Microphone Input LED Display T-shirt

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1 Introduction

1.2 Objective

According to the World Health Organization, over 5% of the world's population suffers from disabling hearing loss[1]. Not only must these people suffer from the life constraints that come with this disability, but it imposes hardships on their communication and understanding of others. While some learn to read lips, or afford medical tools such as hearing aids, to help them cope, this pushes the problem onto their shoulders. For many, this means social and economic ostracization and in young children, can lead to educational impairment. In developing countries, children suffering from hearing impairment often receive no schooling, and adults are much more often unemployed. From day-to-day communication with a random hearing impaired bystander, to the social and educational salvation of millions of deaf individuals worldwide, our idea is an attempt to bridge the communication gap they suffer though.

Our goal is to design a t-shirt with an imbedded device that can communicate vocal audio into text. Whereas previous communication with the hearing impaired is limited to sign language and writing or typing messages, we plan to bring the ability to talk in normal conversation, and allow the hearing impaired individual(s) to read what is said on a display directly on the t-shirt.

1.3 Background

Current hearing impaired communication methods are rudimentary at best. Medical centers advise things such as speaking slowly and clearly, face the hearing impaired individual directly, and minimizing extra noises[2]. Even the U.S. department of justice advises use of a pad and pencil, sign language interpreter, or specialized teletypewriter[3], for important communication to hearing impaired individuals. Even in important situations like law enforcement and medical practice, communication methods with the deaf are severely lacking. Our t-shirt has the capability to revolutionize easy and practical communication with these people, combined with the simplicity of wearing a t-shirt.

1.4 High-Level Requirements

- The microphone, able to be activated and deactivated via switch, should be able to pick up normal conversation level speech, and pass this data effectively to the microcontroller, which in turn converts the audio into text data to be displayed on the LED dot matrix.

- T-shirt must be powered for what is considered a reasonable day outside, approximately 12 hours, before charging is needed.

- T-shirt and circuit must be water resistant, to prevent damage from rain or handwashing, and if at all possible, able to survive in a washing machine, while still maintaining comfortability in wearing.

2 Design

Our t-shirt design requires four main pieces for successful operation: a battery, a microphone, a microcontroller, and an LED dot matrix.
The battery should be able to power the microcontroller and LED matrix for about 12 hours before requiring a recharge. The microphone should be able to detect normal human speech, while not picking up background noise, to be able to correctly transfer the audio data to the microcontroller. The microcontroller will contain a speech-to-text program able to translate the audio data into signals to send to the LED matrix. Lastly, the LED dot matrix will be a large enough array of LEDs as to sufficiently display words and short phrases, to properly communicate sentences to the viewer.

