“Exploratory Analysis of Noise Reduction in a Sedan”

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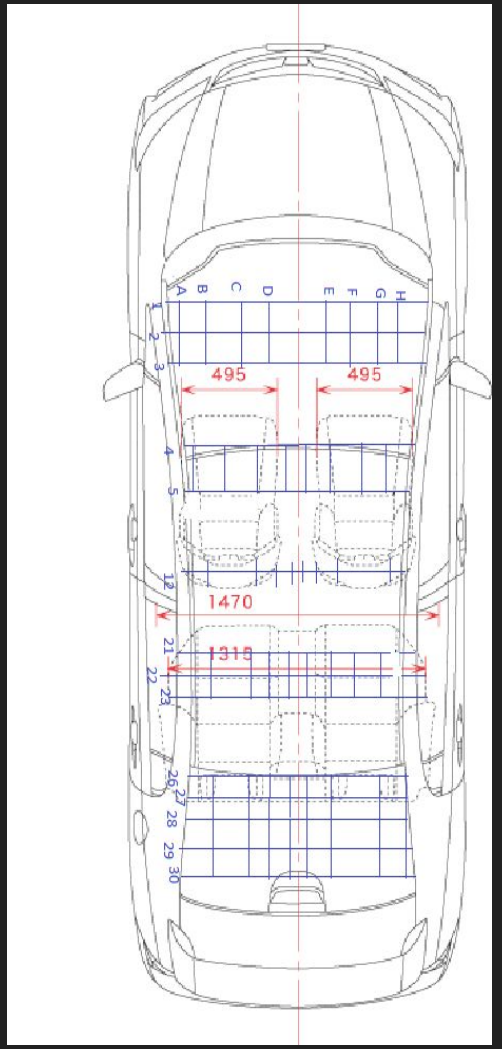
Roadmap

- Introduction:
- Hardware:
- Online Software:
- Procedure:
- Analysis:
- Results:

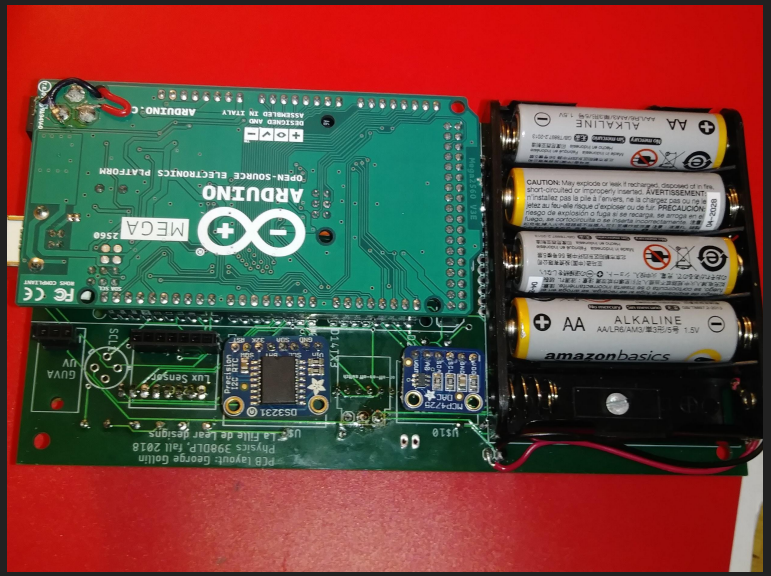
Introduction

- Background:
  - Consumers don’t like ambient noise in cars
  - $$$ invested in this technology
  - What is our interest?
- What did we do?
  - Insulating material around cabin and measure noise generated



Hardware

- Main Components
  - Electret Microphone, Arduino ADC
- Arduino can sample at 32khz
  - We are sampling at 1khz
- Calibration
  - Measured zero



