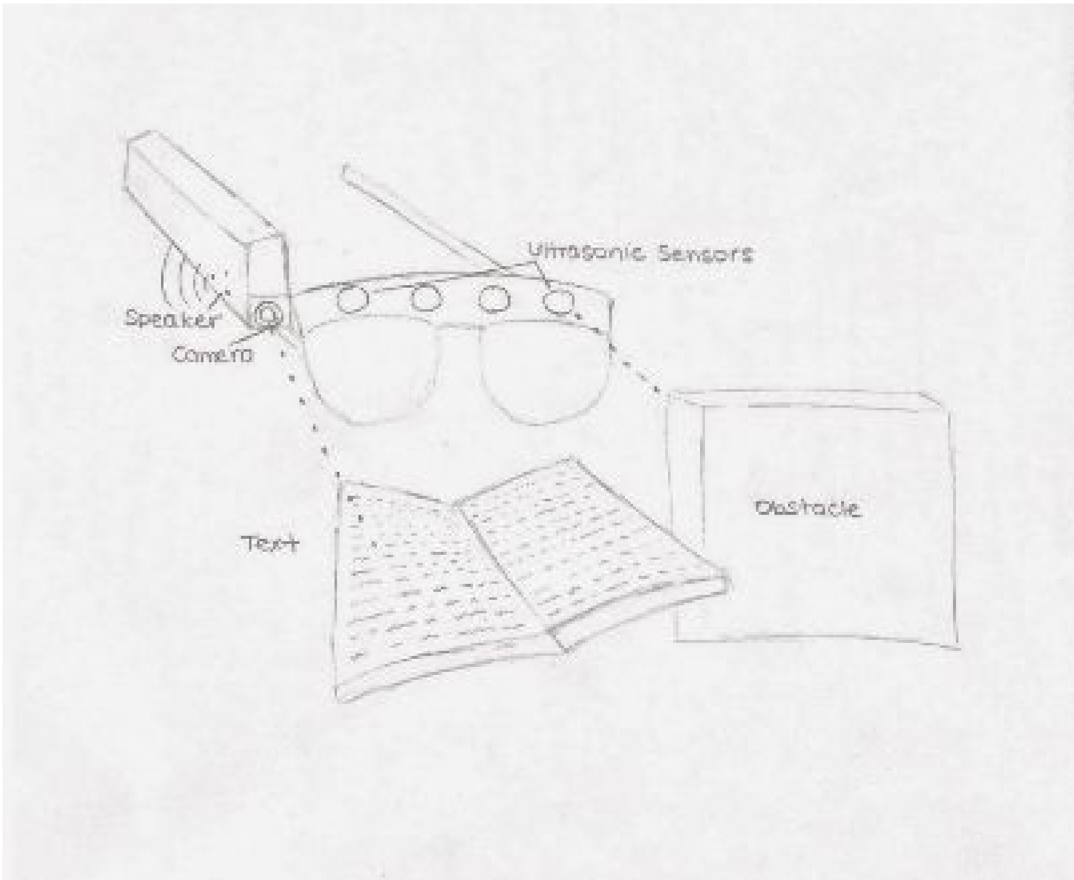
1.2. Background

According to the World Health Organization, there are estimated to be around 285 million people across the globe who are visually impaired. Furthermore, out of those 285 million, around 39 million are completely blind [1]. People with visual impairments represent a unique demographic who face challenges that may not be widely understood by the general population. Developing tools to cater to these specific difficulties, especially through technology, can provide them with a new range of abilities that may have been previously inaccessible.

The current solution generally used to help with indoor and outdoor navigation is a white cane which is held out in front of a user to physically detect obstacles. This however may not be the most effective solution to combat the issue of navigation as it can be quite cumbersome for users to constantly have to physically search for any potential obstacles. This can prove to be even more difficult if the user is also physically impaired. For instance, an older person may not have the physical dexterity to keep swaying their cane whenever they are moving. Additionally, this device does not provide the user with a complete understanding of exactly how far any given obstacle around them is located.

Our project idea aims to enhance the quality of life of those with visual impairments. To achieve this, we intend to make wearable glasses that fulfill multiple purposes simultaneously - mobility and reading. We improve upon the traditional white cane design by eliminating the need for constant physical effort on the user's part. We will also provide the user feedback with regards to direction and distance of the detected obstacles. The second component of our solution is the ability for the glasses to serve as a reading device, enabling real-time text to speech services for the user.

1.3. Physical Design



1.4. High-level Requirements List

We believe that our project will be successful if we can create a product that accurately captures and extracts the text that the user is looking at. It should also be able to convert that text into speech, and read the words to the user through either a speaker or earphones. Lastly, we would like our product to be able to detect any potential obstacles near the user while they are in motion, and notify them using voice feedback.

