Measuring and Analyzing Road Traffic Noise

Stockholm, December 11, 2012
CityHush Training Workshop
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Structure

- Traffic flow analysis with *microphone arrays* and beamforming (measurements)

- Traffic flow analysis with *Traffic Noise Synthesizer* (simulations)
Traffic Flow Analysis with Microphone Arrays
Objective of Work

Statistical Analysis of vehicle driving behavior and resulting noise emission

- Vehicles?
- Speed?
- Acceleration?
- Noise?
- Sources? (wheels, engine)

Real traffic flow

Measurement system
System Components

Video system
Detection of the vehicles with position, speed, acceleration

Audio system
Localisation and quantification of noise sources and emission

Panorama Video Camera
with advanced image processing software

Acoustic Camera
Microphone array with beamforming software
Panorama Camera Module

- 3 VGA ethernet cameras: -60°, 0°, 60°
- Automated rectification (cancellation of image aberrations, e.g. lens position errors, fish eye)
- Automated stitching of panorama view
- All image errors (lens position, fish eye) are corrected
Flexible Array

- Flexible array system
- Modular grids (1.5m x 1.5m)
- Up to 192 microphones
- Panorama camera module with automated microphone position detection
Available Data

Optical Image = Vehicles + Background

Acoustic Image = Sources
Which Sources Correspond to Which Vehicle?

- Continuous vehicle detection
- Vehicle flow simulation to compensate detection errors
Vehicle Detection
(based on image processing)

background

background with foreground

Foreground extraction
detected vehicle
Traffic flow analysis - Example

Original video capture
Traffic flow analysis - Example

Detected objects
Traffic Flow Analysis - Example

Source level detection by virtual microphones (related to 1m distance)
Acoustical Fingerprint of Citroen Electric Vehicle
Array Measurement of Electric Vehicle

Beamforming result (Citroen electric vehicle)
Level vs. Constant Speed and Frequency

- Front tires
- Smooth road surface
- Rear tires

- Low noise tires,
- Standard tires

in dB(A)
Level vs. Constant Speed and Frequency

- **Front tires**
- **Rough road surface**
- **Rear tires**
- **low noise tires**
- **standard tires**

- in dB(A)
Conclusions I

- Measurements possible based on system with panorama camera and flexible large scale array
- Optical detection of vehicles and calculation of physical parameters
- Acoustical detection of sources and generation of time signals
- Synthesis of large number of heterogenous pass-by events (acoustical fingerprint of single vehicles, specific road conditions)
- Data evaluation with standard and psychoacoustic analyses
Traffic Noise Synthesizer
Traffic Noise Synthesis of Vehicles

- **Motivation:**
  Investigate effect of certain measures without measurement uncertainties

- **Advantage:**
  Useable in subjective tests, calculation of any acoustic parameter, audible forecasts possible (of virtual modifications (e.g. warning signals))
Data flow of the traffic noise synthesizer

Vehicle movements

Source model

Propagation

- VISSIM import
- Passby simulation
- Vehicle positions
- Synthesizer
- Post processor
- Synthesis parameter
- Properties
- Driving conditions
- Propagation influences
- Doppler effect
- Binaural filter
- Playback
- File export

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Example of Synthesis: Order analysis and synthesis

Spectrogram of a near-field engine measurement

Order analysis

Order analysis with detected orders

Re-synthesis of orders
Example of Synthesis:
Sound synthesis of an electric vehicle

Order synthesis
Noise synthesis
Synthesis (superposition)
Near-field measurement
Sound example: Mitsubishi iMIEV

Single pass-by sound events during full-load acceleration

- iMIEV E-motor
- iMIEV E-motor + tires
- iMIEV E-motor + tires + converter
- iMIEV E-motor + tires + converter + background noise
Traffic Noise Simulation

Traffic noise of a straight road (30 km/h) with scooters and vehicles

Traffic noise scenario with conventional drives

Traffic noise scenario with electric drives
Benefit of Traffic Noise Synthesizer

- Identification of most efficient noise mitigation measures and actions, which can be virtually experienced

- Efficiency of measures can be assessed not only on the basis of a dB(A)-reduction, but also on the reduction of further relevant parameters

- Decisions for or against specific noise mitigation measures are more grounded
Thank you for your attention!

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