Online Software

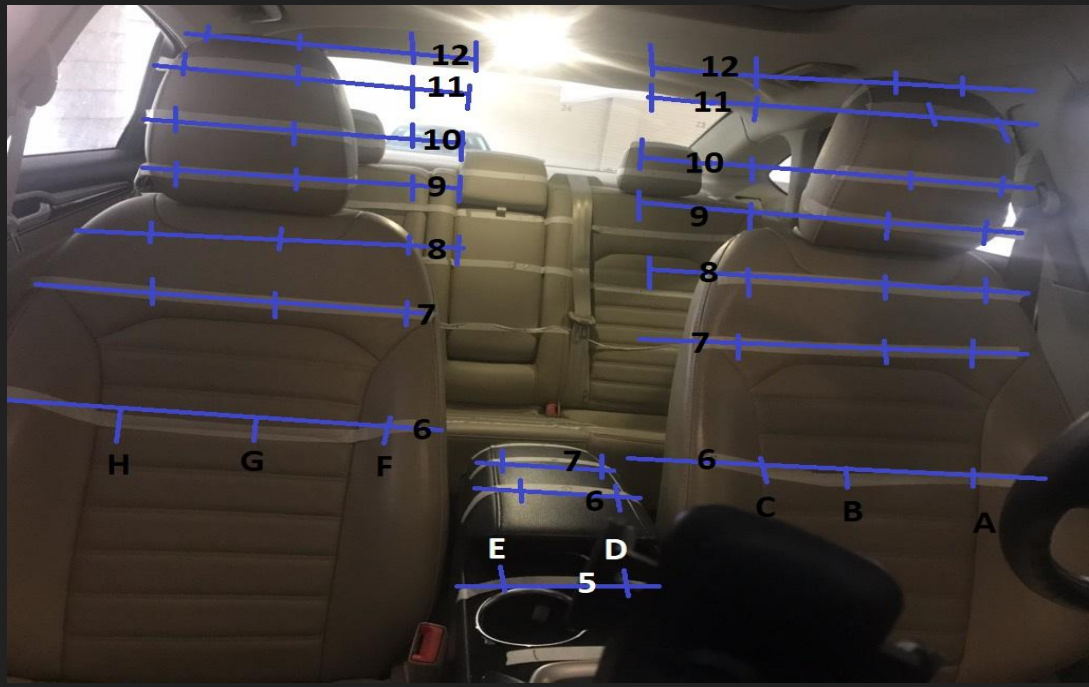
- Main Criteria of DAQ
  - Could wait for user to prompt it to take measurements
  - Can take audio samples from electret microphone as quickly as possible
  - Can calculate the variance value of audio samples
    - What is variance?
  - Can store variance values inside of an SD card in CSV formatting

Experiment Procedure: First Measurement

We created a grid system inside the vehicle of 300 points

We took 100 variance values at each point

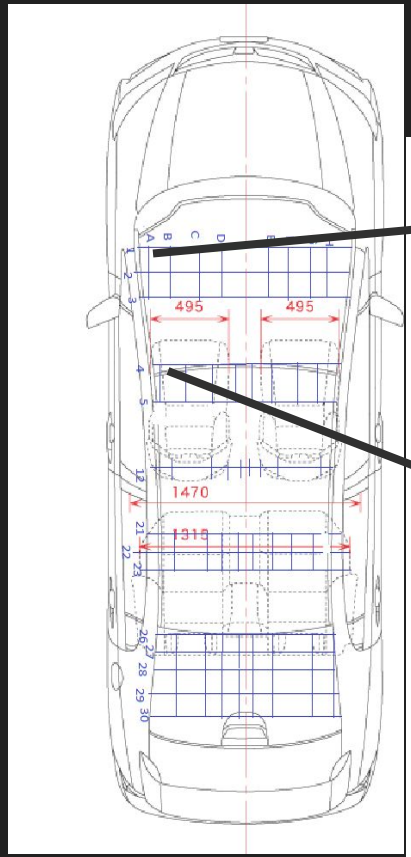
Experiment conducted with fan set to max

