Measuring and Analyzing Road Traffic Noise

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CityHush Training Workshop

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CityHush

SEVENTH FRAMEWORK PROGRAMME

Structure

- Traffic flow analysis with *microphone arrays* and beamforming (measurements)
- Traffic flow analysis with *T*raffic *N*oise *S*ynthesizer (simulations)

Traffic Flow Analysis with Microphone Arrays

Objective of Work

Real traffic flow

Measurement system

=

Statistical Analysis of vehicle driving behavior and resulting noise emission

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

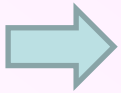
System Components

Video system

Detection of the vehicles
with position, speed, acceleration

Audio system

Localisation and quantification
of noise sources and emission



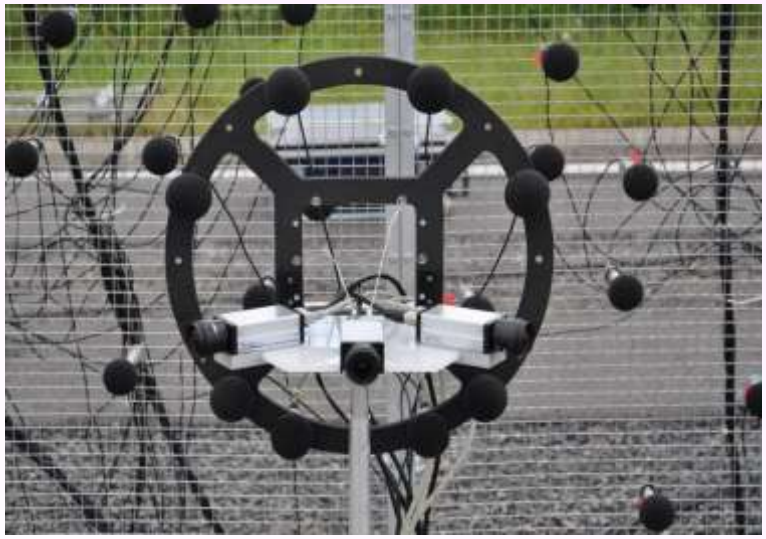
Panorama Video Camera

with advanced image processing software

Acoustic Camera

Microphone array with beamforming software

Panorama Camera Module



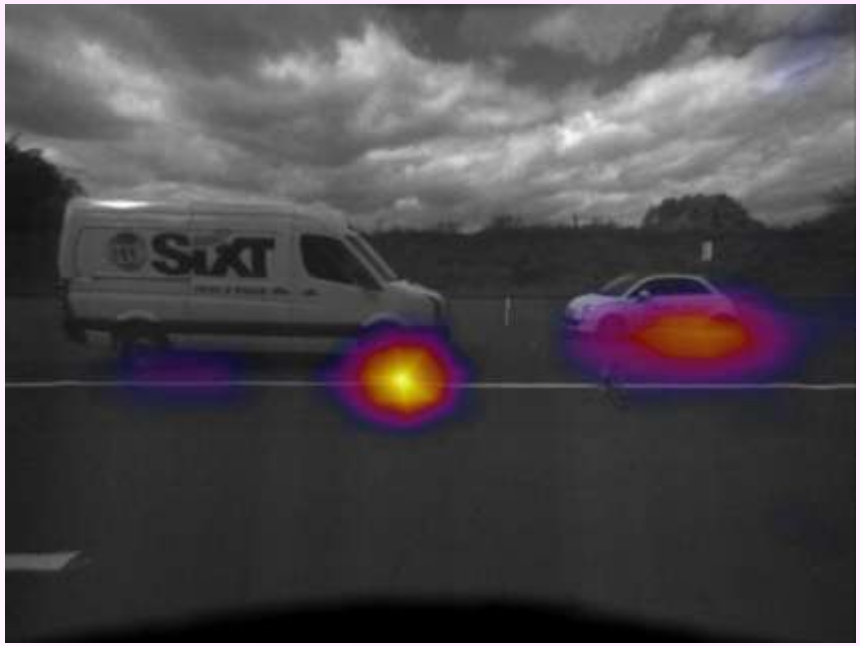
- 3 VGA ethernet cameras: -60° , 0° , 60°
- Automated rectification (cancellation of image aberrations,e.g. lense position errors, fish eye)
- Automated stitching of panorama view
- All image errors (lense position, fish eye) are corrected

