Signal Processing → Data Engineering

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

Tufts University
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)

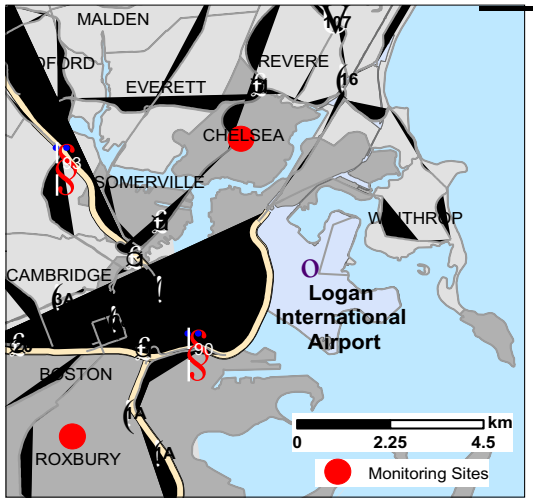
Deliverables list

1. Plots:
   - Spectrogram using short-time FT
   - Weltch'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

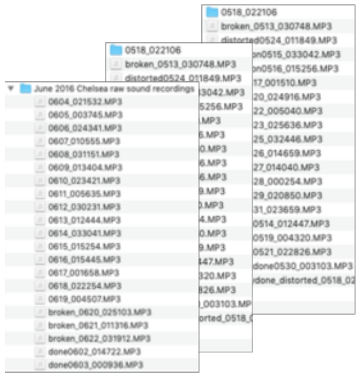
Approach & Tool Kit

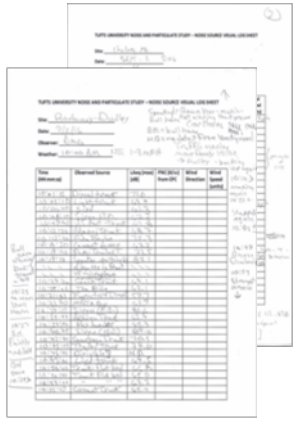
- Noise analytics and spectral analysis
  - Audacity 2.1.3 for pre-processing
  - MATLAB®R2017 for analytics and data visualization

