Multiple Microphone Array

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1 Introduction

1.1 Objective:

The auditory system of hearing animals is extremely sophisticated and serves many important functions. One such function is sound source localization, which refers to the ability of the system to identify the origin of a sound in location and distance and track the sound as it moves. There has been extensive research done in order to create systems that can perform this function, due to the numerous applications, such as data transmission and information recognition.

We believe that this can be solved using array processing with arrays of microphones. With recent improvements in digital microphone technology, it is now possible to build large, efficient arrays. There has been much research done with smaller arrays of microphones, but large arrays have been mostly unexplored. In our project, we plan to design and build a microphone array module that can connect with similar modules to form a scalable array with numerous sensors. The data can be collected from these sensors and stored and processed in some backend system. The modules will be reconfigurable and at least somewhat portable, so that data can be collected in real-world environments and with various configurations.

1.2 Background:

Although this is not a new concept, researchers have largely used different methods for tackling it, due to the lack of adequate microphone technology. For example, Microsoft researchers hoped to build a system with superior sound localization abilities, but given the restriction on the number of microphones that can be build into an array, they instead developed a new maximum likelihood framework for sound localization [1].

There have been efforts to explore larger arrays of microphones, but again, due to the inadequacy of microphone technologies, many of those pursuits failed. The Huge Microphone Array project was such an attempt [2]. In this project, they built a real-time 512 microphone array system as a versatile research platform. Ultimately, they were successful, however the cost was high and they used excessive amounts of hardware. Another project was called LOUD, in which they built a 1020-microphone array. The system performed well with high accuracy and they are currently the record holder for the most microphones built into an array[3]. In our project, we will use modules of microphones that will allow the system to scale to even larger sizes, while keeping cost relatively low and accuracy high.

1.3 High-level requirements:

1. Microphone modules should be able to be reconfigured and scaled without sacrificing quality or precision.

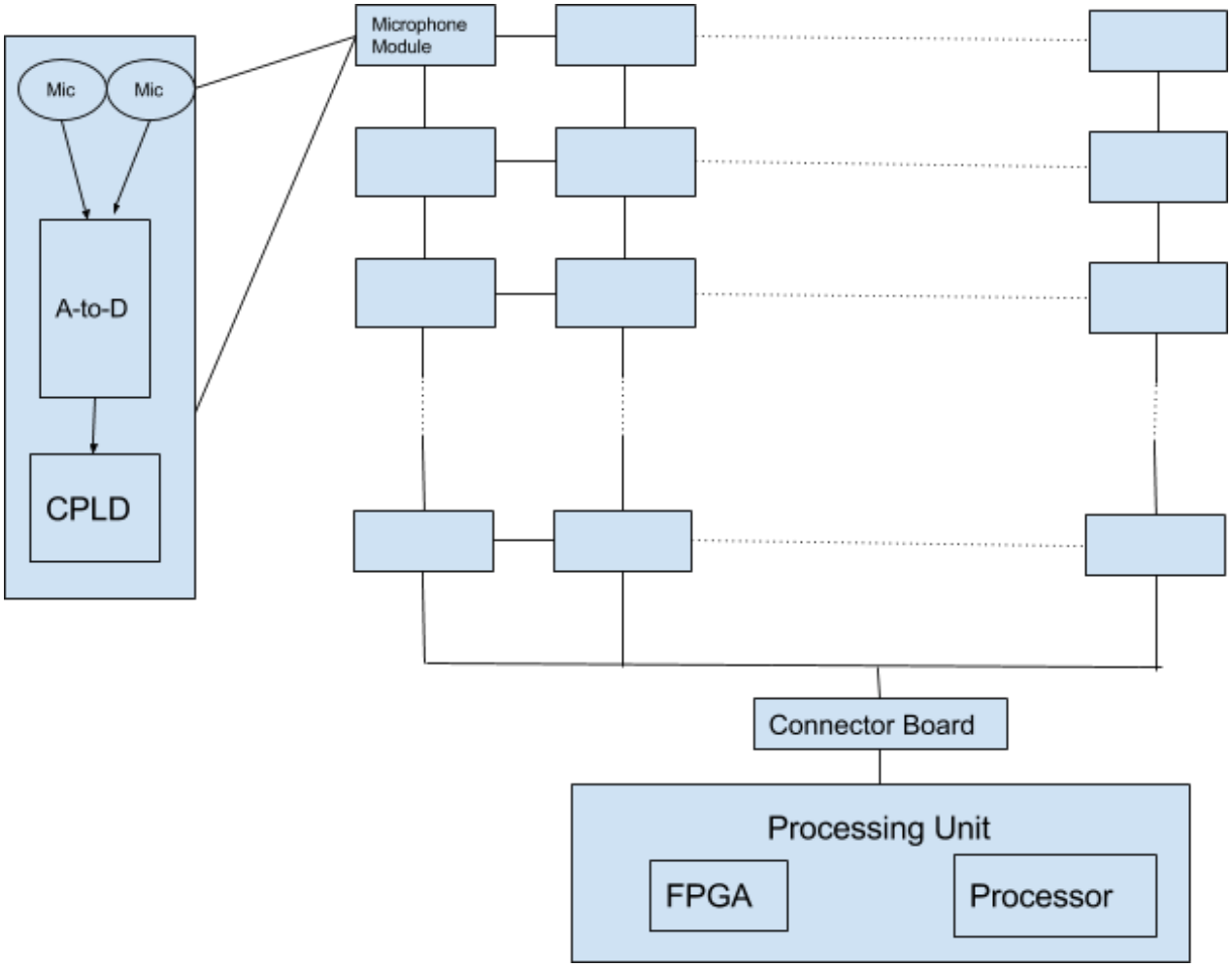
2. There should be a lossless transfer of data from the modules to the backend storage and processing system.