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

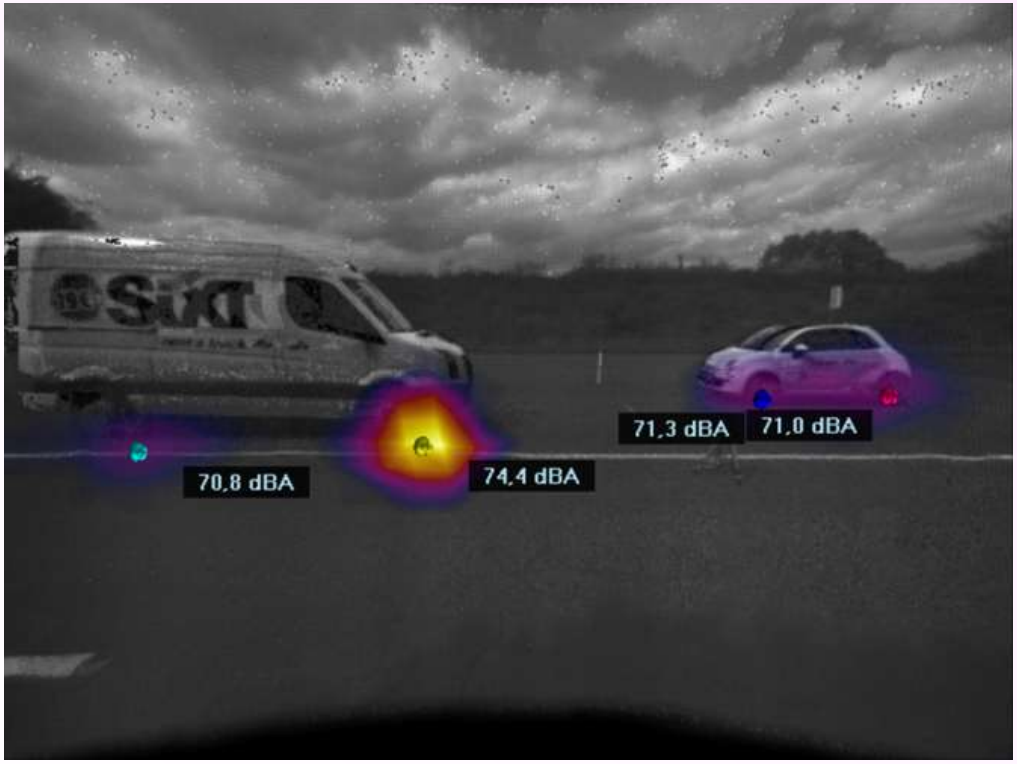
Traffic flow analysis - Example

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

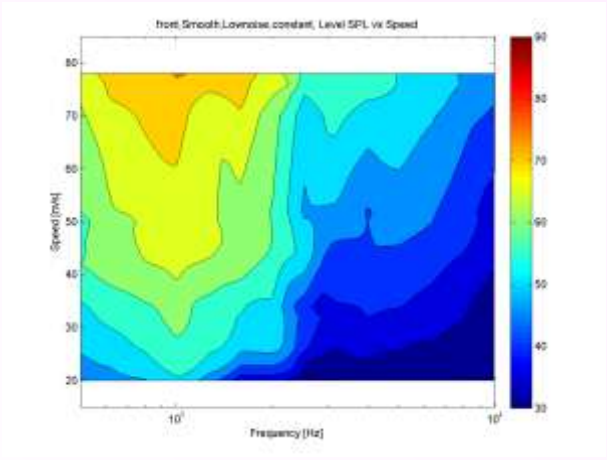
Beamforming result
(Citroen electric vehicle)

