Wearable Directional Sound Amplifier

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1. Introduction

1.1 Objectives :

Microphone arrays are used in many devices today, from hearing aid attachments to more modern commercialized products such as the Amazon Echo. The microphone arrays in these devices are considered small, meaning that they contain fewer than eight microphones. The Amazon Echo contains seven microphones while the Google Home only contains two [1]. A hearing aid with microphone array attachment designed by Bernard Widrow contains six microphones [2]. There has been extensive research done regarding small, uniformly spaced, and fixed microphone arrays but very little regarding large, differently spaced, and mobile arrays.

We intend to develop an easily reproduced and scalable large (greater than eight microphones) microphone array that will be worn on the human body. This will serve many research purposes. It would allow researchers to study how the human body affects the sound acquired by a microphone array as well as providing a large microphone array to run tests which would determine whether there is a benefit to building larger microphone arrays rather than small ones.

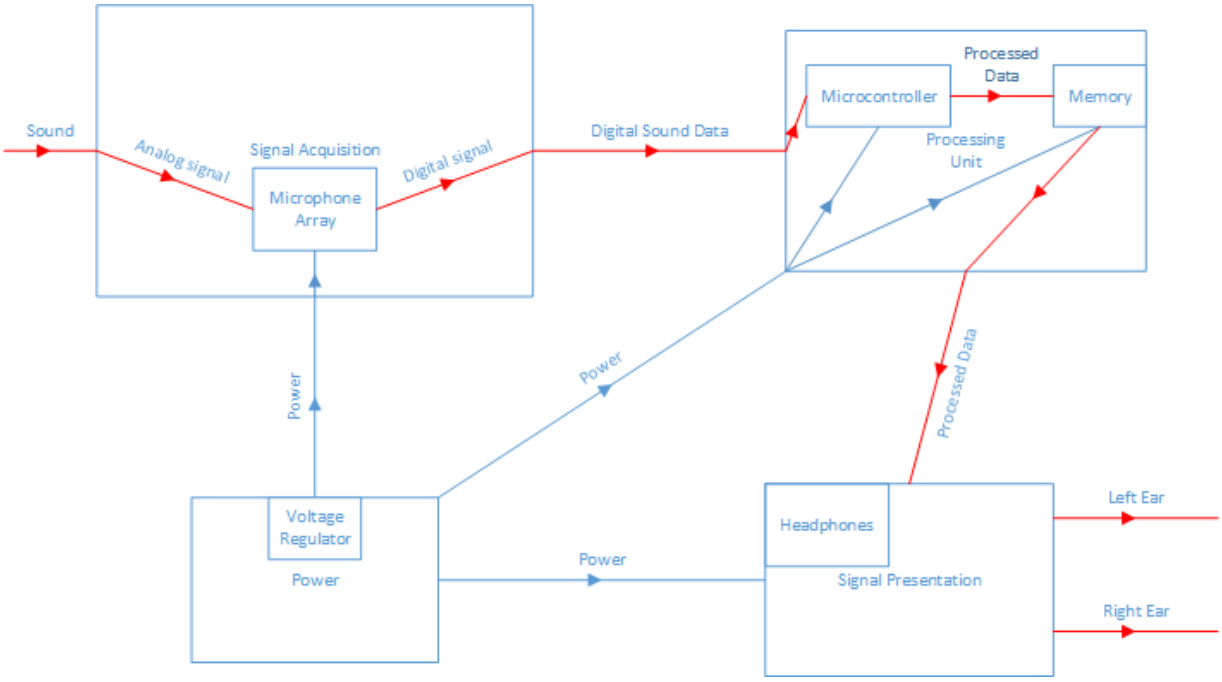
1.2 Background :

Creating a large, wearable microphone array was specifically requested by Professor Singer. There is currently little to none public research available on wearable microphone arrays. While there are many small microphone arrays in commercial products such as the previously mentioned Amazon Echo and Google Home, these arrays are simply placed at a location within a building. We want to study how the human body affects the sound that the microphones receive; clearly there will be some interference from the body on sounds that are blocked by the body as well as sounds echoing off the body from different directions.