Data Preprocessing – Audio Files



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

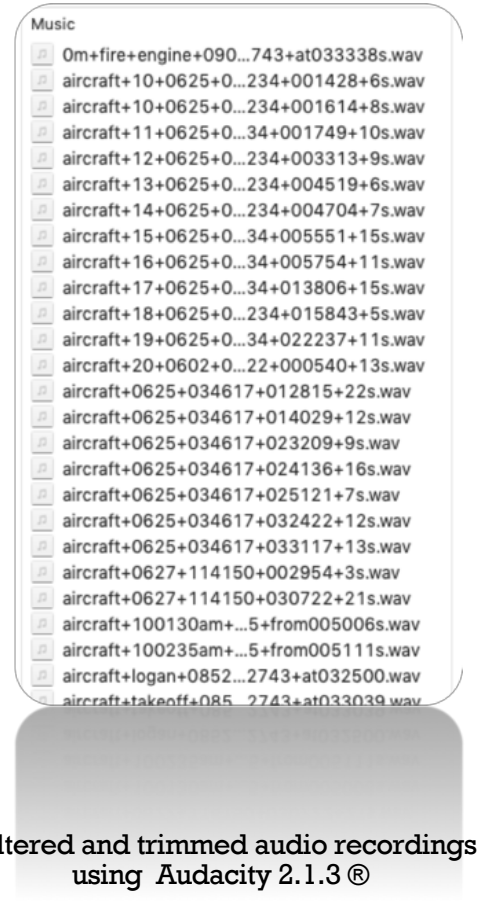




Audacity 2.1.3

Original Audio Recordings

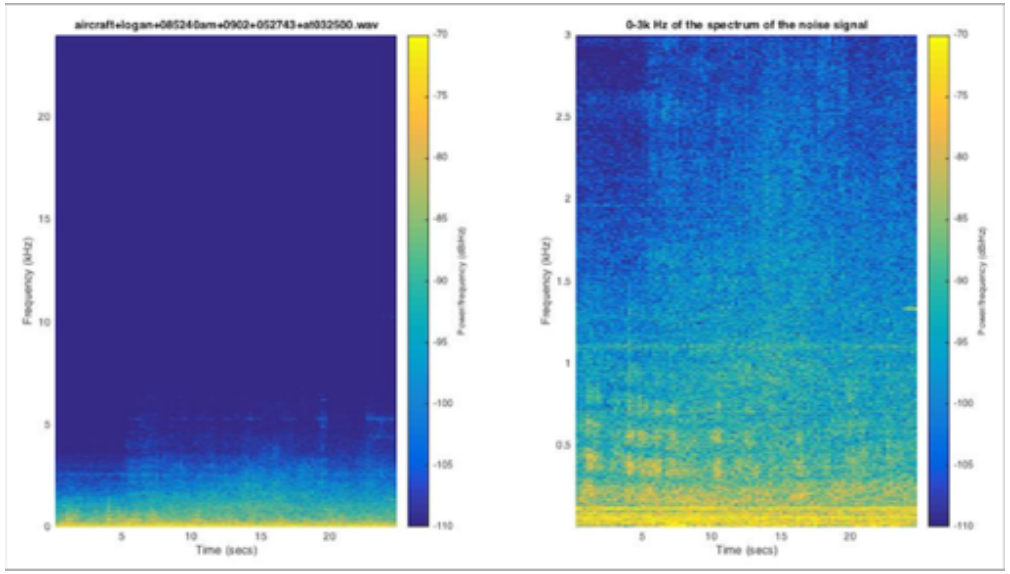
Noise Source Visual Log Sheet



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

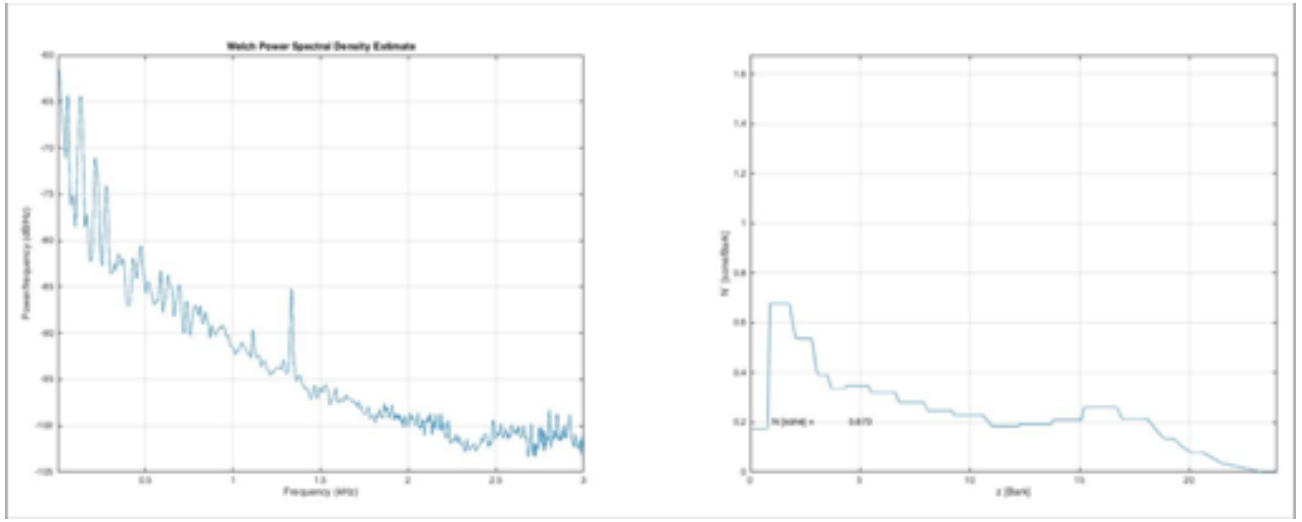
Tufts University
Graduate School of Arts and Sciences

