Innovation in individual vehicle noise management

Presentation to TEKH Acoustics 2019
Contents

• Problem definition
• Solutions in Aus/NZ
• Analysis techniques
• Alternate hardware
• Classification
Individual vehicle noise

- Complaints
- Investigations required
- Is the source actually what people think?
- Limited ability to mitigate
Engine braking

- Supplementary braking system that vents during the compression cycle
- Not just using gears to slow down
- Less of an issue with modern trucks
- Culture of drivers
Current hardware

Installation details

Features / issues

• High resolution camera with Number Plate Recognition
• Uses “in-service engine braking algorithm”
• Limited fixed cameras with high relocation costs
• Long lead time to address community concern
Current processing algorithm

**RMS Modulation**
- A-weighted
- 5ms average
- 200 Hz resample
- Band-pass filter (5-80Hz)

**Variables**
- RMS threshold level
- Bandpass filter
Accuracy

Sources of error

• False positives
  • Birds
  • Rain
  • Wind

• Truck vs bike
  • Unable to differentiate

Limitations

• Too many events to manually view
• Commercial system restricts this to samples with valid number plate
Our solution - hardware

• Pole mounted
• Solar powered
• Low-power processor (Raspberry Pi)
• Camera
• Remote access (3G)
General concept

Read from sensor
Analysis code
Standard OS functions
Interface with Altissimo server

altissimo.nz
Problems

Power
• Solar panel capacity
• Charging circuits
• Reboot cycle corrupt disk image
• Newer hardware has higher power draw

Remote access / communications
• USB modems targeted at consumers (Windows)
• Support for linux
• Bulk availability
• No remote ‘reboot’ facility
Hardware details

Processor
- Full size 3B/3B+
- Pi Zero
- Balance between processor power and current draw

Power management
- Shuts down on low battery voltage
- Watchdog to restart Pi if software stops running

Hologram IoT modems

MPPT solar charger
Hardware - progress
Machine learning

Training dataset

Feature extraction

Train/test

Result
Machine learning – training dataset
Machine learning – feature extraction

• 32 different analyses
  • Spectral
  • Energy
  • Chroma
  • Beats
Machine learning – test/train

Source: mapr.com
## Machine learning - classification

**Engine Braking classified as:**

<table>
<thead>
<tr>
<th>Engine braking</th>
<th>Trucks</th>
<th>Motorbikes</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>98%</td>
<td>1%</td>
<td>0%</td>
<td>1%</td>
</tr>
</tbody>
</table>

**Motorbikes classified as:**

<table>
<thead>
<tr>
<th>Engine braking</th>
<th>Trucks</th>
<th>Motorbikes</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>6%</td>
<td>83%</td>
<td>9%</td>
</tr>
</tbody>
</table>

**Trucks classified as:**

<table>
<thead>
<tr>
<th>Engine braking</th>
<th>Trucks (accel/decel)</th>
<th>Motorbikes</th>
<th>Trucks – body slap / curbing</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>3%</td>
<td>63%</td>
<td>4%</td>
<td>18%</td>
<td>11%</td>
</tr>
</tbody>
</table>
Results

[Graph showing data points for different categories such as Horn, Siren, Engine braking, Truck acceleration/deceleration, Bang or rattle, Car, and Motorbike over a 24-hour period from 0h to 20h, with a note indicating the time of day (2019-02-11).]
Differences in analysis techniques

Analytical
• Come up with a metric
  • Level
  • Frequency
  • Modulation
• Compare with criteria

Machine learning
• Define output categories
• Manually classify training set (~2000 events)
• Train
• Test and tweak parameters
Conclusion

• Site selection is important
• Cheaper hardware allows more units to be installed
• Ability to mount directly to pole significantly reduces lead time
• Machine learning can give better outcomes than trying to come up with analytical solutions
Contacts

Michael Smith
michael@altissimo.nz

Rob Wareing
rob@altissimo.nz