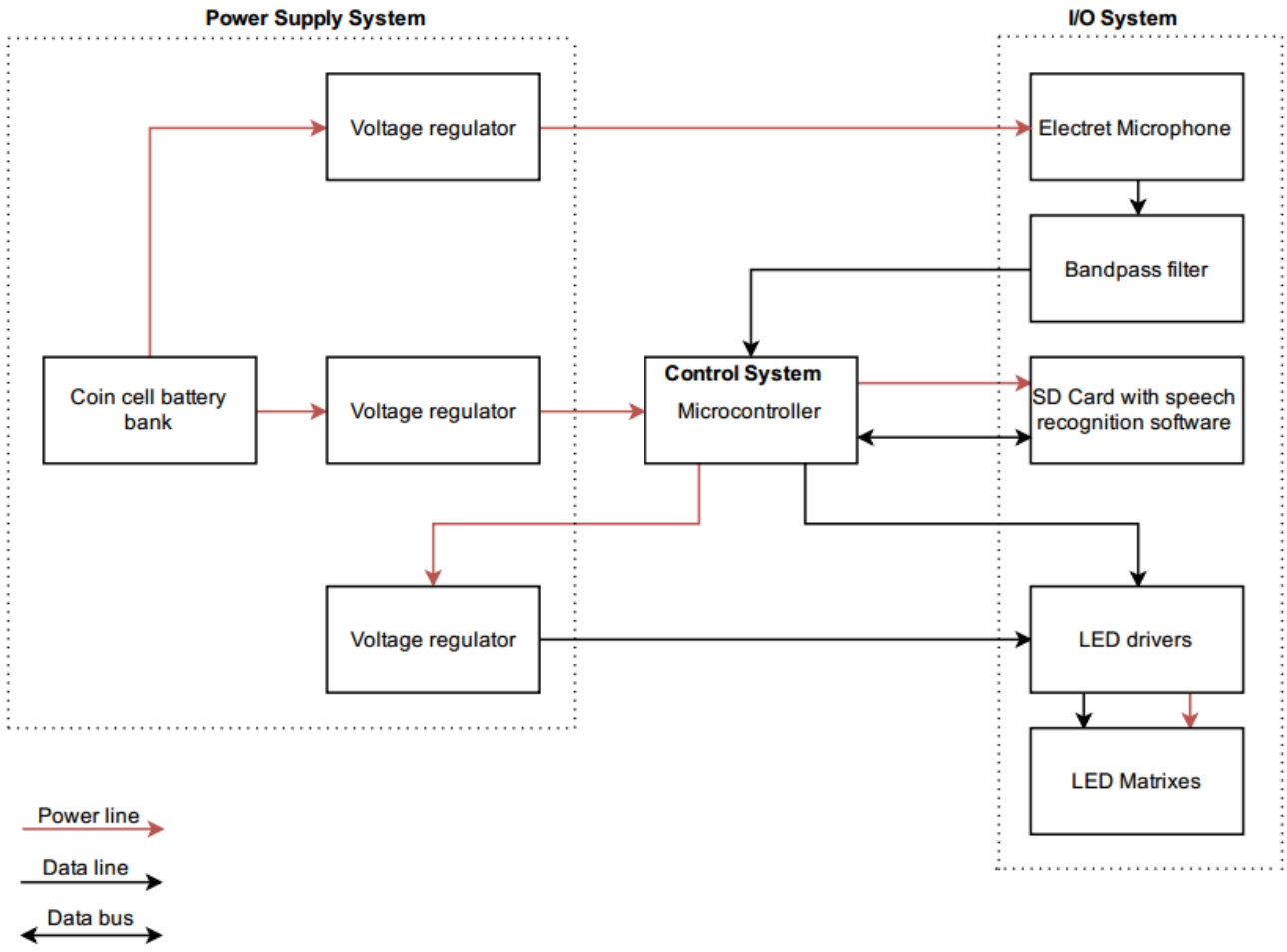

Figure 1. Hardware Block Diagram

2.2 Power Supply

A portable power supply is required to power the LED array on the Tshirt. A coin cell battery bank will power the LED matrixes and the microcontroller. Voltage regulators will maintain constant voltage signals

to the microphone and microcontroller. The microcontroller will power LED drivers that will in turn power the LED matrixes.

2.2.1 Coin cell battery bank

A small array of coin cell batteries will power the T-shirt. Coin cell batteries use less physical space than alternatives, while meeting the low power requirements of the project.

Requirement 1: The battery will need to supply 6V at a capacity of at least 300mAh to provide enough energy for the shirt to be worn for 5 hours of operation.

2.2.2 Voltage regulators

The battery will need to provide a steady input voltage to both the microcontroller and the microphone. The voltage regulators will ensure that the supplied voltage is steady.

2.3 Control Unit

The microcontroller receives audio (speech) input from the microphone, processes it into text, and displays that text on the LED matrixes.

2.3.1 Microcontroller

The microcontroller will be responsible for processing speech data and sending the proper output signals to the LED matrixes to display the text.

Requirement 1: The microcontroller must use less than 40mW of power on average.
Requirement 2: It must have enough storage to be able to buffer data long enough to process it.
Requirement 3: The delay in processing and displaying the input must not exceed 500ms.

2.3.2 Push button

To save energy, we will include a push button to power on the circuit. This will also allow the user to choose when he wishes to display his speech on the LED display.

2.4 I/O System

Data is captured by the microphone, preprocessed by a bandpass filter, sent to the microcontroller for further processing, and finally sent to the LED matrixes for display. An SD card is required for program storage.

2.4.1 Bandpass filter

A bandpass filter will be used to attenuate any frequencies outside of those necessary to represent the human vocal range.

