

Signal Processing



Data Engineering

# Spectral Identification *of* Localized Roadway, Aircraft, And Rail Transportation Noise Sources

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Electrical Engineering

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# Objectives

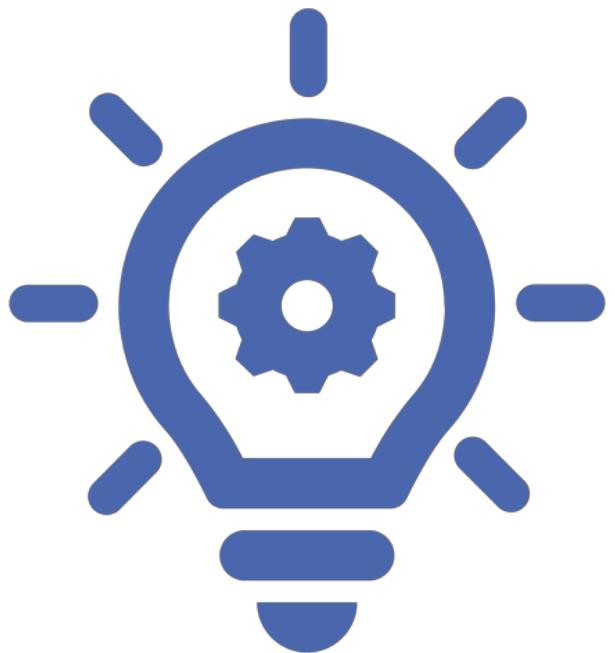
- Clean up ~200 days of co-located noise and PM data from two urban impacted sites in Chelsea, MA and in Roxbury, MA
- Define and potentially identify air and noise pollution sources by utilizing spectral analysis of transportation noise and co-analyzing particle number count (PNC)

# Deliverables list

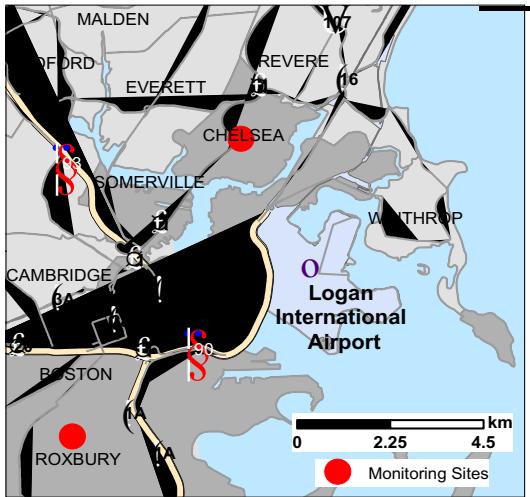
1. Plots:
  - Spectrogram using short-time FT
  - Welch's Power Density
  - partial loudness sone/bark
  - 1/3-octave spectrum
2. get the freq ranges from 0-3k(Hz)  
calculate fraction of power accordingly
3. 'notboxplots' and 'box plots' of the power distribution
4. gscatter(X\_mean, Variance) labeled by group for ML classification