Data Engineering – parameters of interests



original noise spectrum

0-3kHz
noise spectrum

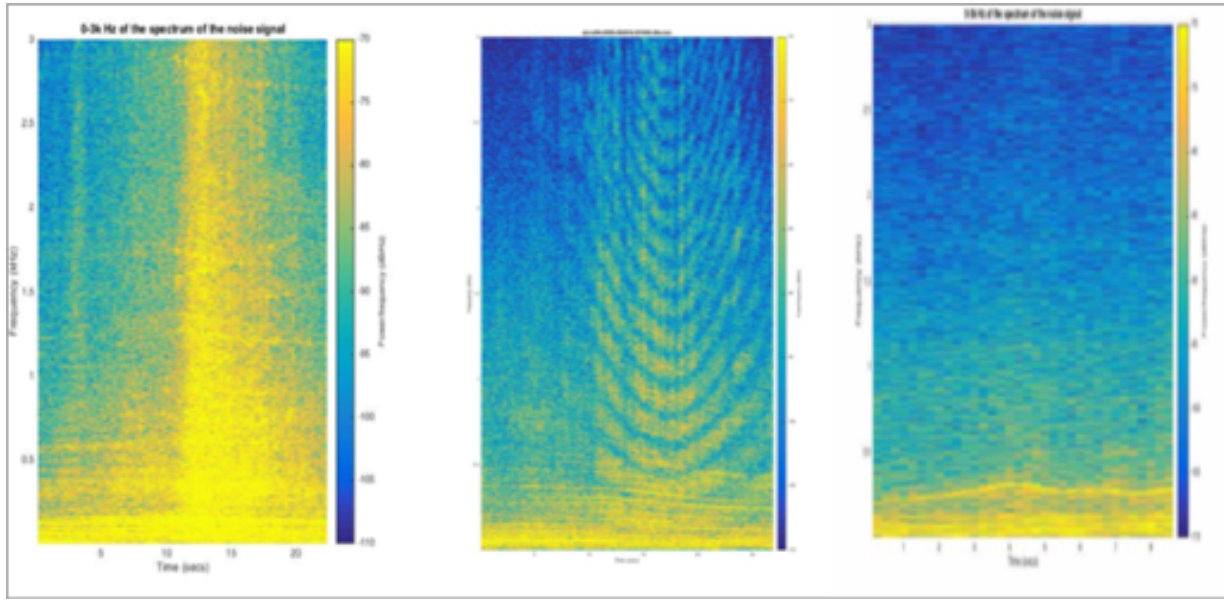


Welch's power spectral density (PSD) estimate

partial loudness

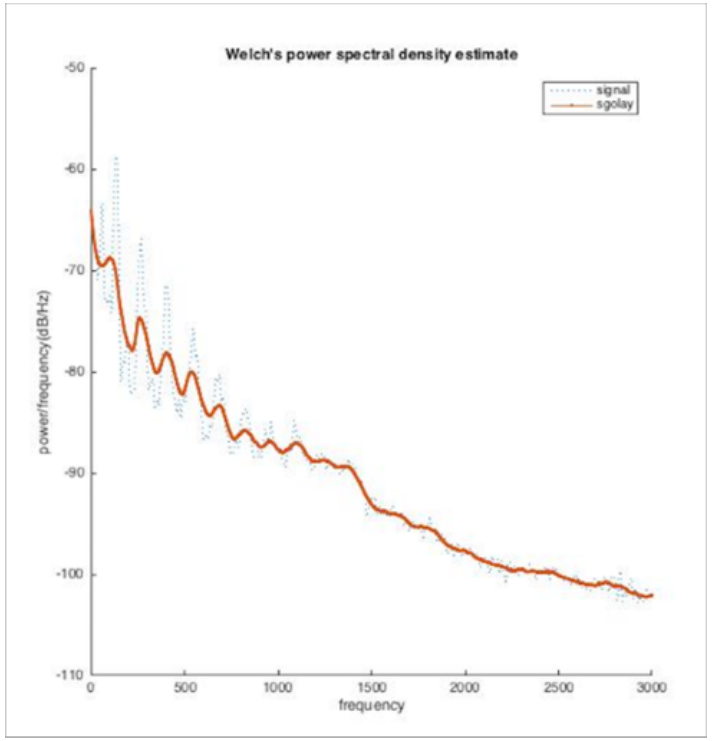
Doppler Effects

– 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).

