Louis Flinn - 02548319

Report on Design Idea - Sensory Augmentation of the Vision System

1. Idea and Motivation

For blind or visually impaired individuals, any restoration or augmentation to their visual system can vastly improve their independence and quality of life [1]. Humans have an impressive ability to extrapolate a small amount of data about their environment into a mental model of their position relative to their surroundings, even as they move. Akin to a seeing person's ability to navigate with their eyes shut whilst opening them momentarily at 5-10 second intervals.

I propose a headband or baseball cap, which would stand out less than a headband, with an array of ~7 infrared time of flight sensors on the exterior. The interior would contain an equal number of buzzers located behind their respective sensor. These buzzers would vibrate at a frequency, intensity, or at intervals corresponding to the distance of an obstacle from the wearer. It would split the average human horizontal field of view of roughly 180 degrees [2] into 7 segments. This is based on some research, the time-of-flight sensors I have looked at have a FOV of ~27º so an array of 7 would give the wearer a field of perception of ~189º, slightly wider than the average human.

Figure 1 - Mock-Up of the Exterior of the Headband

This idea was chosen due to videos [3] of blind people who have developed an ability akin to echolocation used by bats and dolphins, which greatly improves their freedom, restoring most of the abilities of a seeing person.

2. What it Augments and How

Blind or visually impaired individuals tend to rely primarily on tactile and auditory senses to navigate their environments. This device would provide a form of 'artificial vision' by allowing the user to detect and navigate around objects in their environment, enhancing their spatial awareness. It is sensory augmentation of the vision system in the form of range augmentation, extending the users sensing range by integrating additional sensors [4].

The device could increase user's freedom by removing the fear of navigating unfamiliar places due to the real time feedback. The use of vibration through buzzers is non-invasive and can be intuitively understood. Different intensities, frequencies, or intervals of vibration can convey the distance and potentially the size of objects (by the number of 'vision segments' it spans), making the learning curve for use of this device relatively short. It could complement other aids such as guide dogs or canes, giving another layer of information about the wearer's environment. It would be particularly useful in situations where traditional aids are less effective, such as detecting elevated obstacles with no ground level profile, which a cane would not detect. Extrapolating its use cases, it could be integrated with other technologies, such as GPS navigation where the vibration direction corresponds to the direction in which the user should move. An appeal of this project is its relative simplicity and ease of implementation.

3. Proposed Implementation

3.1. System Chassis

An off the shelf headband or baseball cap would be used to house the sensors on the user's head. Microcontroller and power supply should be mounted on an armband to reduce weight and size of the head mounted system.

3.2. System Design

Sensor Layout

Design the array layout of the time-of-flight sensors on the headband or cap. Even distribution can be ensured by using a 3D printed bracket.

Buzzer System Design

Plan the interior design for the placement of buzzers corresponding to each sensor segment. These could potentially be embedded in a silicone band to separate them slightly from the user's head, increase comfort, and ensure their position remains constant.

Signal Processing

Write an algorithm to translate sensor data into meaningful vibrational feedback, there may be libraries online for processing the sensor output depending on the sensor selected.

Power Management

Design a power supply system for the sensors, buzzers and microcontroller. Likely battery-powered, ensure its lightweight and has sufficient capacity.

3.3. Software Development

Firmware Development

Write firmware for the microcontroller to process sensor data and control buzzer feedback.

Testing and Calibration

Test the system with various obstacles and distances to calibrate the vibrational feedback accurately.

3.4. Additional Features

The system should contain a button on the side or on the armband to toggle on and off, the user wouldn't want it triggering during a conversation for example.

3.5. Components

Headband or baseball cap
7 x Elegoo Avoidance Time of Flight Sensors from Sensor Kit
Or (Preferably)
7 x VL53L1X Time of Flight (ToF) Sensor Breakout (Improved range and accuracy) Link
7 x Buzzers
Wires
Breadboard
Arduino Nano 33 IoT (due to its 14 digital I/O pins, 8 analogue input pins, 11 of these 22 pins can be used for PWM out [5].)
Push button
3D printer PLA filament
Miscellaneous electronics components

3.6. Pseudocode

```
Initialize System:
  Set up Raspberry Pi Pico GPIO pins for ToF sensors, buzzers, and button
  Configure each ToF sensor (7 sensors)
  Configure each buzzer (7 buzzers)
  Set system state to OFF

Main Loop:
  While True:
    If button is pressed:
      Toggle system state (ON/OFF)

    If system state is ON:
      For each ToF sensor in array:
        Read distance from the sensor
        Calculate feedback intensity based on distance
        Activate corresponding buzzer with calculated feedback

    Else:
      Turn off all buzzers

Calculate Feedback Intensity(distance):
  Define thresholds for distance ranges
```

