PROJECT SAURON
FINAL PROJECT REVIEW

Senior Design Project
Spring 2016

Special thanks to:

UMass Amherst College of Engineering

UMASS AMHERST M5

MathWorks

Project Sauron

Final Project Review

Advisor:
Tilman Wolf

Zach Goodman
EE

Walter Brown
CSE & CS

Omid Meh
CSE & EE

Jose LaSalle
EE

System Overview

Sauron is a microphone array system utilizing 16 microphones to create a highly directional audio output, allowing it's user to enhance and isolate sound in a specified location.

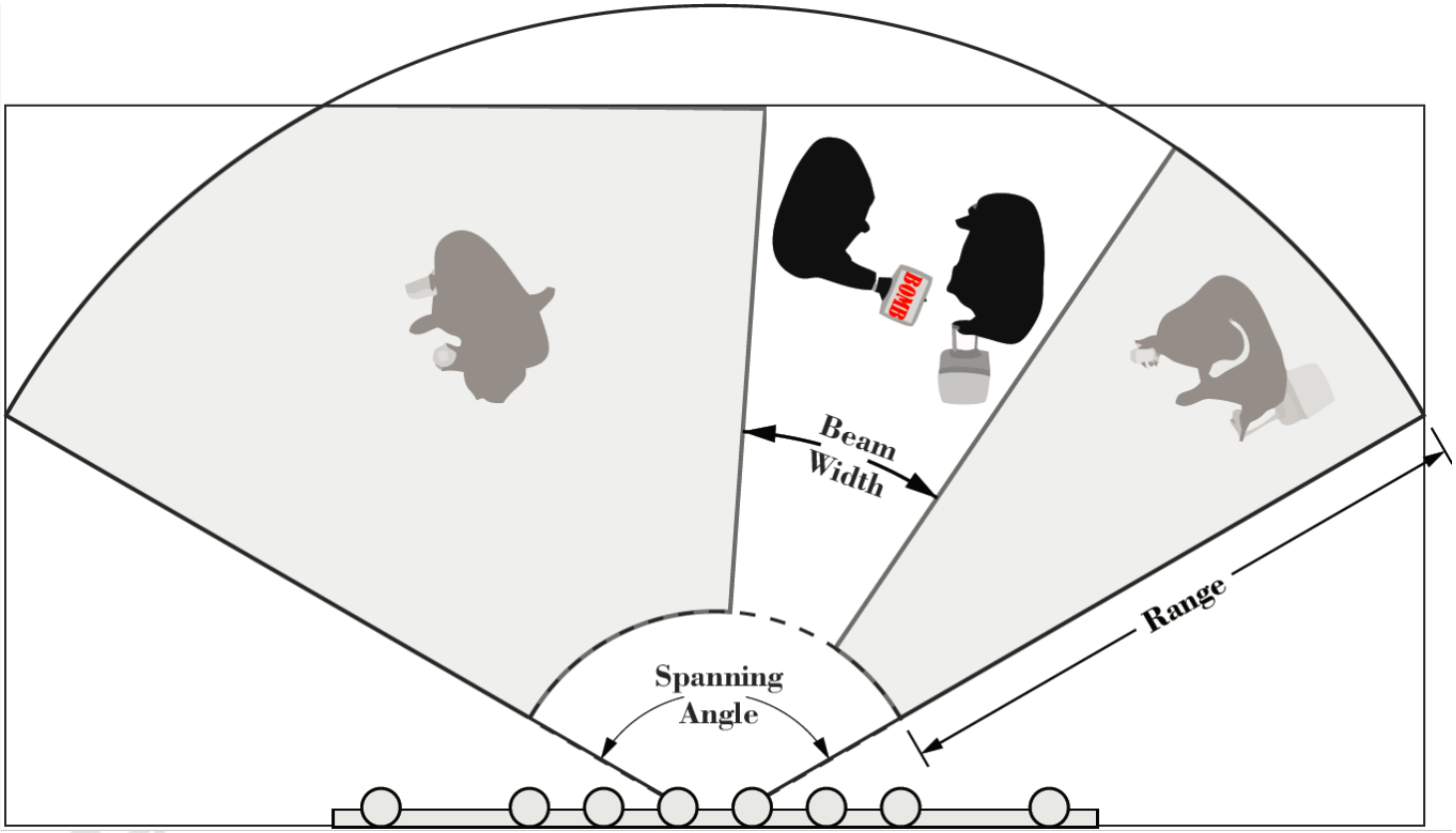
Introduction

- Motivation
  - Prevention of crime
  - Investigation of crime
  - Protection of Civilian
- Ethics
  - Often a violation of privacy
  - Usually limited to circumstances where public safety is at risk
  - Ultimately, it is up to the user.

Agenda

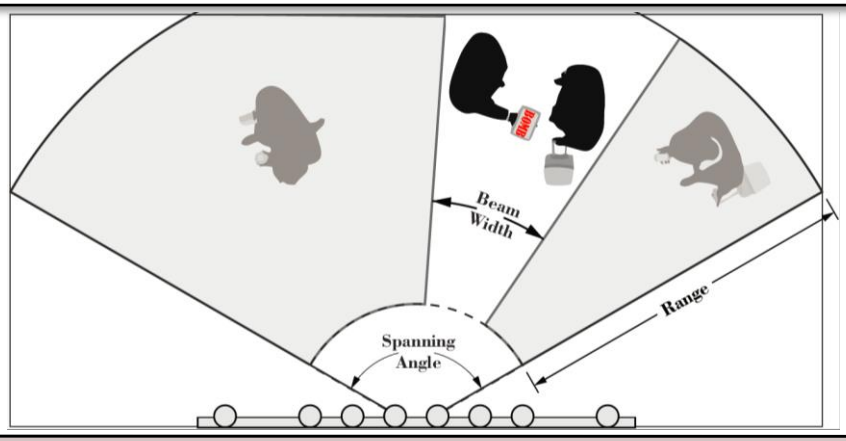
- System Description
  - Specifications
  - Block Diagram
  - Block Description
- Demonstration
- Conclusion