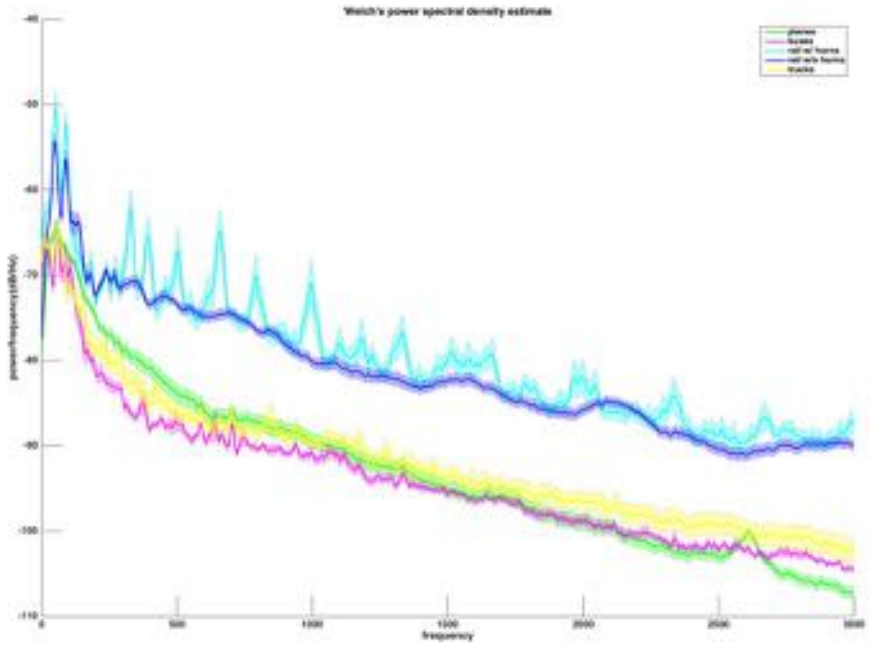
Welch's Power Spectral Density Estimate



Welch's power spectral density estimate with sgolayfilt

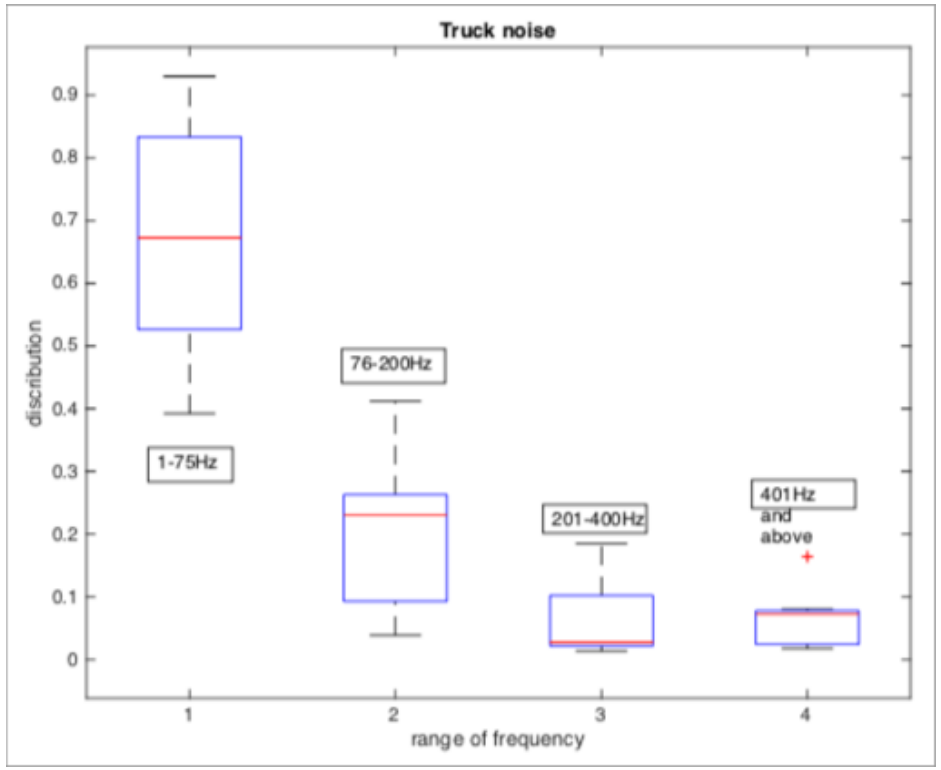
Fitting Methods

- Savitzky-Golay filtering