3. Lower cost microphones and module infrastructure

2 Design

2.1 Block Diagram

The system will require two sections in order to operate properly: microphone modules, and a processing unit. The modules will be chained together and plugged into connector boards, which are then connected to the processing unit.



2.1.1 Microphone modules:

Each module will contain a small number of microphones (e.g. 2 - 4), one stereo A-D converter, and a small CPLD. The A-to-D converter will sample at 16 KHz and will generate 24-bit serial data for each microphone.

2.1.2 Processing unit:

The processing unit will require one FPGA and a processor motherboard. The FPGA will convert the serial data from the array into packets of words, which will then be streamed into the processor. The processor will then handle the storage and processing of that data.

2.2 Risk Analysis

The most significant risk to the successful completion of the project is probably moving the data from the modules to the processing unit. In order to make sure that there is no loss in data, there are many factors to consider. Signal routing, memory, bandwidth, and storage will be critical. Clock synchronization for each module will also be important.

3 Ethics and Safety

The main safety issue with our project should be considered when the array is scaled up to a large size. If the system is not mechanically sturdy and rugged, there is a possibility that the array will collapse in some way and cause injury. To ensure that this situation does not occur, we will make sure to connect each module securely, as well as fastening the entire system to a stable anchor, such as the wall or a table.

The primary ethical issue involved is that there is a risk that people could use this technology for unlawful audio surveillance. This would go against #9 of the IEEE Code of Ethics, since this “malicious act” could potentially injure someone’s “property, reputation, or employment”.

References

[1] Zhang et al. 2008. Maximum Likelihood Sound Source Localization and Beamforming for Directional Microphone Arrays in Distributed Meetings. IEEE Transactions on Multiple Media, Vol. 10, No. 3.

[2] Silverman et al. 2002. The Huge Microphone Array. IEEE Concurrency. Vol. 6, Issue 4.

[3] Weinstein et al. 2004. LOUD: A 1020-Node Modular Microphone Array and Beamformer for Intelligent Computing Spaces.