# Approach & Tool Kit

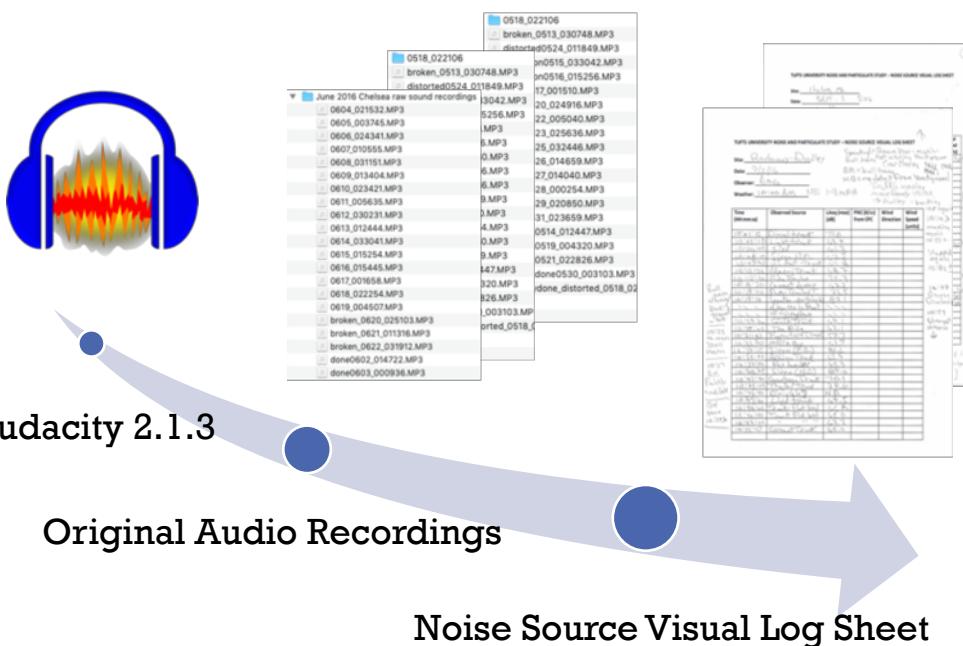
- Noise analytics and spectral analysis
  - Audacity 2.1.3 for pre-processing
  - MATLAB®R2017 for analytics and data visualization



# Data Preprocessing – Audio Files



Monitoring Sites in Chelsea and Roxbury, MA, showing proximity to major highways and Logan International Airport