System Specifications

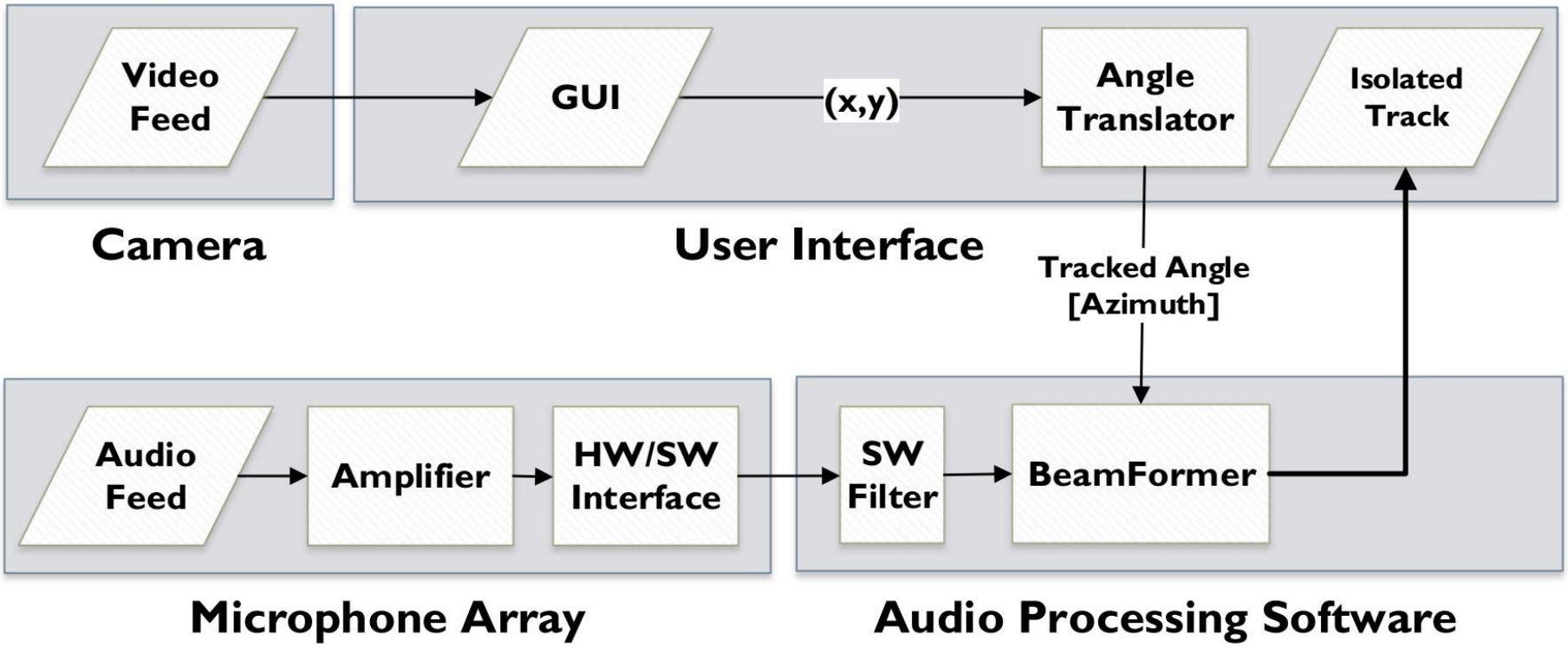


System Specifications

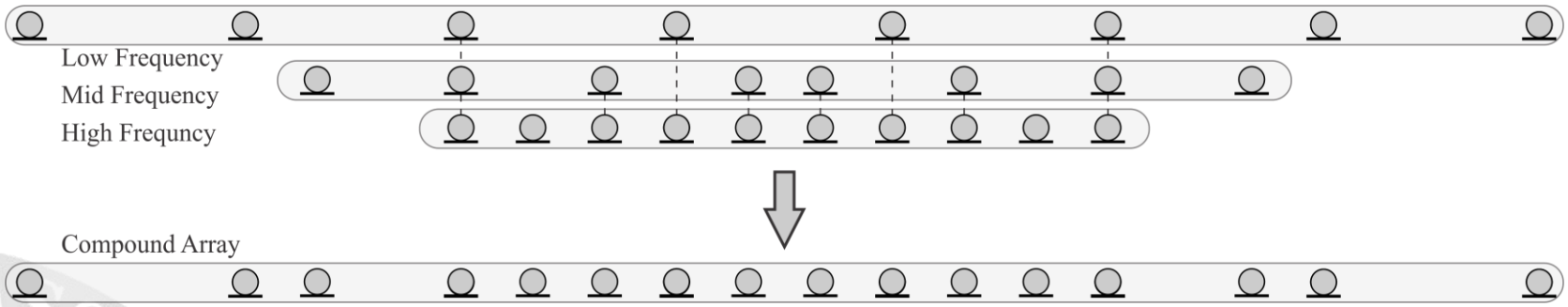
Specification	Promised	Achieved
Range	1 to 3 meters	1 to 3 meters
Angle of Operation	-65º to 65º	-65º to 65º
Maximum -10dB beamwidth	40º	30º
Frequency Range	1kHz to 3.5kHz	500Hz to 5kHz
Real-time Delay	10s	5s
Error in angle selection	20º	10º



