Predicting highly-resolved traffic noise (using data available as a by-product of Urban Traffic Management and Control systems)

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Background

• Modelling noise has been a topic since the 1960s.
• Since the END 2002, there has been the need for noise maps every 5 years in ‘agglomerations’ – last 2017
• Recognition that we can calculate noise very well for freely-flowing traffic conditions, but less well for interrupted flows
• Can we use the wealth of UTMC information to assist in calculation and mapping?
• Can we control for noise? (and would we want to?)
A Spatio-Temporal Model

Spatially:
- We have a network made of ‘nodes and links’
- We have a fleet of multiple vehicle types (car, MGV, HGV/Bus)
- Our vehicles have four operational modes
  - Cruising, Accelerating, Decelerating, Idling

Temporally, we have two operational modes:
- Uninterrupted operation under a green signal
- Interrupted operation by a red signal
Calculating Sound

- Use CNOSSOS-EU based procedure
  - Calculate Sound Power Level (SPwL)
  - 2x sources on an individual vehicle (Rolling & Power)
  - 8x octave bands for broadband total

- Calculate look-up table of Sound Exposure Level values (SELs) for individual vehicle modes
- Scale by vehicle flow in mode
- Propagate and convert contributions from all sources to get $L_{Aeq}$ levels
Calculating Sound (Simplified...)

Basic CNOSSOS-EU Sound Power (speed and vehicle type dependent):

- \( L_{Veh} = f(L_{power} + L_{rolling}) \), \( L_{rolling} = a + b \log_{10} \left( \frac{V}{V_{ref}} \right) \), \( L_{power} = c + d \left( \frac{V-V_{ref}}{V_{ref}} \right) \)

Correction of Sound Power to SELs (speed and geometry dependent):

- \( SEL_{Veh} = L_{Veh} - 10 \log_{10} V + 10 \log_{10} d + 10 \log_{10} a - 10 \log_{10} [4\pi d'^2] - \Delta Lg \)

Sound ‘Energy’ contribution from a vehicle class in a period:

- \( E_{Veh} = 10 \log_{10} [(10^{0.1E_{Veh,idl}} \cdot Q_{Veh}) + (10^{0.1E_{Veh,cru}} \cdot Q_{Veh}) + (10^{0.1E_{Veh,acc}} \cdot Q_{Veh}) + (10^{0.1E_{Veh,dec}} \cdot Q_{Veh})] \)

Correction to \( L_{Aeq,T} \):

- \( L_{Aeq}(T) = 10 \log_{10} \left[ \frac{1}{T} (E_{car} + E_{MGV} + E_{HGV} + (T - Q_{car} - Q_{LGV} - Q_{HGV}) \cdot 10^{0.1L_{back}}) \right] \)

We’re glossing over loads of assumptions regarding CNOSSOS parameters (e.g. road surface) here! – see also Paoprayoon et al., 2005 and Watts et al., 2004
Where to get Traffic Data?

• Use Newcastle City Council’s SCOOT (Split, Cycle, Offset, Optimisation) system (TRL UK, Hunt et al., 1981)

• Data either measured or generated from SCOOT used in this research include:
  • Flow: an estimate of stop-line arrival flow in veh/h or veh/5min;
  • Delay: an estimate of the total delay experienced by all vehicles arriving at the stop-line, in units of 1/10th vehicle hours/hour;
  • Occupancy: the number of quarter-second intervals a traffic loop detector embedded in the road pavement is occupied by vehicles during the overall time period (in this study 5 min)

• Collected via NUIDAP (Newcastle University Integrated Data Access Platform)
How to Calibrate/Validate?

• Use data collected from inexpensive eMote sensors

• See for yourself at: www.urbanobservatory.co.uk
Study Area – eMotes 1707, 1703
Sample SCOOT data (Flow, Occupancy, Speed)

- Link 10141Z is straight-ahead flow, 10141P is a right-turn pocket
- Mote 1707 is near the stop-line whilst 1703 is mid-link.
States provided for each 5 minutes namely Quiet (1) Smooth Flow (2) Start-Stop (3) and Congestion (4) for each five minutes used in CNOSSUS
Models Tested

• Three Scenarios (Weekdays 07:00 – 19:00):

  • ‘Free-Flow’ - assumed average flows and speed

  • ‘Free-Flow’ and speed with CNOSSUS junction corrections assuming constant periods of SCOOT state. Each state has defined proportions of traffic mode
    • N10141Z (straight-ahead) quiet and smooth states 40% and 60% respectively
    • N10141P (right-turn movement only) quiet (67%), smooth (24%) and busy (9%).

  • Using SCOOT derived flow and speed with known flow regime for each five minute period and corrected for the spatial changes upstream and downstream of the link.
Results: Site 1707 - Stopline

1. ‘Free Flow’
   Absolute error: 3.7dBA
   RMSE: 4.1dBA

2. +CNOSSOS Junction Correction
   Absolute error: 2.0dBA
   RMSE: 2.0dBA

3. Spatio-Temporal using SCOOT data
   Absolute error: 0.5dBA
   RMSE: 1.9dBA
Results: Site 1703 – Mid-Link

1. ‘Free Flow’
   - Absolute error: 4.3dBA
   - RMSE: 4.7dBA

2. +CNOSSOS Junction Correction
   - Absolute error: 3.9dBA
   - RMSE: 4.3dBA

3. Spatio-Temporal using SCOOT data
   - Absolute error: 1.4dBA
   - RMSE: 1.9dBA
Difference (predicted-measured) in $L_{Aeq,5-min}$

1. ‘Free Flow’

Difference between 1. and 2.

2. +CNOSSOS Junction Correction

Difference between 1. and 3.

3. Spatio-Temporal using SCOOT data
Conclusions and Limitations

• Three variants of a noise prediction model developed – each using UTMC (SCOOT) data in a different way

• Most effective model used breakdown of links into four sections and included flow regimes. Using free-flow, average speed underestimated noise

• Also can obtain distributions of noise, rather than just single values

• Limited by simple calculations of speed from SCOOT occupancy and delay – e.g. masking can occur using inductive loops

• No way (yet) of getting different attributes for different vehicle classes from SCOOT, or in assumptions

• Other effects? Road surface? Site characteristics? Non-traffic noise?

• Nearside links only considered
Thank you for listening
Any questions?

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