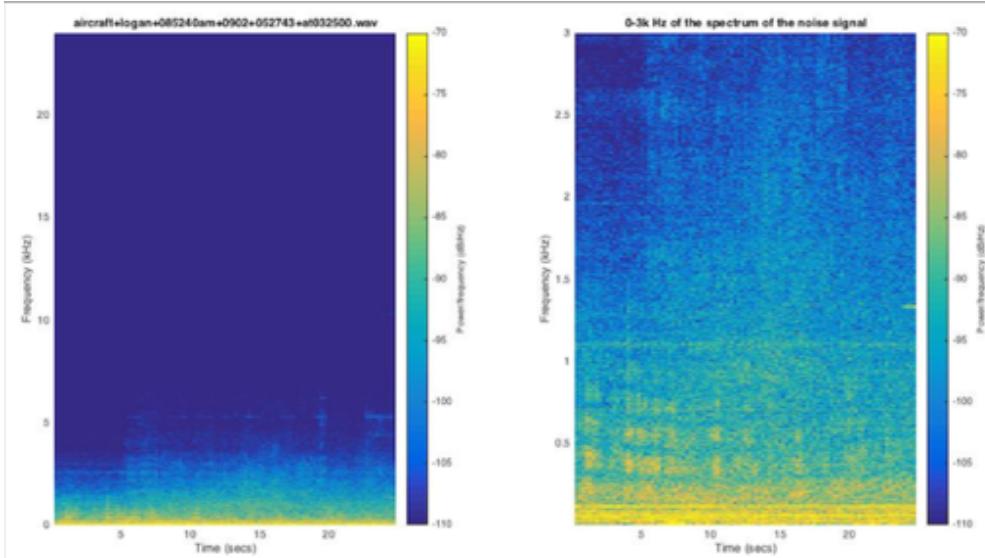


List of filtered and trimmed audio recordings after using Audacity 2.1.3 ®

Music
Om+fire+engine+090...743+at033338s.wav
aircraft+10+0625+0...234+001428+6s.wav
aircraft+10+0625+0...234+001614+8s.wav
aircraft+11+0625+0...34+001749+10s.wav
aircraft+12+0625+0...234+003313+9s.wav
aircraft+13+0625+0...234+004519+6s.wav
aircraft+14+0625+0...234+004704+7s.wav
aircraft+15+0625+0...34+005551+15s.wav
aircraft+16+0625+0...34+005754+11s.wav
aircraft+17+0625+0...34+013806+15s.wav
aircraft+18+0625+0...234+015843+5s.wav
aircraft+19+0625+0...34+022237+11s.wav
aircraft+20+0602+0...22+000540+13s.wav
aircraft+0625+034617+012815+22s.wav
aircraft+0625+034617+014029+12s.wav
aircraft+0625+034617+023209+9s.wav
aircraft+0625+034617+024136+16s.wav
aircraft+0625+034617+025121+7s.wav
aircraft+0625+034617+032422+12s.wav
aircraft+0625+034617+033117+13s.wav
aircraft+0627+114150+002954+3s.wav
aircraft+0627+114150+030722+21s.wav
aircraft+100130am+...5+from005006s.wav
aircraft+100235am+...5+from005111s.wav
aircraft+logan+0852...2743+at032500.wav
aircraft+takeoff+085...2743+at033039.wav