Block Diagram

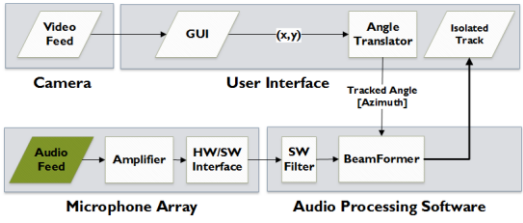


Mic Array: Geometry

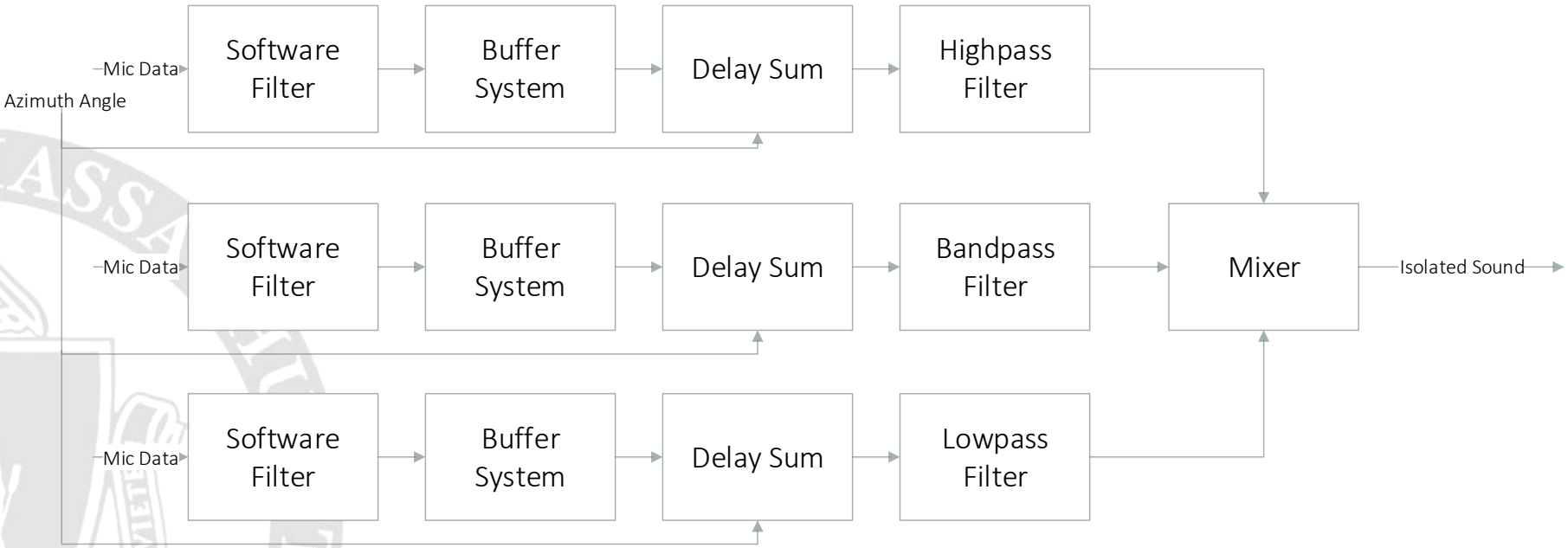


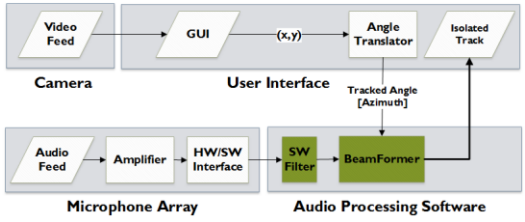
- ULA Tuned for Human Voice
  - 400Hz – 5k
- Supports three different bands

Mode	Range (KHz)	Spacing (cm)	Elem count
Low	0.4 - 1	21	8
Mid	1 - 1.7	14	8
High	1.7 - 5	7	10