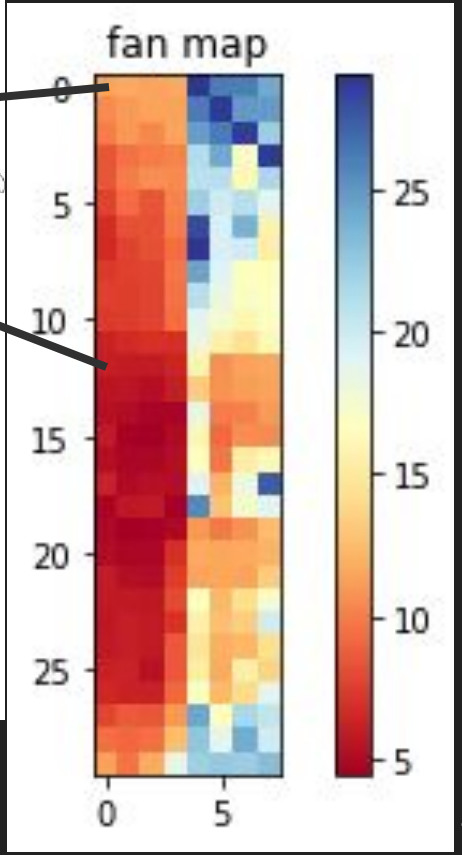


Results of First Experiment

>Place the insulation in the footwell and dashboard.

>Possible further experiment by placing the insulation in the back of the car





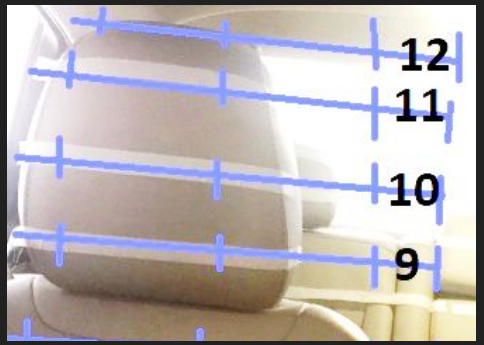
Procedures: Second Set of Measurements

Narrowed our focus to Passenger Headrest

Experiment one: 0.5” insulation in footwell

Experiment two: 1” insulation in footwell

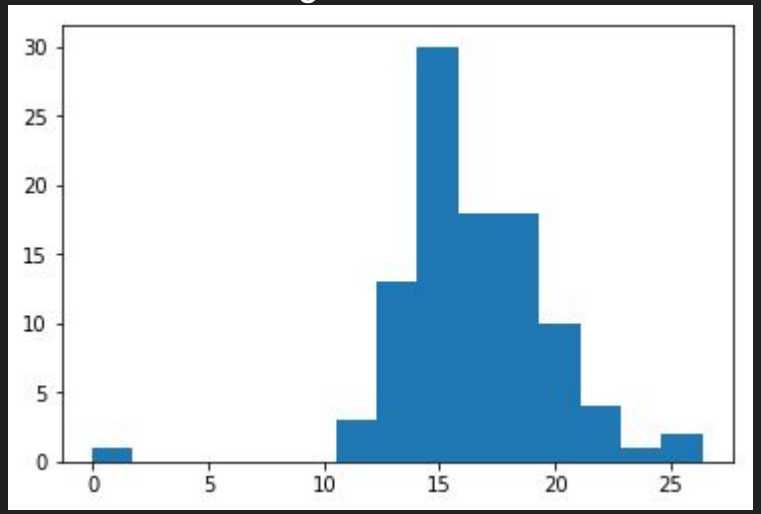
Experiment three: 0.5” insulation across dashboard



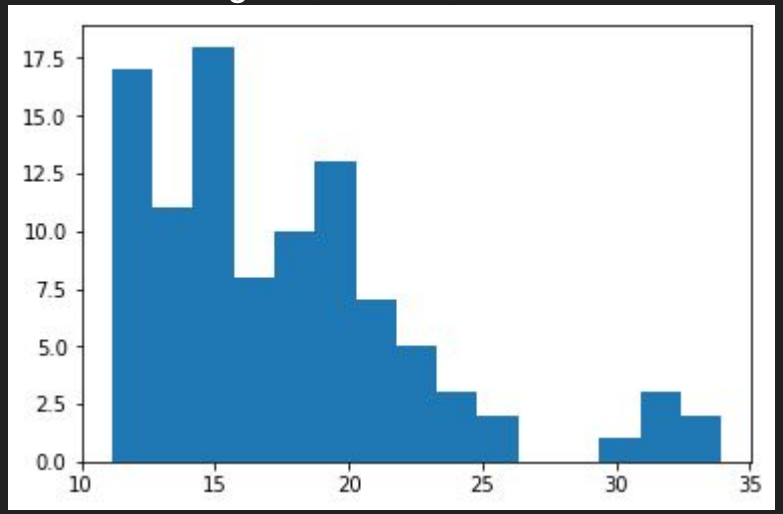
Analysis of Second Measurement: Check of Normality