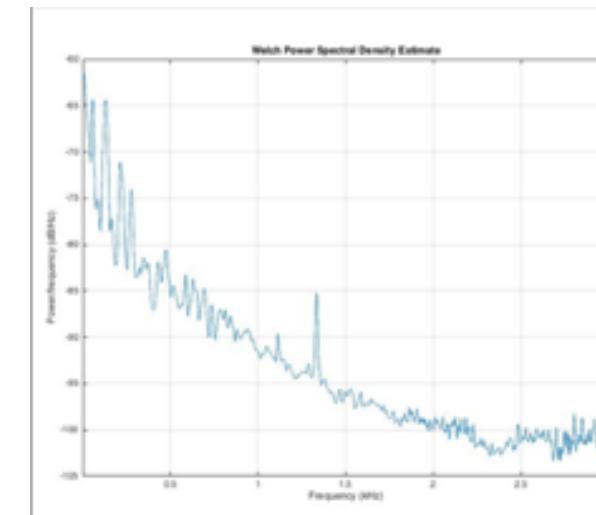
# Data Engineering

## – parameters of interests

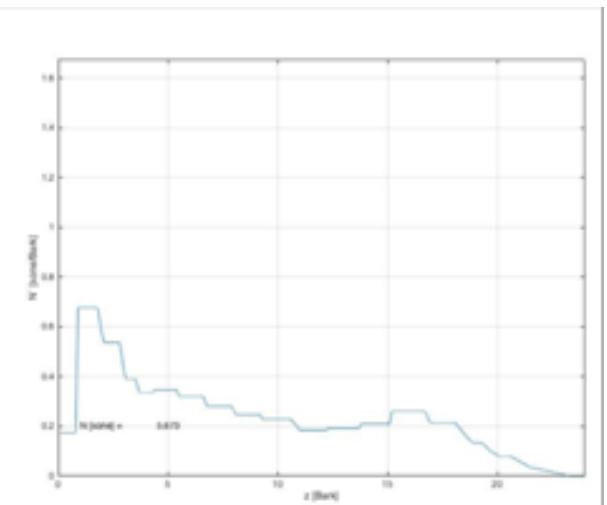


original noise spectrum

0-3kHz  
noise spectrum

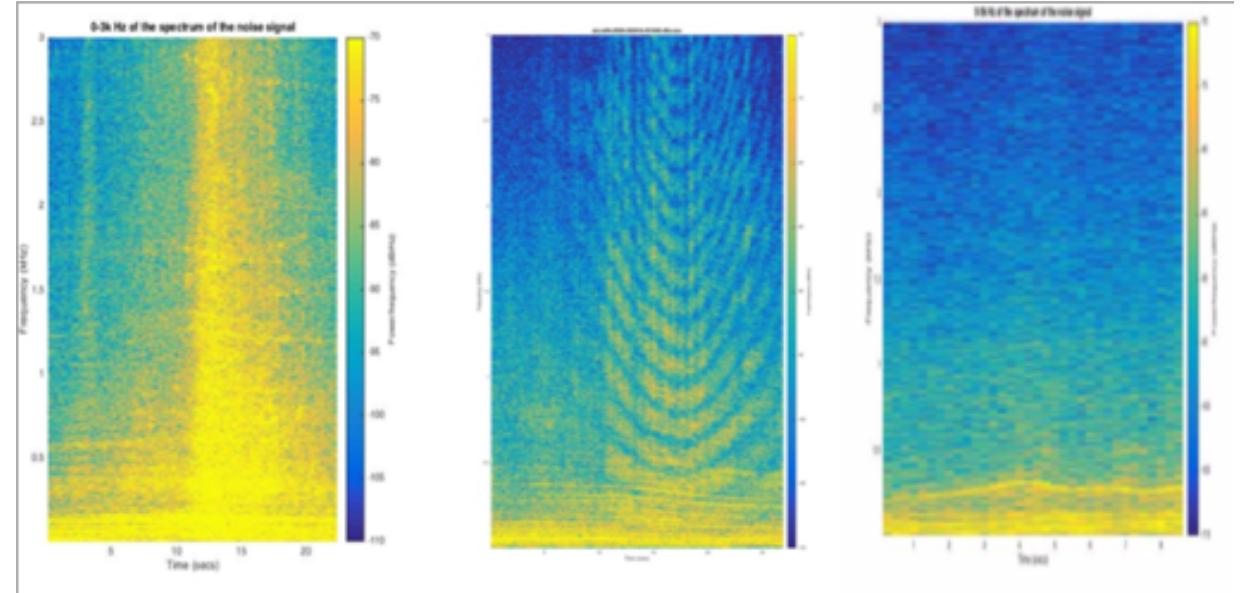


Welch's power spectral density (PSD)  
estimate



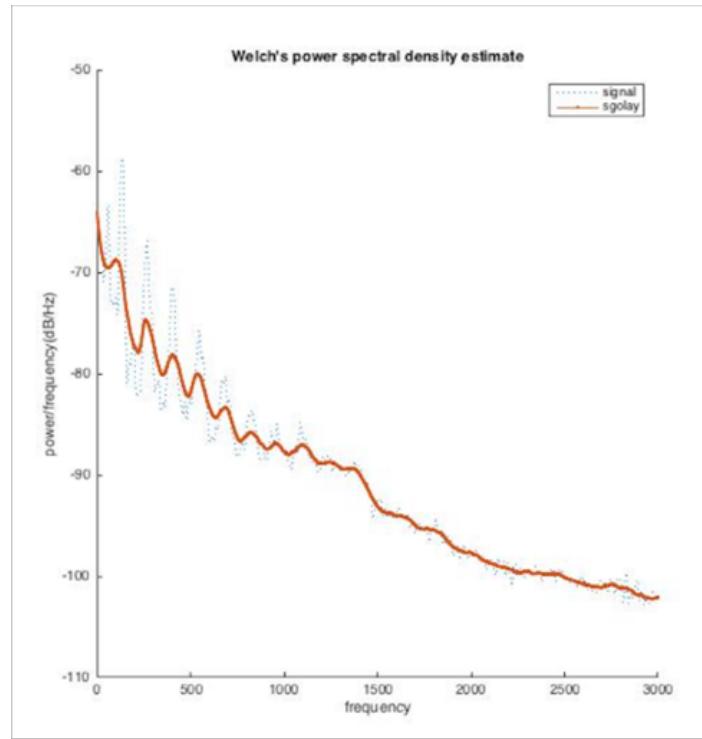
partial loudness

# Doppler Effects – from 0 to 3kHz



Spectral plots of train, aircraft and truck (L to R), frequency (kHz) vs. time (secs). Color bars represent power/frequency (dB/Hz).

