“Exploratory Analysis of Noise Reduction in a Sedan”

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Physics 398 DLP
December 7th, 2018
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.