1.3 High-level Requirement List :

- Amplified/ attenuated sound depending on where the sound coming from
- Echo cancellation between the microphone and the speak in the ear
- Low latency(about 4-10ms)

2. Design
2.1 Block Diagram :



2.1.1 Signal Acquisition Module

The module will be made up of a series of microphones that will automatically convert the analog sound into digital data that will be sent.

2.1.2 Power Module

This is not a main part of the project, so the design will use an external power supply with a voltage regulator to prevent burning out the circuit.

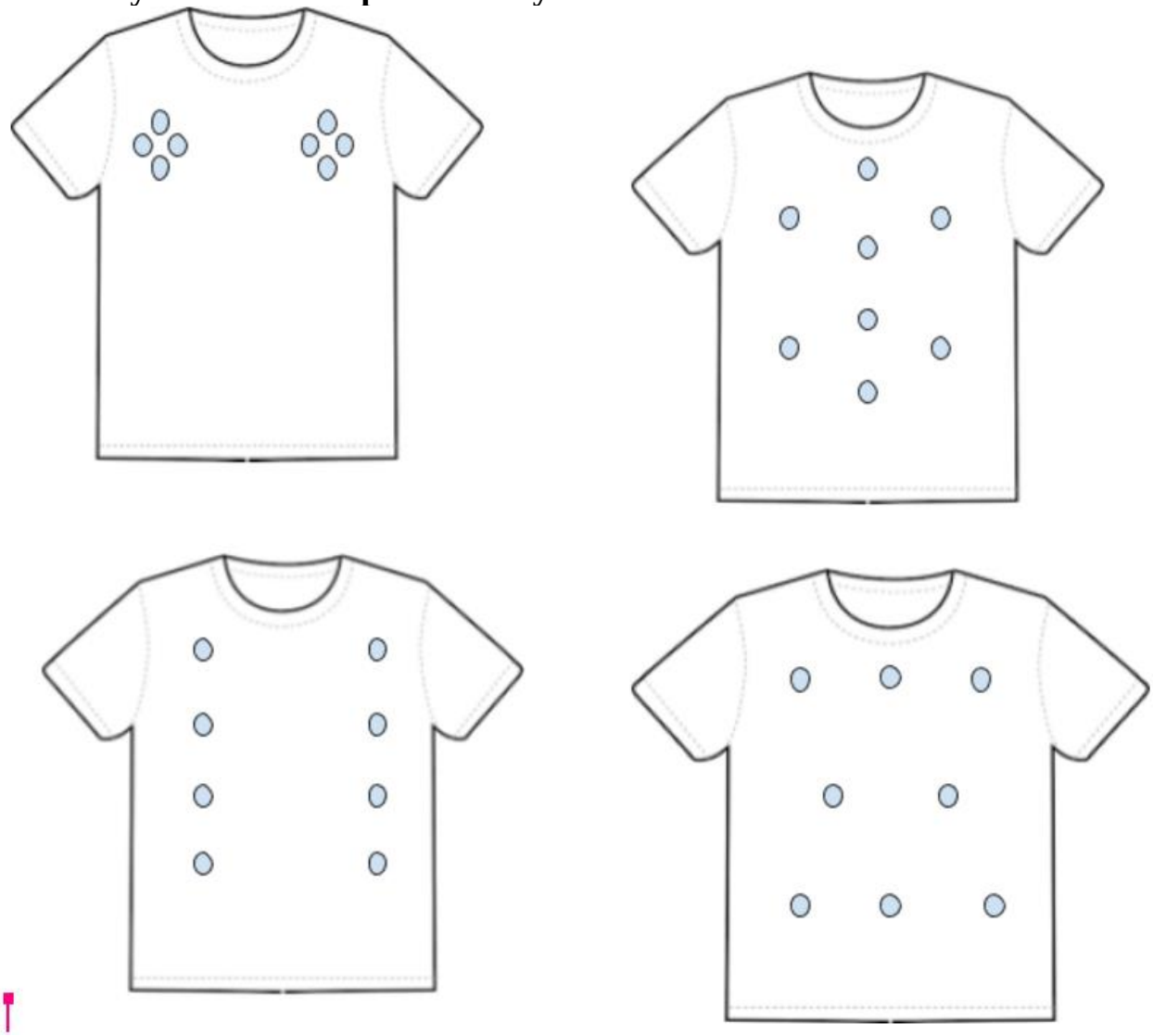
2.1.3 Processing Unit

This unit is made up of the memory and the microcontroller. The microcontroller will need to be able to take data from up to at least 8 microphone almost simultaneously and then process it and send it to memory. The memory will need to be able to store at least a minute worth of sound data from the microcontroller.

2.1.4 Signal Presentation

This is also not a main part of the project; this is just an application of what this can be used for, so it will just have an input for a headphone jack, so the user can hear the amplified sound. The memory should also be able to be uploaded to an external hard drive.

2.2 Possible Layouts for Microphone Array :



The top left figuration is the easiest design since the microphones are close together and are probably the most comfy since they don't cause the shirt to be constricted as much but spatial resolution is lost they are close together. The bottom right will have the most spatial resolution but will be the hardest to design since the microphones need to be transmitting data and if there are wires connected all over the place, it will make the shirt more constricting in movement.

2.3 Risk Analysis

The amount of data be moved is the biggest concern since it needs to be synchronized and needs to be inputted into the same location and if there is not enough input ports, then some data will be lost in order to take turns sampling different microphones. Memory may also be a concern since a microphone sampling at 40kHz in order to achieve human hearing range, will take 240,000 samples in a minute, so the memory would hold over a million samples for all 8 microphones.