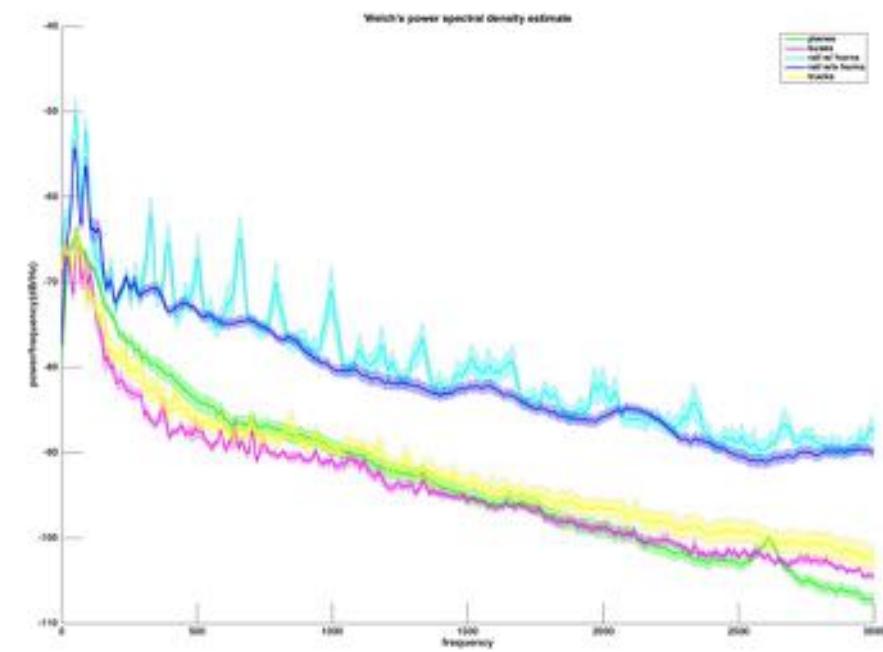
# Welch's Power Spectral Density Estimate



Welch's power spectral density estimate  
with sgolayfilt

## Fitting Methods

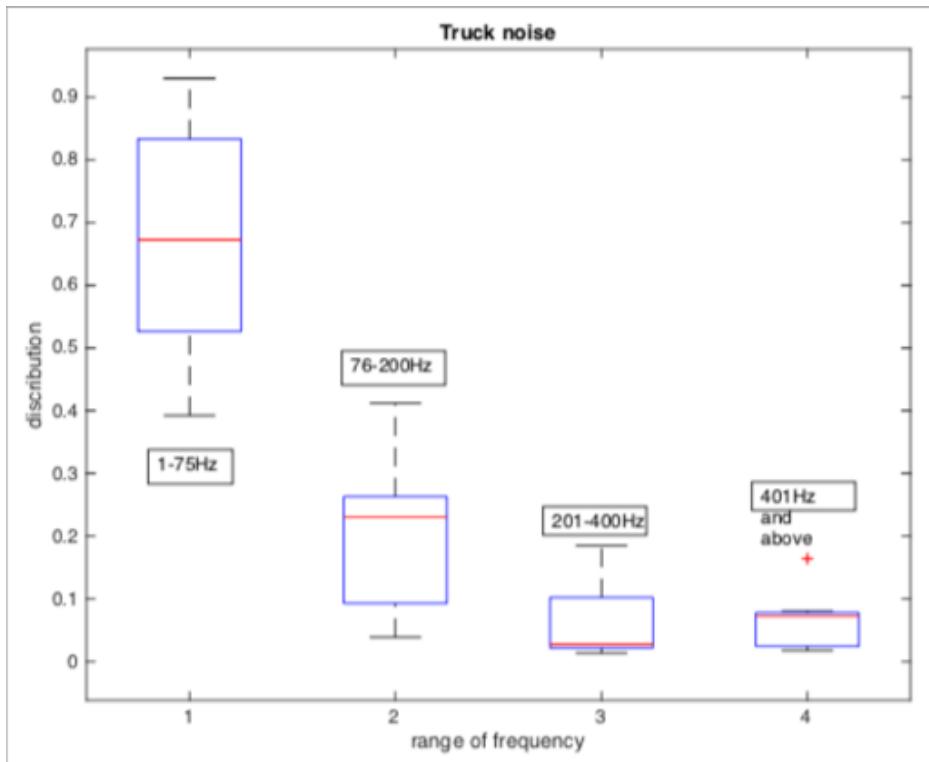
- Savitzky-Golay filtering
  - difference between fit and  $P_{xx}$ (dB)