Control Histograms

Histogram, Point 1,0



Histogram, Point 0,0



Bootstrap method

> Take data [100 variance values]; sample from it with replacement

>find feature of all Bootstrapped samples [means]

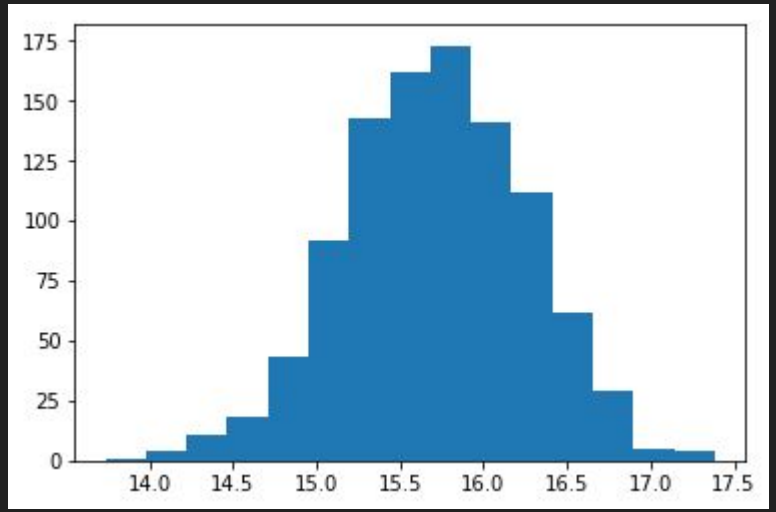
>find the variance on set of all features from Bootstrapped Samples

This gives confidence interval for true feature of dataset

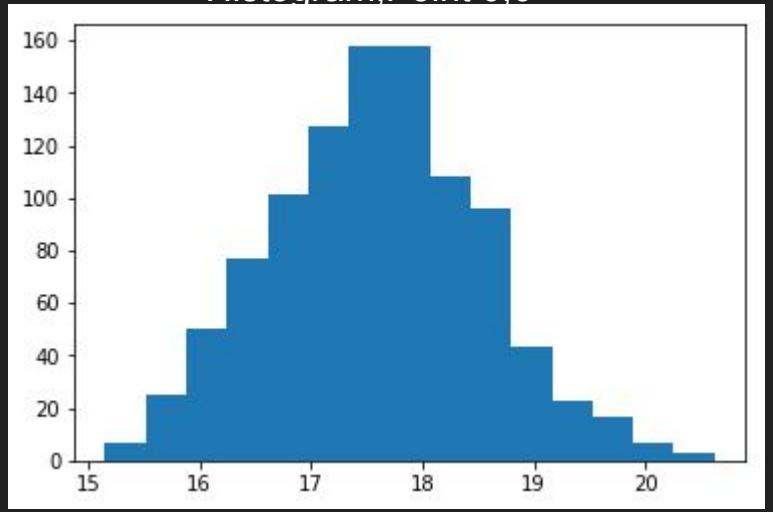
Benefits: Allows us to find errors on estimators without knowing the parent distribution.

Bootstrapped Histograms, B = 1000

Histogram , Point 1,0



Histogram,Point 0,0



Interpreting Results

Lower is better

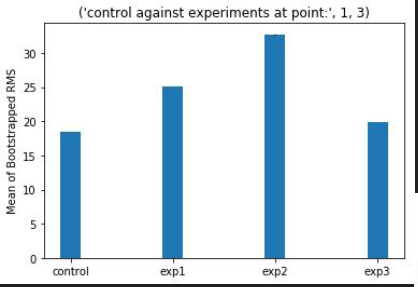
>Operant definition of “Strong Result:”

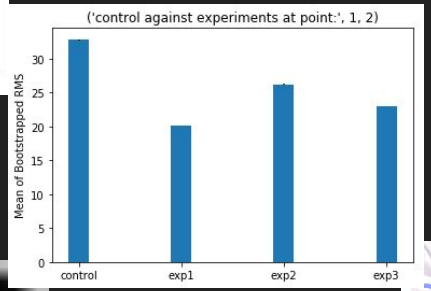
Significant reduction in mean variance value calculated at each eight points on the headrest.