Requirement 1: The bandpass filter must filter out any frequencies below 300Hz and any frequencies above 3KHz.

2.4.2 Microphone

An electret microphone will capture audio and send the signals back to the microcontroller.

Requirement 1: The microphone must be able to pick up sounds with frequencies of at least 300Hz and up to 3Khz.
Requirement 2: It must be able to pick up sounds with intensities of at least 50db.

2.4.3 SD Card

An SD card is required to store the speech recognition software.

Requirement 1: The added I/O read/write delay must not increase the overall delay to a delay of more than 500ms.

2.4.4 LED Matrix

The LED matrix will receive scanning signals from the microcontroller which will quickly light up each row in order to create the effect of a constant light source while allowing each dot to be addressable.

Requirement 1: The display must be visible from 5m away.

2.4.5 LED Driver

The LED driver is in charge of taking input signals from the microcontroller and displaying them on each LED matrix.

Requirement 1: The LED driver must be able to supply up to 10mA to each dot.
Requirement 2: It must be able to display arbitrary LED patterns based on microcontroller input.

2.5 Software

Software is required to process audio input from the microphone and output the text of recognized words onto the LED display matrixes.

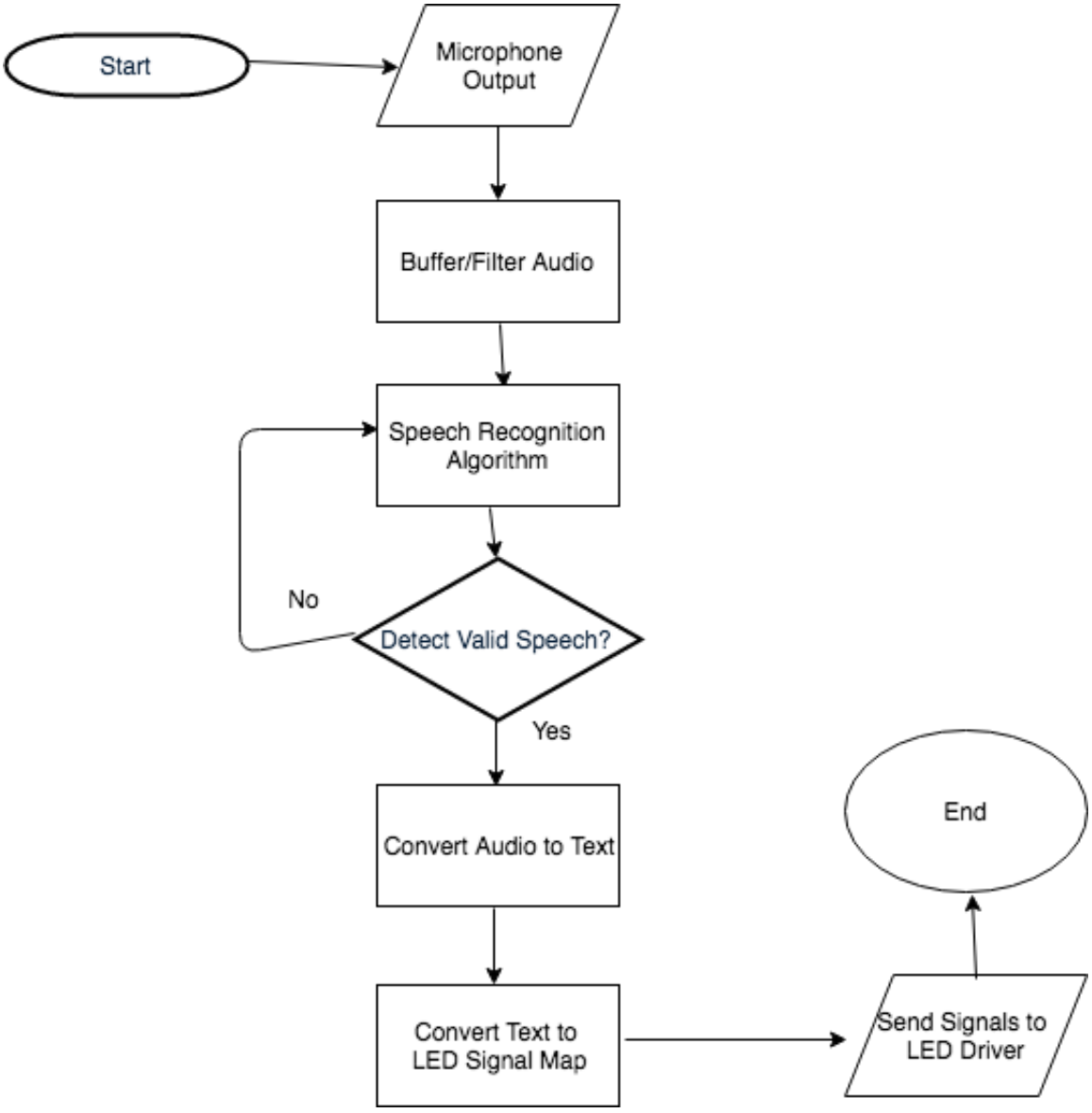

Figure 2. Software Block Diagram

2.5.1 Speech recognition

The speech recognition software processes the input audio from spoken words into text.

Requirement 1: The buffer required to process the data must not exceed that available on a candidate required microcontroller.
Requirement 2: The delay in processing the audio data must not exceed (500ms – I/O delay – display delay).
Requirement 3: The sample rate must be at least 8Kb/s.
Requirement 4: The software must recognize both male and female voices.

2.6 Risk Analysis

The software we use is likely the most significant risk to the completion of our design. The software we use is tasked with receiving audio input and converting it into text data for the LEDs. This process is unreasonable to recreate ourselves within the constraint of this project, so we are using 3rd party speech to text conversion software. This runs the risk of not working properly, since we are relying on being presented with semi-working code and word libraries, and piecing the code together to serve our purposes. Worst case, if the software does not work, is that we have a microphone and an LED display, but nothing for the microcontroller to use to light the proper LEDs up.