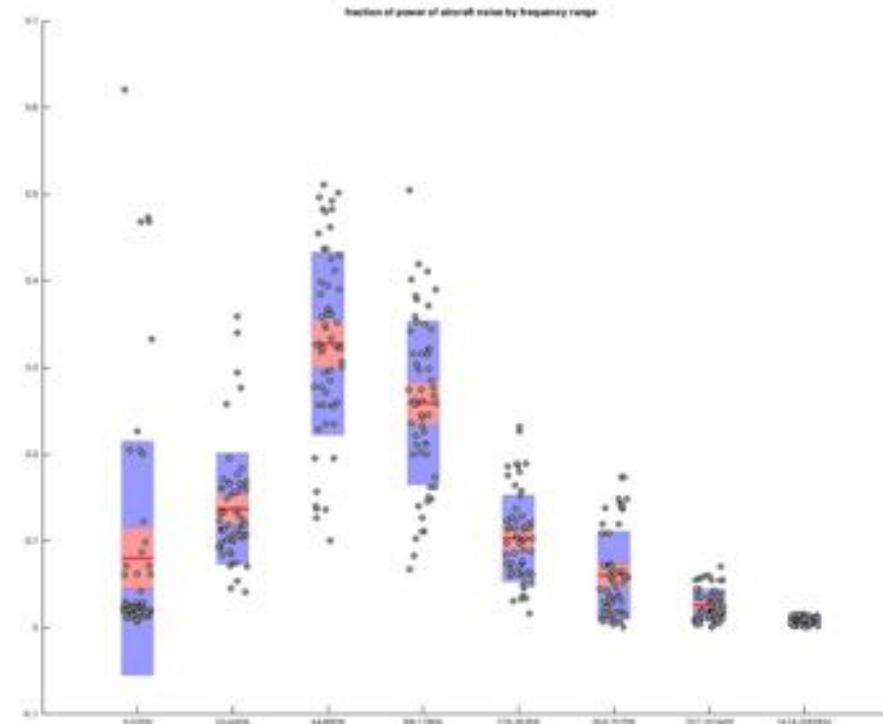
Welch's power spectral density estimate for  
transportation noise sources by class.  
Power/frequency (dB/Hz) vs. frequency (Hz), with 95%  
confidence bounds