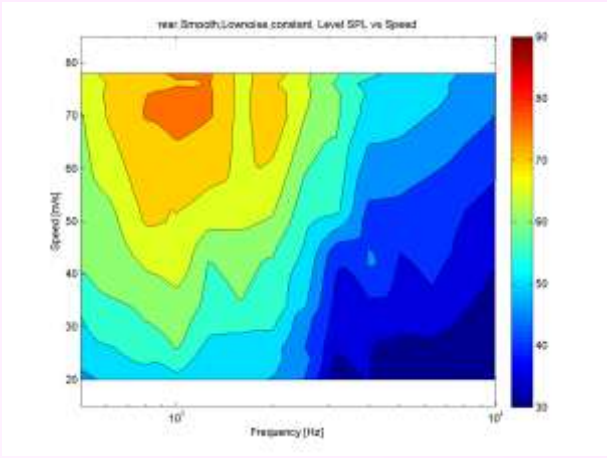
Level vs. Constant Speed and Frequency

Front tires

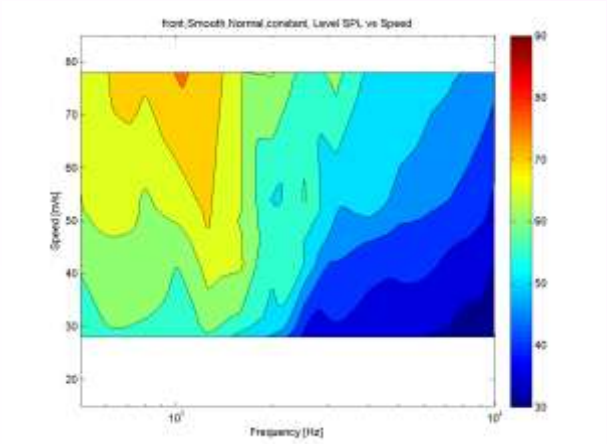
Rear tires

Smooth road surface

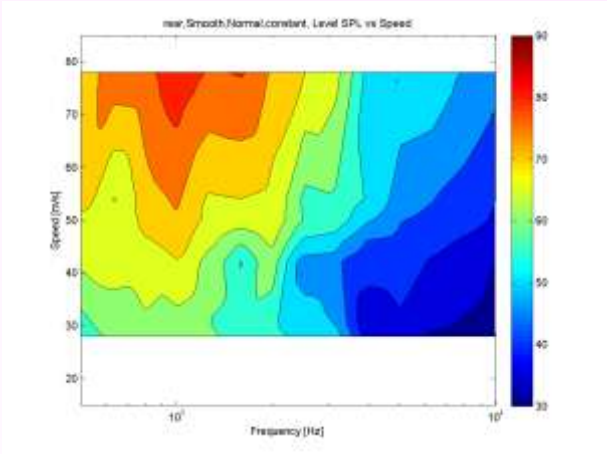




low noise tires,



standard tires



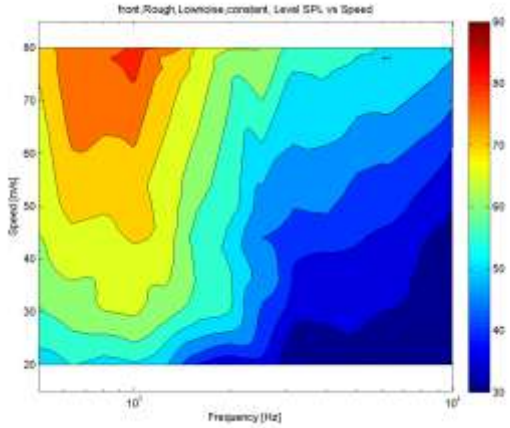
in dB(A)

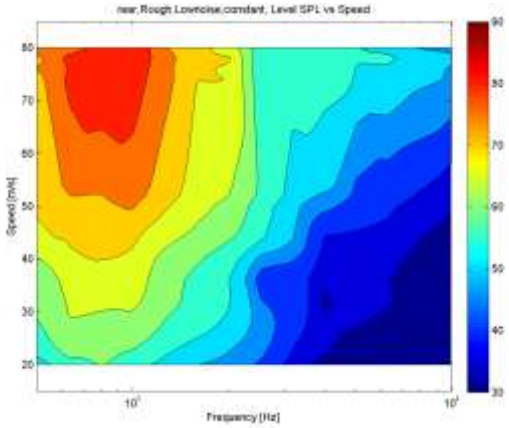
Level vs. Constant Speed and Frequency

Front tires

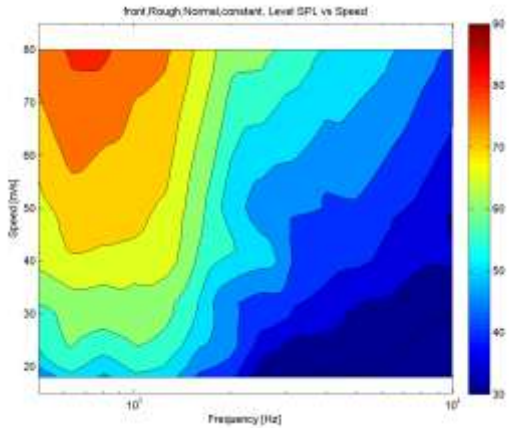
Rear tires

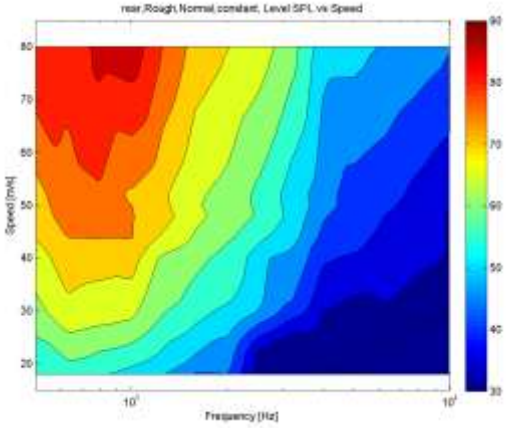
Rough road surface





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 heterogenuous pass-by events (acoustical fingerprint of single vehicles, specific road conditions)
- Data evaluation with standard and psychoacoustic analyses