Map distance to intensity levels (closer object = higher intensity)
Return intensity level

Button Pressed():
Check if the button state has changed
Debounce to avoid false triggers
Return True if button state changed, False otherwise

3.7. System Overview

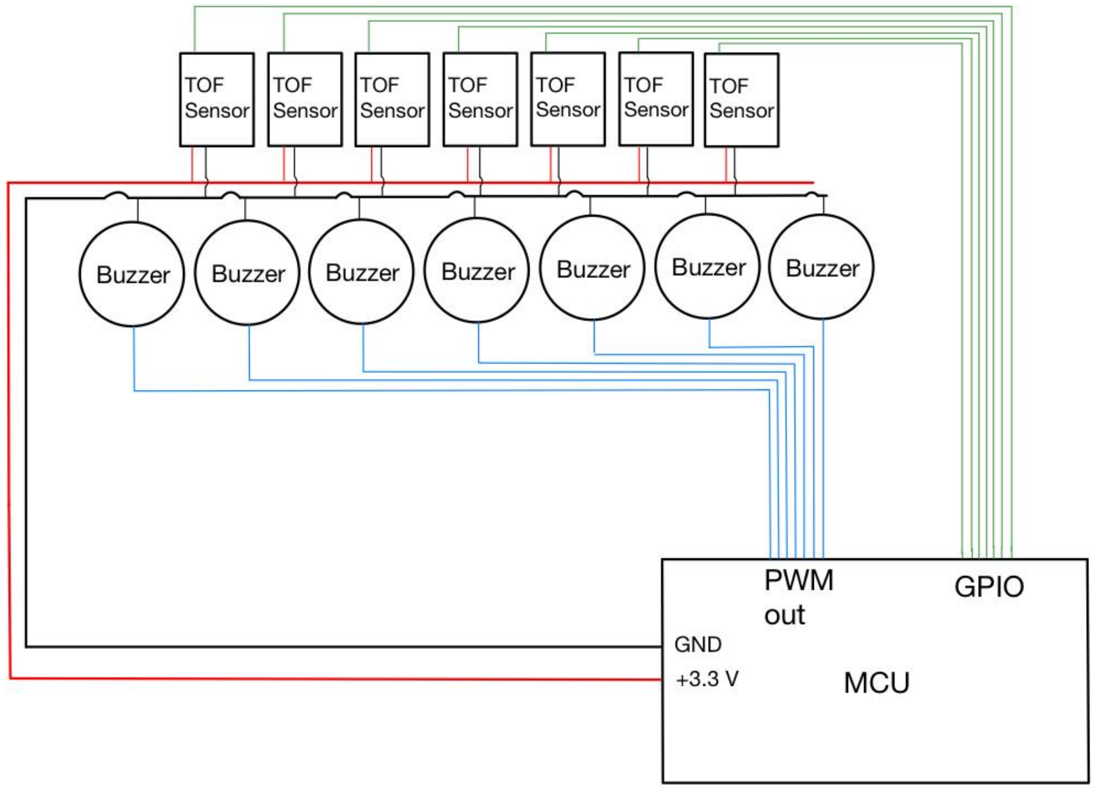

Figure 2 - Basic System Overview

References

[1]
M. Mashiata *et al.*, "Towards assisting visually impaired individuals: A review on current status and future prospects," *Biosensors and Bioelectronics: X*, vol. 12, p. 100265, Oct. 2022, doi: https://doi.org/10.1016/j.biosx.2022.100265.

[2]
J. Lienhard, "Binocular Vision | The Engines of Our Ingenuity," *engines.egr.uh.edu*. https://engines.egr.uh.edu/episode/2581 (accessed Jan. 28, 2024).

[3]
screenocean, “The Boy Who Sees Without Eyes,” *YouTube*. May 30, 2012. Accessed: Jan. 28, 2024. [YouTube Video]. Available: https://www.youtube.com/watch?v=TeFRkAYb1uk

[4]
J. Eden, “Principles of movement augmentation,” *Imperial.ac.uk*, Jan. 19, 2024. https://bb.imperial.ac.uk/ultra/courses/_37475_1/cl/outline (accessed Jan. 28, 2024).

[5]
“Introduction to the Nano 33 IoT – ITP Physical Computing,” *Nyu.edu*, 2023. https://itp.nyu.edu/physcomp/introduction-to-the-nano-33-iot/#:~:text=Input%20and%20Output%20(GPIO)%20Pins (accessed Jan. 28, 2024).

Word Count: 919