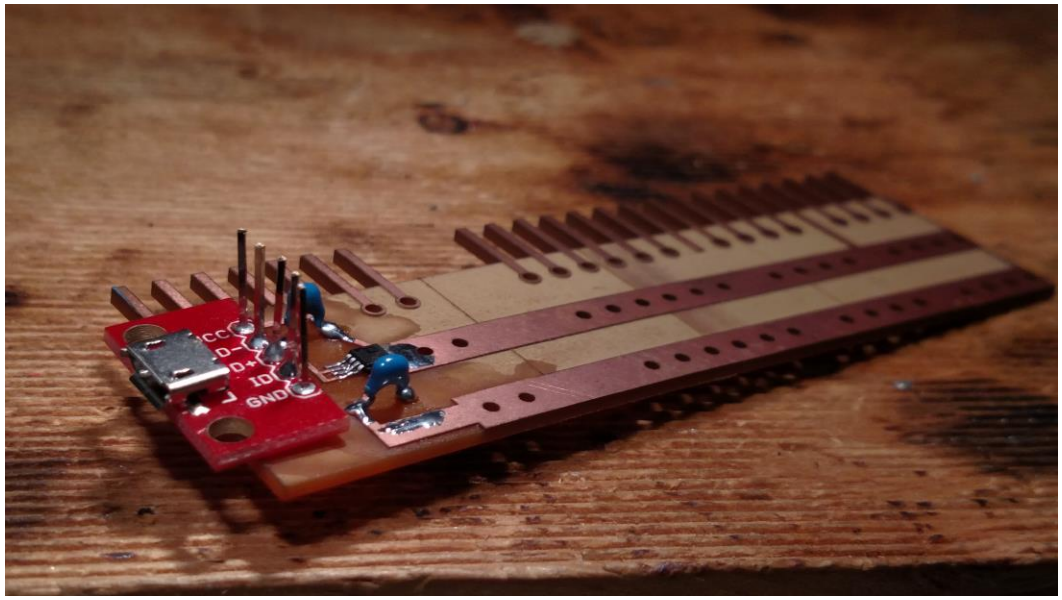
Beamformer

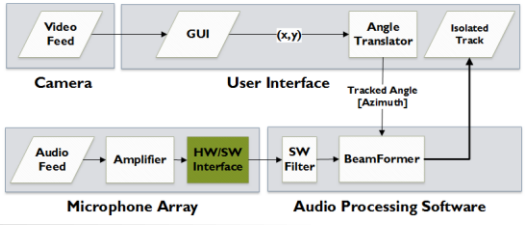

Mic Data
Azimuth Angle
Software Filter
Buffer System
Delay Sum
Highpass Filter
Mic Data
Software Filter
Buffer System
Delay Sum
Bandpass Filter
Mixer
Isolated Sound
Mic Data
Software Filter
Buffer System
Delay Sum
Lowpass Filter


Video Feed
GUI
(x,y)
Angle Translator
Isolated Track
Camera
User Interface
Tracked Angle [Azimuth]
Audio Feed
Amplifier
HW/SW Interface
SW Filter
BeamFormer
Microphone Array
Audio Processing Software

Mic Array: Hardware

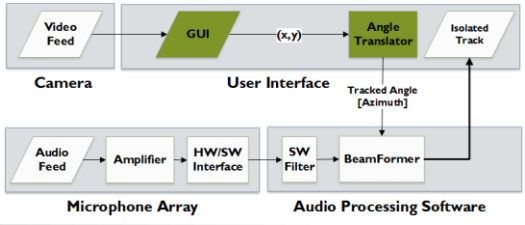
- Mic Module
- ADC Breakout
- Power Regulator