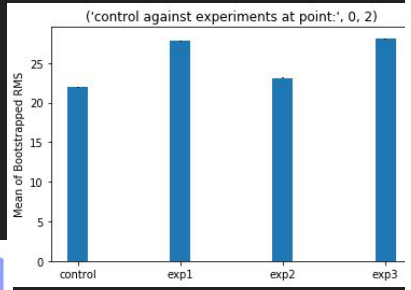
>Operant definition of “Weak Result:”

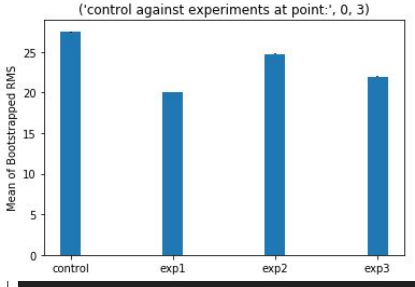
Significant reduction in mean variance values calculated on simply majority of points.

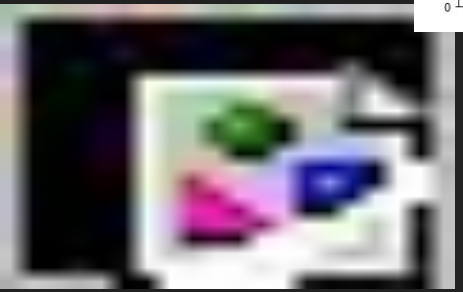
Not very instructive view of all results

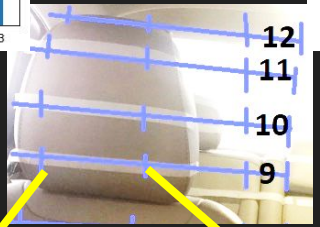


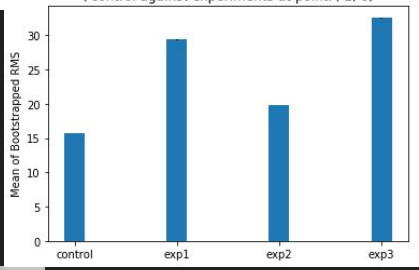


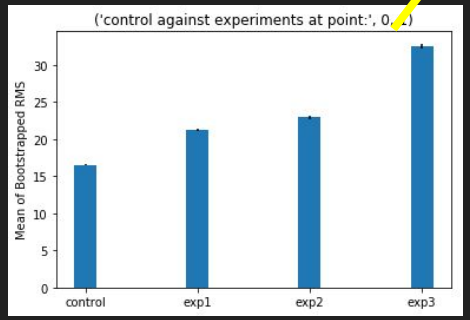












Results

- Data did not show a strong reduction in the noise by the passenger seat
  - On 5 points all experiments performed worse than result
  - No experimental case gave a weak improvement in noise
- There were statistically significant differences in noise levels at individual points
- Denim Material was ineffective
  - How can Sound Insulation cause more noise?
    - Noise contamination from changing road conditions
    - Possible that insulation was merely reflecting the noise instead of absorbing it

What’s Next?

- Tweak experiment process
  - Microphone array that can record at the same time
  - Don’t do the experiment while driving
  - Test with insulation in the back of the vehicle
- More extensive analysis
  - Analyze frequency spectrum
  - Triangulation of point sources
  - Different materials
  - Insulate entire vehicle

Summary

- Denim insulation seems ineffective in quantity used to reduce the noise experienced by the passenger

- Arduino device was able to detect significant results between points

- Exploratory phase revealed improvements that could be made to clarify results and reduce systematic uncertainties