3. Ethics and Safety

There are two main safety concerns for this projects, making sure that the device does not damage the listener's' hearing any farther and not allowing the listener to be injured by the device. Due to the speakers being in the user's ears, it is important to limit the volume of sound coming from them. Human ears can be damaged to exposure to sounds reaching 85 dB or higher so we will limit the outgoing sound to 80 dB [3]. The microphone array, speakers, and power supply will need to be electrically insulated to ensure that the listener is not accidentally injured by an exposed circuit.

The main ethical concern is that people may use this wearable microphone array improperly. Our wearable microphone array should be used to conduct research regarding large wearable microphone arrays but if used incorrectly may be used to potentially spy on other people, thus violating people's privacy and failing to comply with Section 9 of the IEEE Code of Ethics [4]. This ethical guideline states that we should "avoid injuring others, their property, reputation, or employment by false or malicious action" and we believe that using our array to spy on other parties would violate this guideline. However we are unable to avoid this as amplifying sound specific directions is a critical part of our project. We are going to add a warning label on the product stating that the product should be used for research purposes only.

References

[1] A. Tilley, "Google home vs. Amazon echo: Everything you need to know," in *Forbes*, Forbes, 2016. [Online]. Available: http://www.forbes.com/sites/aarontilley/2016/10/04/google-home-vs-amazon-echo/#20ae56f55963. Accessed: Feb. 15, 2017.

[2] B. Widrow, "Stanford," in *Stanford*, 2001. [Online]. Available: http://www-isl.stanford.edu/~widrow/papers/j2001amicrophone.pdf. Accessed: Feb. 15, 2017.

[3]D. Decibels, "Noise induced hearing loss," 2001. [Online]. Available: http://dangerousdecibels.org/education/information-center/noise-induced-hearing-loss/. Accessed: Feb. 17, 2017.

[4] (2017) IEEE Code of Ethics. [Online]. Available : http://www.ieee.org/about/corporate/governance/p7-8.html