  - difference between fit and Pxx(dB)

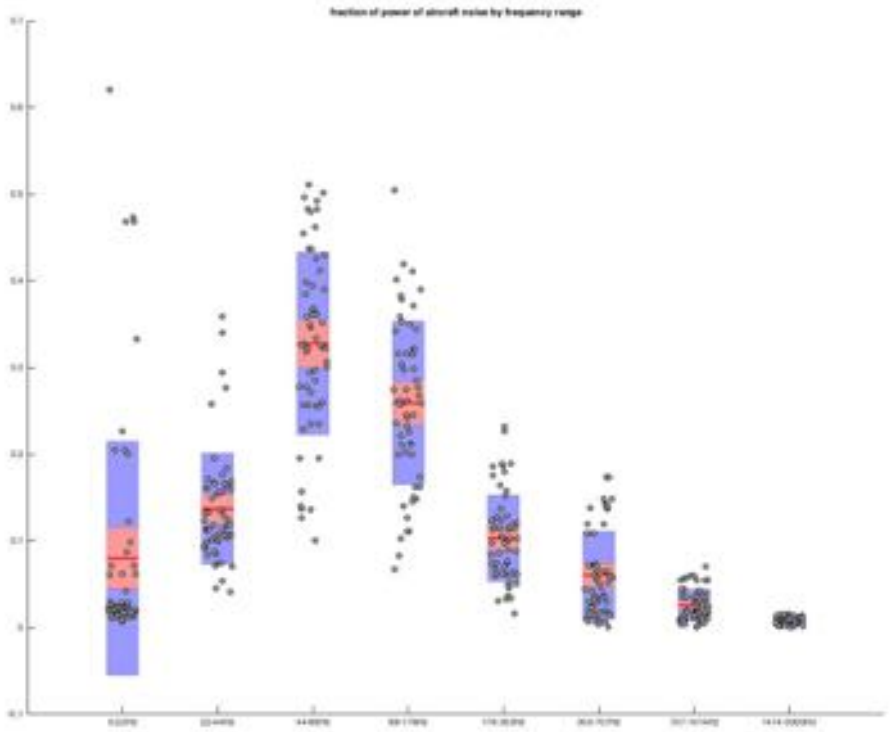


Welch's power spectral density estimate for transportation noise sources by class. Power/frequency (dB/Hz) vs. frequency (Hz), *with 95% confidence bounds*

