EECS 452 MDE - Laser Microphone Methods

MICHIGAN ENGINEERING
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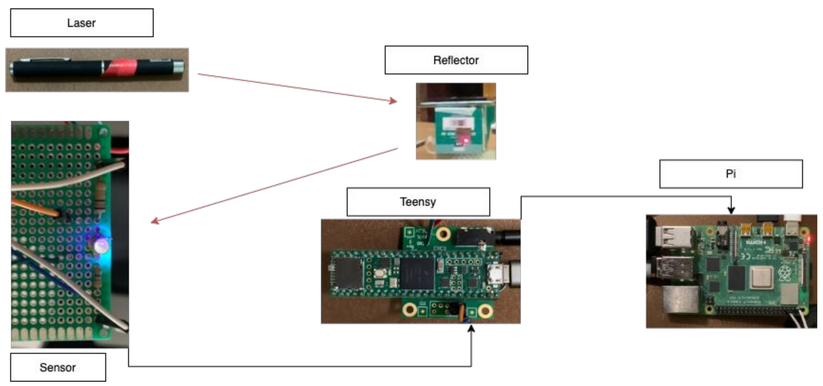
Introduction

In applications where one wants to externally listen into a room, most traditional microphone devices would need to have been set up in advance, however this study presents an approach using light reflected off a window or any other reflective surface to “listen in” on conversations or other audio data within a room at a distance.

Materials and Setup



Algorithims

Filtering

The analog signal on the teensy is put through an Equiripple FIR Bandpass filter with cutoff frequencies of 100 Hz and 4.5 kHz.

Spectral Subtraction

The filtered signal has its spectral magnitude reduced by the magnitude of an earlier recorded noise signal (no speech being present).

Spectral Gating

Below and above a statistically set number of standard deviations from the sample’s average spectral magnitude, everything is zeroed

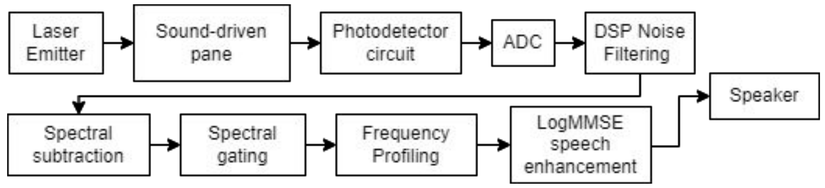
Frequency Profiling

Multiplying the received signal vector by the inverse of the derived transfer function of the mirror, we regain a signal similar to the original audio.

Speech Enhancement

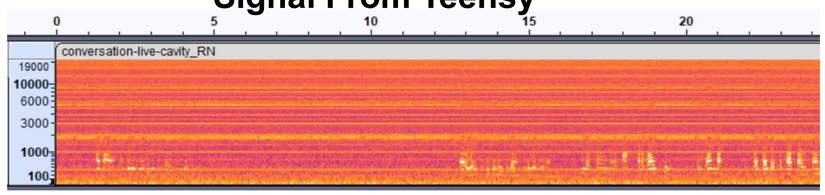
Minimum Mean-Squared Error log-spectra Estimator

Signal Flowchart

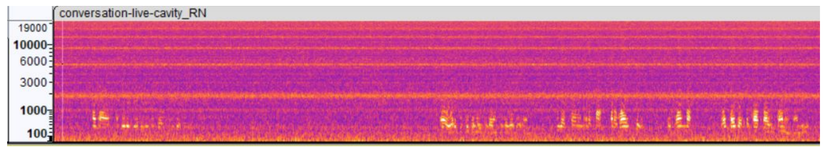


Spectogram Results

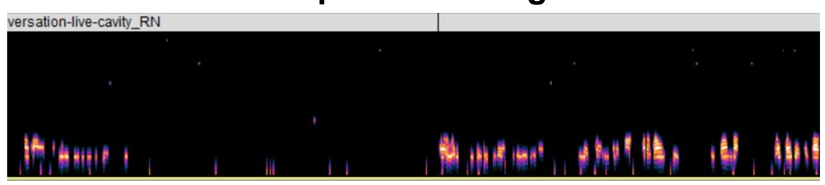
Signal From Teensy



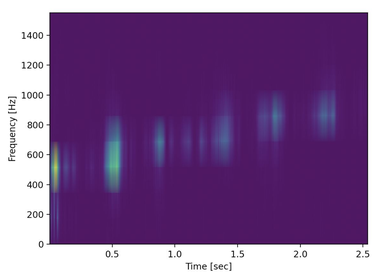
Post Spectral Subtraction

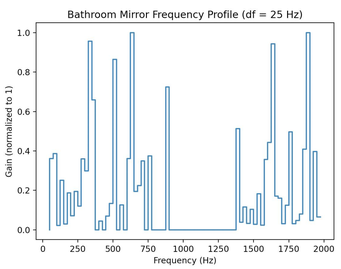


Post Spectral Gating



Profiling Kernel Generation





Results

Method / Test	A	B	C	D	E
Band Pass Filtering					
Spectral Methods					
Mirror Profiling					
Speech Enhancement					
Noise	1.50	2.55	2.42	2.32	2.27
Speech Intelligibility	2.12	2.22	2.22	2.00	2.10
Average Score	1.81	**2.39**	**2.33**	2.16	2.19

Challenges / Future Recomendations

Issue

1. Spectral subtraction and gating requires manual tuning
2. Inconsistent Audio Quality
3. Noise from op - amp amplifier circuits

Possible Solution

1. Could develop adaptive tuning algorithm to learn optimal tuning parameters with training
2. Increase rigidity of setup
3. Changed to common emitter amplifier setup

Acknowledgements

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References

1. Ephraim, Y. & Malah, David. (1985). Speech Enhancement Using a Minimum Mean-Square Error Log-Spectral Amplitude Estimator. Acoustics, Speech and Signal Processing, IEEE Transactions on. 33. 443 - 445. 10.1109/TASSP.1985.1164550.
2. G. S. Kang and L. J. Fransen, "Quality improvement of LPC-processed noisy speech by using spectral subtraction," in IEEE Transactions on Acoustics, Speech, and Signal Processing, vol. 37, no. 6, pp. 939-942, June 1989.