Luckily, the software choice we are considering has a plethora of resources in terms of use and troubleshooting. So while we can't adjust the large scale functions of the software we are implementing, we have the ability to tweak, fine-tune, and otherwise troubleshoot it to our specifications. Unfortunately, if we are unable to troubleshoot the software to fix it completely, it puts most of the functionality of the project in jeopardy.

3 Safety and Ethics

There are several potential safety hazards with this project. First and foremost is the implementation of an electric device inside a t-shirt. Despite warnings to the contrary, there exists the scenario in which people go out in heavy rain with this shirt, jump into pools, or throw it in a washer/dryer. Aligning ourselves with the IEEE Code of Ethics #1[5], we acknowledge the possible safety concerns of our idea, and will do everything in our ability to ensure the safety of the wearer in our design. We believe that the benefits of communication advancement outweigh the dangers of such an idea.

Another potential danger is our NiMH battery. While rechargeable and a generally safe battery, the NiMH has dangers relating to overcharging or charging too quickly, including, but not limited to: hydrogen gas buildup rupturing the battery as well as battery temperature reaching unsafe levels[4].

Finally, we plan to ensure that our design adheres to at least IP54 (ideally IP57) guidelines, in order to keep the product in working condition under rainfall (IP54), and ideally, under duress of a washing machine (IP57).

References

[1] "Deafness and Hearing Loss." *World Health Organization,* Web. 06 Feb 2017. <http://www.who.int/mediacentre/factsheets/fs300/en/>

[2] "Communicating with People with Hearing Loss." UCSF Medical Center. Web. 06 Feb. 2017. <https://www.ucsfhealth.org/education/communicating_with_people_with_hearing_loss/>

[3] "Communicating with People who are Deaf or Hard of Hearing: Ada Guide for Law Enforcement Officers." U.S. Department of Justice. Web. 06 Feb. 2017. <https://www.ada.gov/lawenfcomm.htm>

[4] "Nickel–metal Hydride Battery." Wikipedia. Wikimedia Foundation. Web. 06 Feb. 2017. https://en.wikipedia.org/wiki/Nickel%E2%80%93metal_hydride_battery

[5] “IEEE Code of Ethics.” IEEE. Web. 08 Feb. 2017. <http://www.ieee.org/about/corporate/governance/p7-8.html>