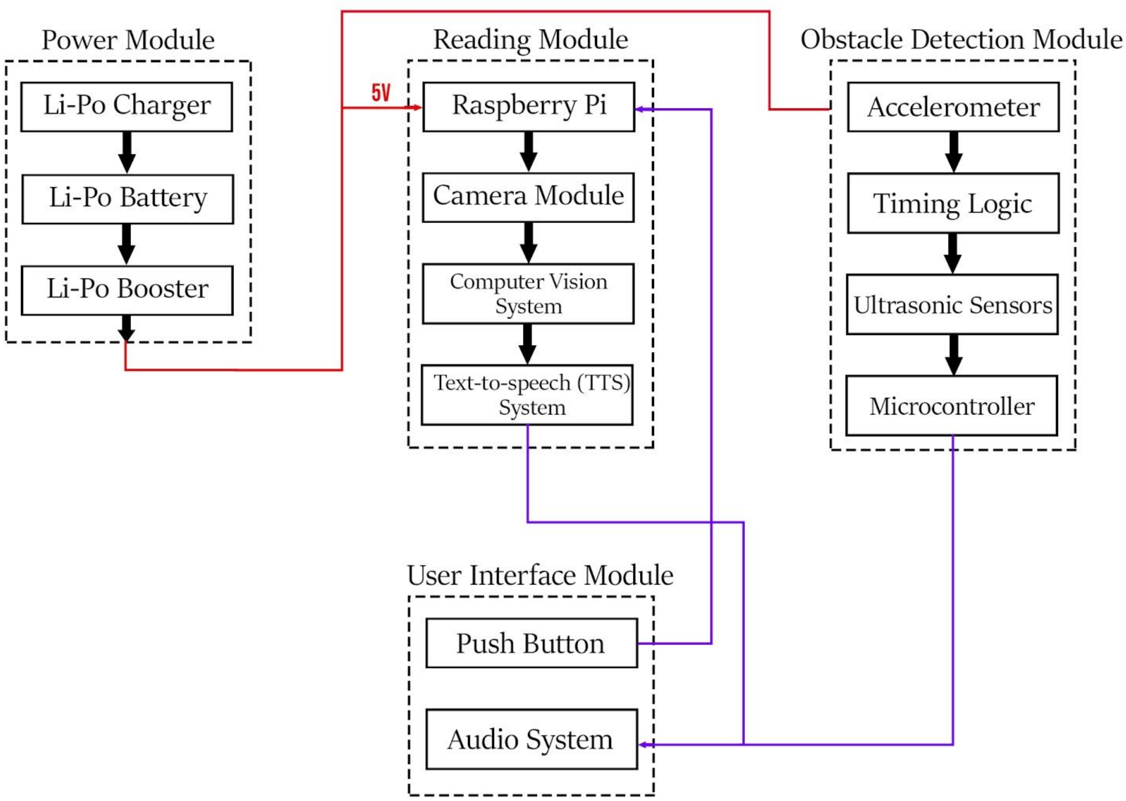
- The device should be able to detect obstacles in front of a mobile user within a 2 meter range and an angle of 30 degrees, within an error range of 5 inches.
- The device should be able to operate without recharging for at least 4 hours.
- The reading module should be able to read text with an accuracy of at least 85%.

2. Design

2.1. Block Diagram

Blocks

- Power Module
- Reading Module
- Obstacle Detection Module
- User Interface Module



2.2. Power Module

This module will be supplying power for our entire project. It will allow for consistent and safe power distribution throughout the components as well as within the system.

2.2.1. Lithium-ion Battery

Lithium-ion batteries will supply power to our Control Module, Obstacle Detection Module, and all internal components. We plan on using a 3.7 V, 2000 mAh lithium-ion battery. This will allow for our device to be fairly light and comfortable for the user.

Requirements:

1) The battery must supply 3.7 V to the system.
2) The battery must be rechargeable.
3) The battery must have enough capacity to operate for at least 4 hours.

2.2.2. Lithium-ion Charger

A lithium-ion charger can recharge our lithium-ion batteries via micro USB. This is necessary because we need a method to recharge the batteries, and this would be very convenient for the user.

Requirements:

1) Charger should be able to fully recharge the batteries within 2 hours.

2.2.3. Power Booster

A power booster will convert the 3.7V battery output to 5.2V DC to power the Raspberry Pi.

Requirements:

1) The power booster should be able to output at least 5V to effectively power all our components.

2.3. Reading Module

This module will be used for converting the text the user is seeing into characters using OCR, that will then be read aloud to them.

2.3.1. Camera

A camera will capture real-time images of text placed in front of the glasses which will then be transferred to our computer vision module for processing.

Requirements:

1) Camera must be able to take a high enough resolution picture of the text needed to be read.
2) Camera must be able to send the images to the Computer Vision System in order to be processed.

2.3.2. Computer Vision System

This system will run OCR software on the output of the camera module to convert the captured images into text, which can then be sent to the text-to-speech system.