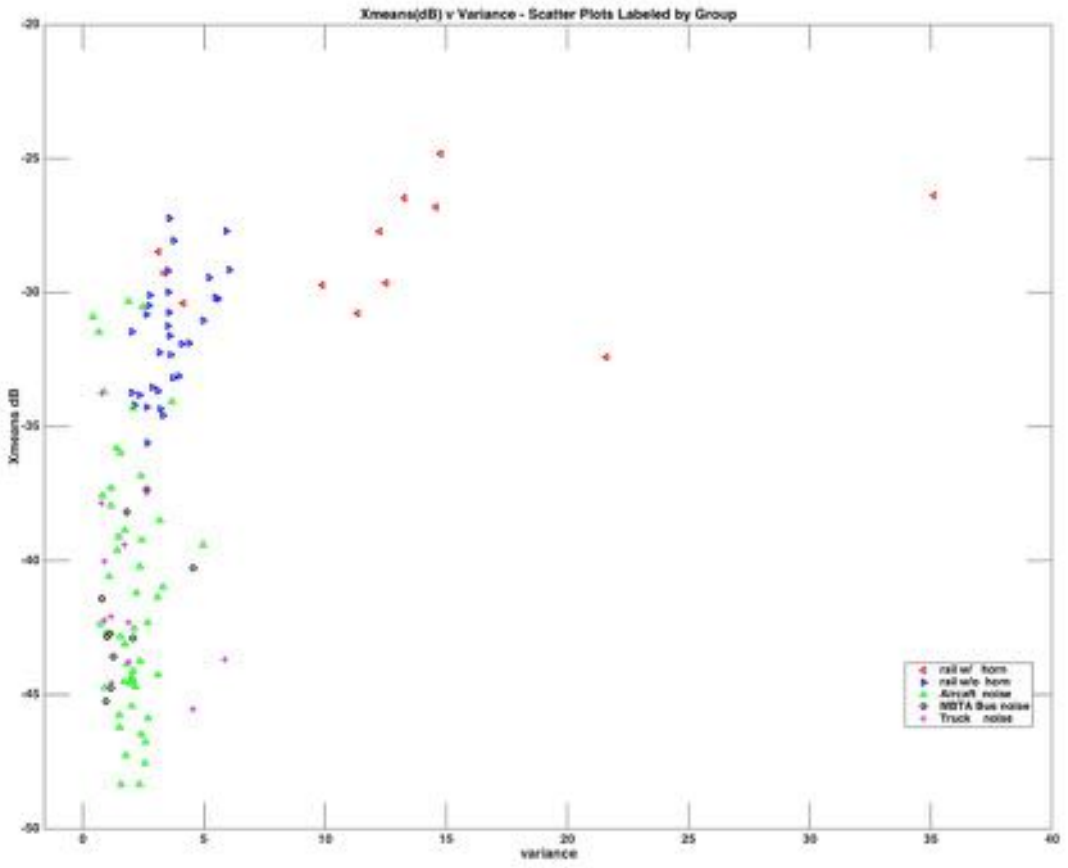
Box Plots – another vivid graphs



fraction of power of truck noise
using Box Plot



fraction of power of aircraft noise
using notBoxPlot



Xmeans (dB) vs Variance

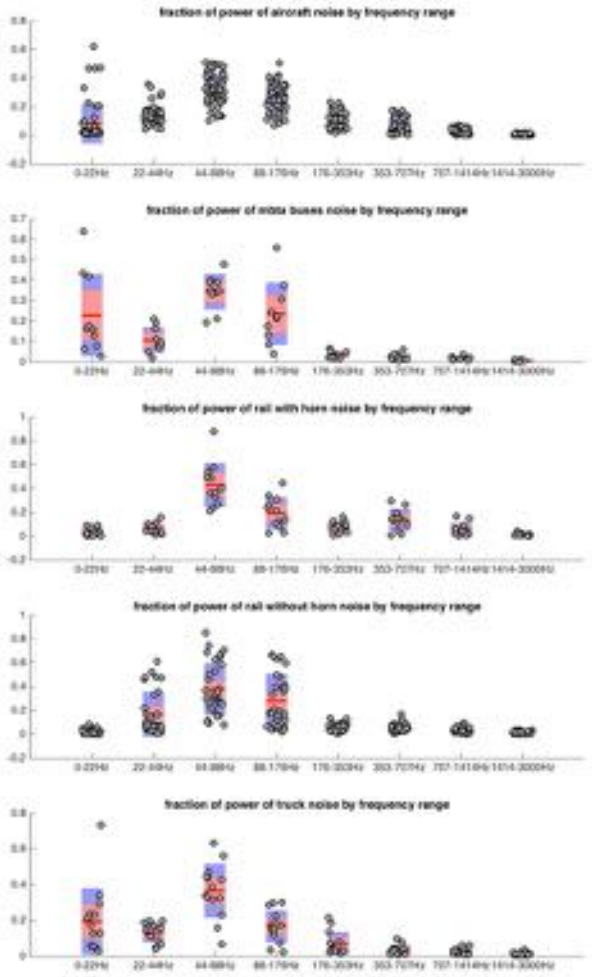
X_mean, dB = $10 * \log_{10} \mu(x^2)$

Variance =

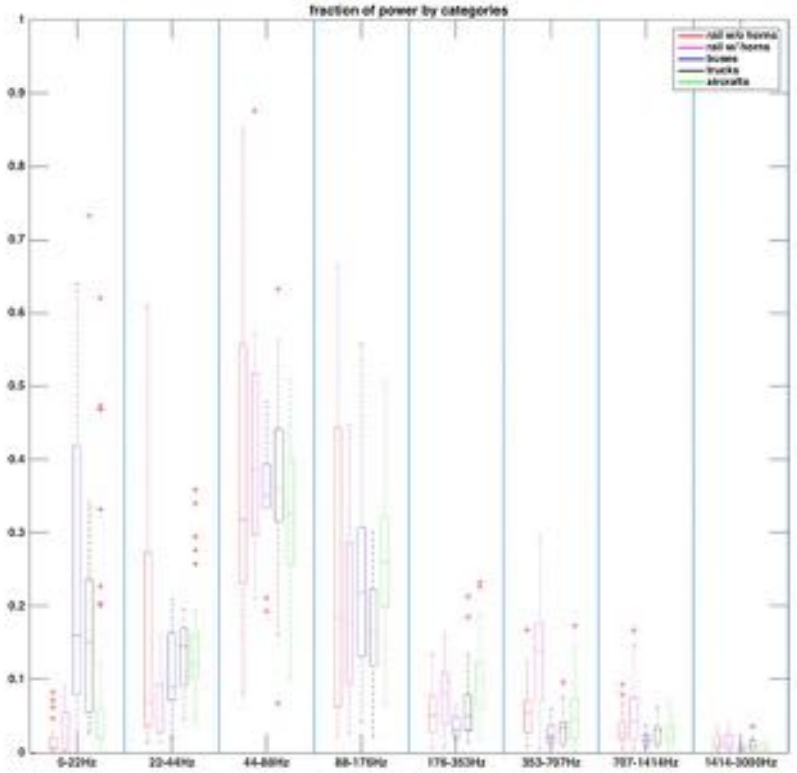