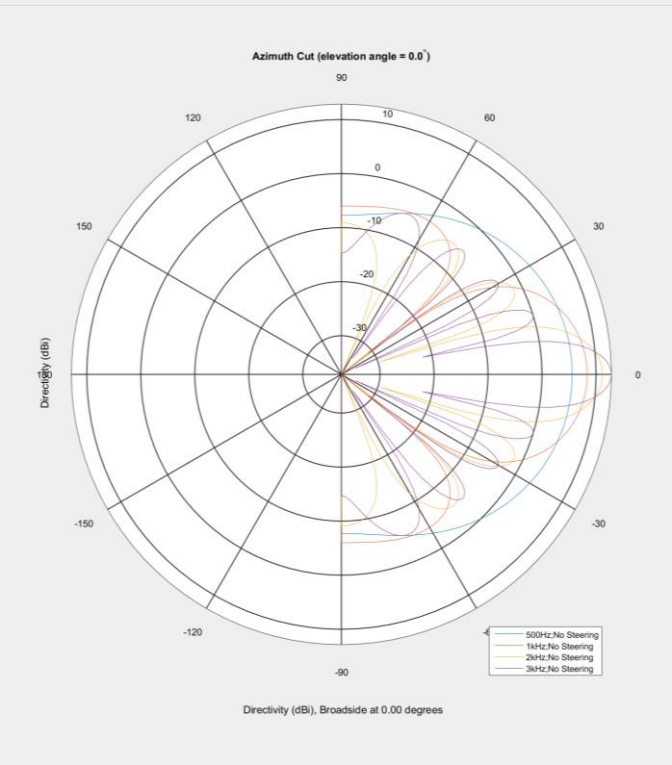
GUI

- Mouse determines beamforming coordinates
- Curved indicator shows beamforming direction
- Indicator restricted by spanning angle

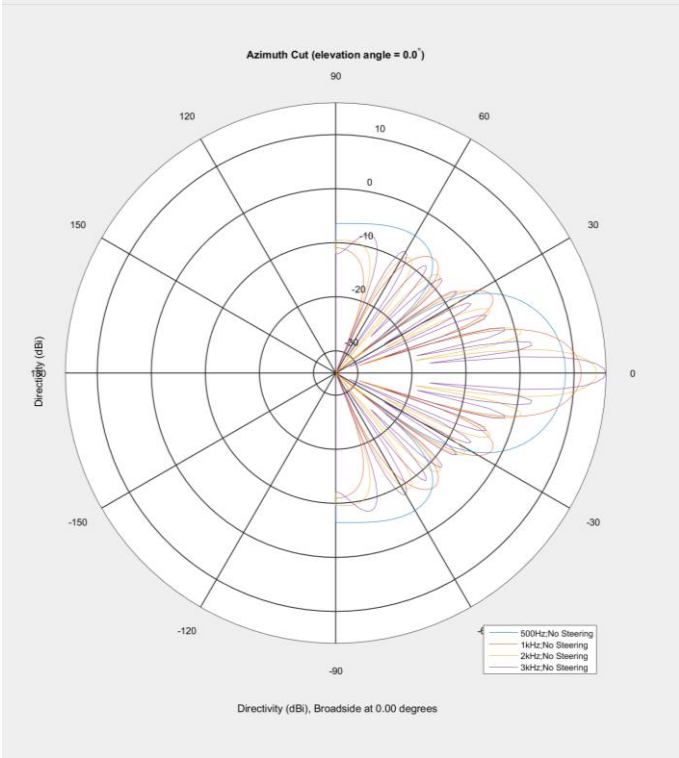


Performance Comparison

8 Microphone



16 Microphone



Performance Comparison

8 Microphone

Frequency	500 Hz	1 kHz	2 kHz	3 kHz
Directivity (dBi)	5.6	8.4	11.2	12.85
Beam Width (deg)	90	50	30	20

16 Microphone

Frequency	500 Hz	1 kHz	2 kHz	3 kHz
Directivity (dBi)	8.4	11.28	14.19	15.9
Beam Width (deg)	30	20	15	10

Performance Improvement

Frequency	500 Hz	1 kHz	2 kHz	3 kHz
Directivity (dBi)	2.8	2.88	2.99	3.05
Beam Width (deg)	-60	-30	-15	-10

System Demonstration

Bill of Materials

Component	Price	UOM	Qty	Production Cost	Development Cost
Alpha Wires	Free for UMass	item	1	NA	$0
Microphone Module	$10.00	item	16	$160.00	$160.00
Microphone Mount	$1.50	item	16	$24.00	$24.00
Alpha Wires	$0.50	feet	6	$3.00	$3.00
NI ADC	$650.00	item	1	$650.00	$650.00
MicroUSB Breakout	$2.00	item	1	$2.00	$2.00
3.3V regulator	$2.00	item	1	$2.00	$2.00
1 uF Capacitors	$0.25	item	2	$0.50	$0.50
FR-4 Board	Free Samples	square feet		$20.00	NA
Camera	$45.00	item	1	$45.00	$45.00
TOTAL				$906.50	$886.50

Conclusion

- Challenges
  - Frequency Range
  - Real-Time
  - Interactive Demo
- Limitations
  - Processing Speed
  - Reverb
- End Product