Requirements:

1) System must be able to detect the presence of any text placed in front of the camera.
2) System must be able to convert the detected text into characters with an accuracy of at least 85%.

2.3.3. Text-to-Speech System

This system will process the characters imputed through the computer vision system, and output the audio of the text through the user interface module.

Requirements:

1) System must be able to convert the output of the OCR to audio signals and accurately output it to the user interface module.

2.3.4. Raspberry Pi

The Raspberry Pi will be used to process the images taken by the camera using OCR. It implements the text-to-speech system using audio output, and also processes the data from the ultrasonic sensors.

Requirements:

1) The device must be able to connect to a camera.
2) The device must be able to output audio via an audio jack.
3) The device must have enough memory to run OCR software.

2.4. Obstacle Detection Module

This module will be used in determining whether there is an obstacle in the way of the user's path. If the module detects any obstructions, it will also alert the user using voice feedback through the audio system, so that they can safely avoid the obstacle.

2.4.1. Microcontroller

The microcontroller will be used to receive input from the ultrasonic sensors and accelerometer.

Requirements:

1) Microcontroller must process ultrasonic sensor output data, as well as the accelerometer output data.
2) Microcontroller must communicate with the user interface through the audio system when there are obstacles within a certain range of the user as detected by the ultrasonic sensor.

2.4.2. Ultrasonic Sensors

Ultrasonic sensors will be used to detect objects in the path of the user, determining how far away those objects are and what direction they are in relation to the user.

Requirements:

1) Ultrasonic sensors must be able to detect objects within 2 meters of the user.
2) Ultrasonic sensors should detect objects within a combined 30 degree range [2].

2.4.3. Accelerometer

The accelerometer will serve as a trigger for obstacle detection by determining whether a user is in motion. Given that the user is in motion, the device will begin to detect objects around the user.

Requirements:

1) Accelerometer must be sensitive to user movement while walking.

2.4.4. Timing Logic

The timing logic will be used to trigger the ultrasonic sensor. We can use a 555 timer chip to send a periodic pulse that triggers the sensors to transmit ultrasonic pulses outward in search of obstacles.

Requirements:

1) The timer must generate a pulse of at least 10 μS in duration in order to correctly trigger the ultrasonic sensors [2].

2.5. User Interface Module

This module determines how the user interacts with the physical device. The push button will be used for triggering the text-to-speech feature, while the audio system will be used to enforce voice feedback.

2.5.1. Push Button

The push button will allow for the activation of the reading module through user input. This ensures that the device only takes images of text and sends them to be processed when required by the user.

Requirements:

1) Push button should activate the reading functionality of the device, so that this feature is not being used when not necessary.
2) Push button should be easily accessible to the user and must not be difficult to use.

2.5.2. Audio System

The audio system will relay text-to-speech translation to the user, as well as feedback related to obstacle detection.

Requirements:

1) Audio system should be able to transmit the translation of the text to the user through speakers.
2) Audio system should also be able to accurately alert the user when they are nearing an obstacle.

2.6. Risk Analysis

The portion of our project that we believe could present the most challenges is the obstacle detection module. Since mobility/navigation is such a critical task, it is important that our device should have a reasonably high accuracy, and false positives/negatives are a concern. Depending on our final design and placement of sensors, detecting obstacles of varying heights could also pose a problem. In order for the glasses to be used in all environments around one's home, we would need to ensure that if there are any obstacles in the path of the user, they are detected and the user is appropriately notified.

3. Ethics and Safety

The ethics behind our product design and the safe usage of our final product are of the utmost importance to us. We are determined to uphold and apply IEEE's Code of Ethics and address all possible ethical or safety concerns. As outlined in IEEE's fifth Code of Ethics, it is our responsibility to be transparent and realistic in terms of the capabilities of our product [3]. Provided that our product is used as an assistive device for the visually impaired, it becomes crucial that we conduct rigorous testing and provide complete disclosure of the accuracy of our product to ensure the safety of our consumers. IEEE's first Code of Ethics emphasizes the paramount importance of the safety, health, and welfare of the public [3]. To eliminate potential hazards resulting from close contact with electrical components, we plan to enclose our hardware components and power supply in a separate compartment that attaches to the side of the user's glasses. This design would also allow for a more portable and compact solution. Ultimately, we strive to provide the best possible solution for our consumers. Seeking criticism as well as acknowledging and correcting errors as noted in IEEE's fifth Code of Ethics, would allow us to continuously improve upon our product [3].

References

[1] World Health Organization, Global Data on Visual Impairment, [Online], Available: https://www.who.int/blindness/publications/globaldata/en/

[2] Sparkfun, HC-SR04 Ultrasonic Sensor Datasheet, [Online], Available: https://cdn.sparkfun.com/datasheets/Sensors/Proximity/HCSR04.pdf

[3] ieee.org, IEEE Code of Ethics, [Online], Available: https://www.ieee.org/about/corporate/governance/p7-8.html