σ^2 *of* $10 * \log_{10} pwelch(x, hann\ window) - sgolayfilt(\mathbf{x})$

where X[:] is the signal

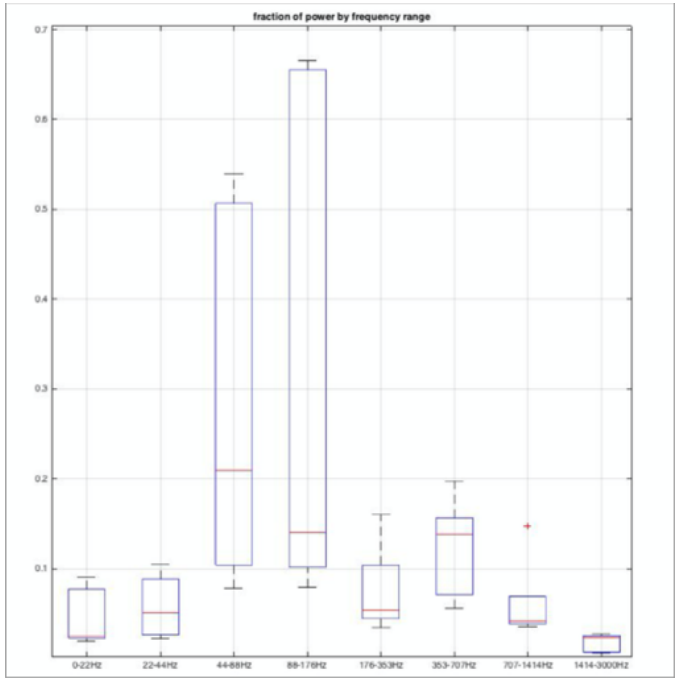
'Naive Bayes'
'Classification Tree'
'K - Nearest Neighbor'
and other ML Classifications



(a)



(b)



(c)

Take Away From Master Project

fraction of power by categories

Note: redundant information shown in (a) and (b)

Q & A