# Box Plots

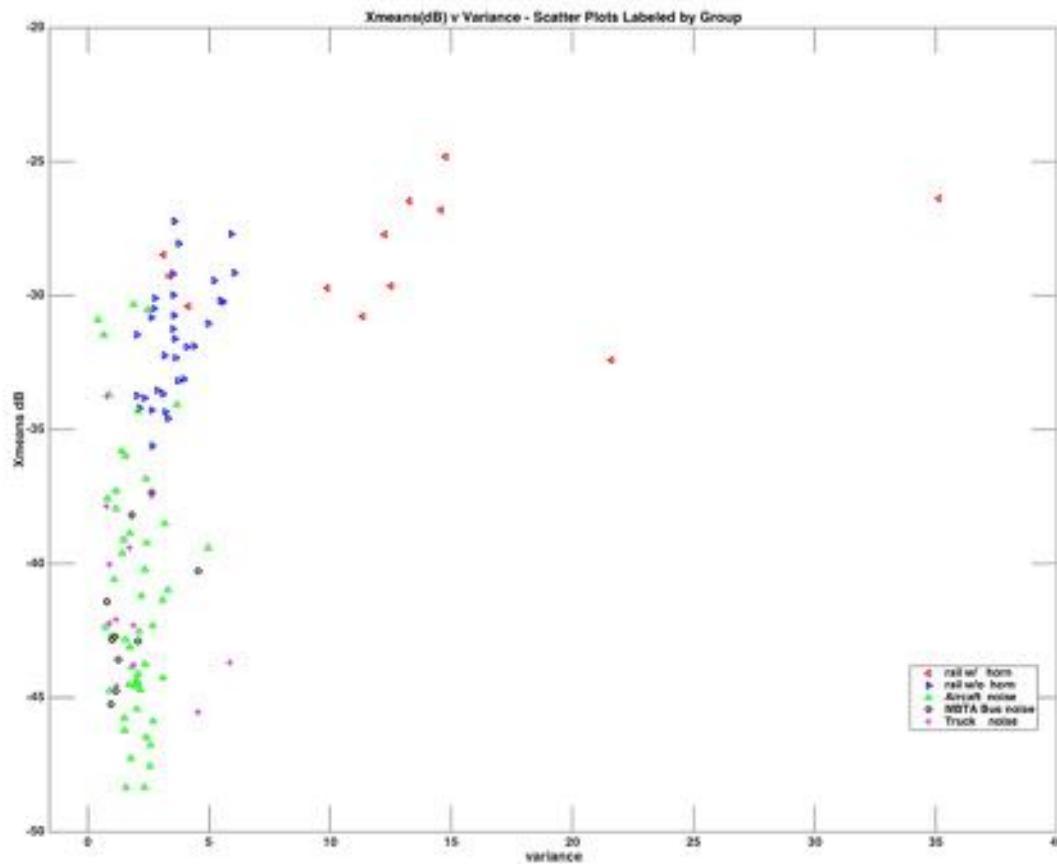
– another vivid graphs



fraction of power of truck noise  
using Box Plot



fraction of power of aircraft noise  
using notBoxPlot



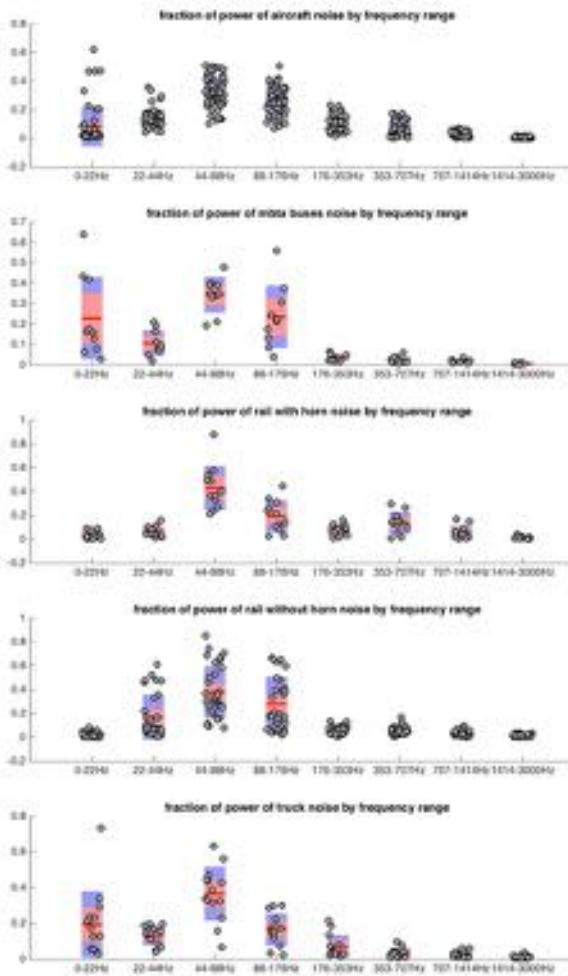
$$X_{\text{mean, dB}} = 10 * \log_{10} \mu(x^2)$$

**Variance =**

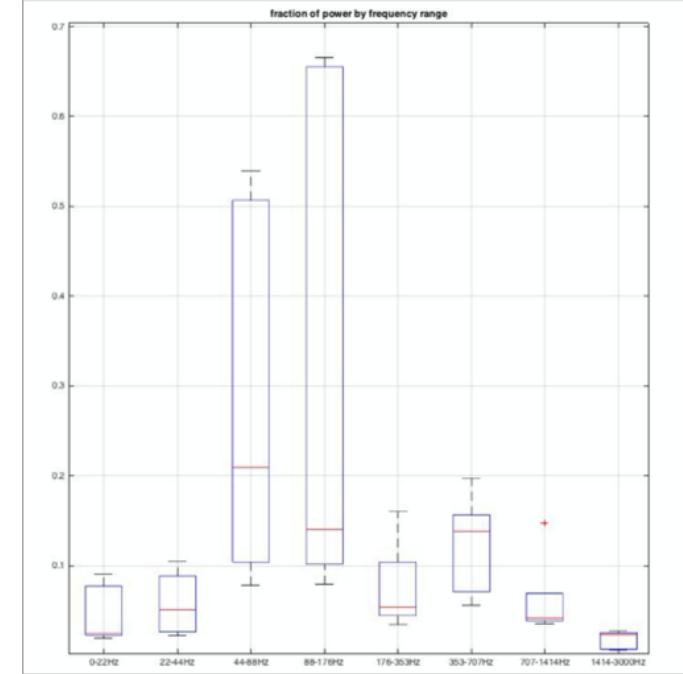
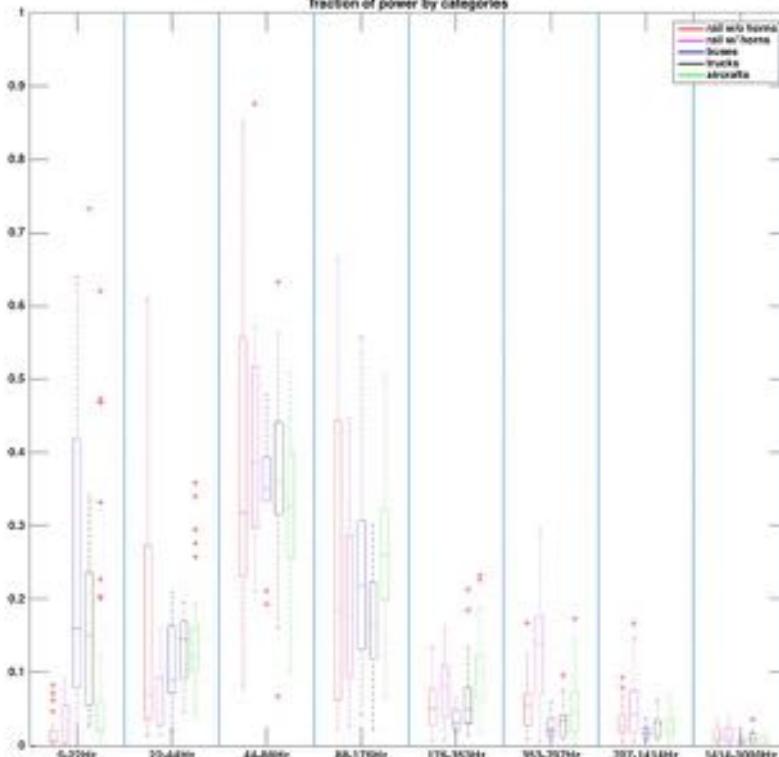
$$\sigma^2 \text{ of } 10 * \log_{10} \text{pwelch}(x, \text{hann window}) - \text{sgolayfilt}(x)$$

where  $X[:]$  is the signal

**'Naive Bayes'**  
**'Classification Tree'**  
**'K - Nearest Neighbor'**  
 and other ML Classifications



**fraction of power by categories**  
Note: redundant information shown  
in (a) and (b)



# Take Away From Master Project



**THANK YOU!**

Thank You For Watching My Presentation.

Q & A