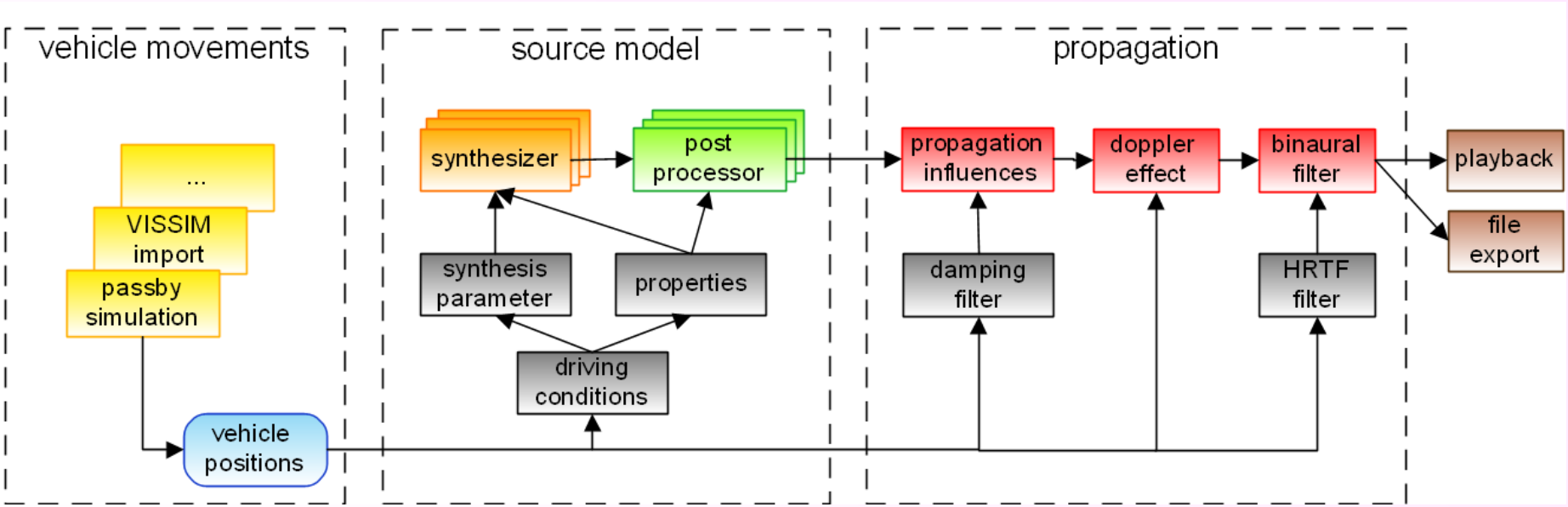
Traffic Noise Synthesizer

Traffic Noise Synthesis of Vehicles

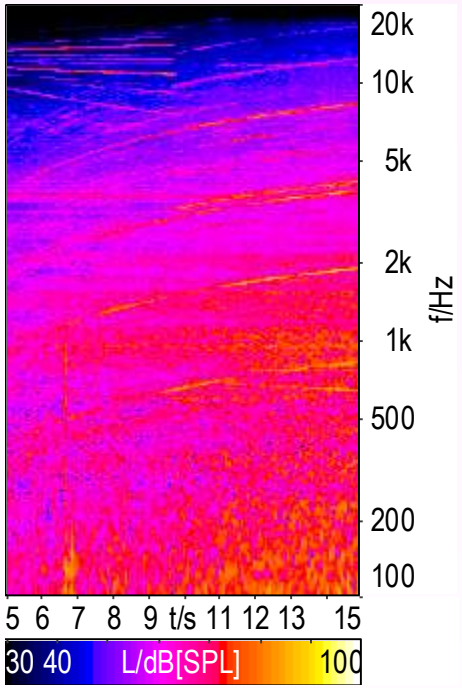
- Motivation:
  Investigate effect of certain measures without measurement uncertainties
- Advantage:

  Useable in subjective tests, calculation of any acoustic parameter, audible forecasts possible (of virtual modifications (e.g. warning signals)

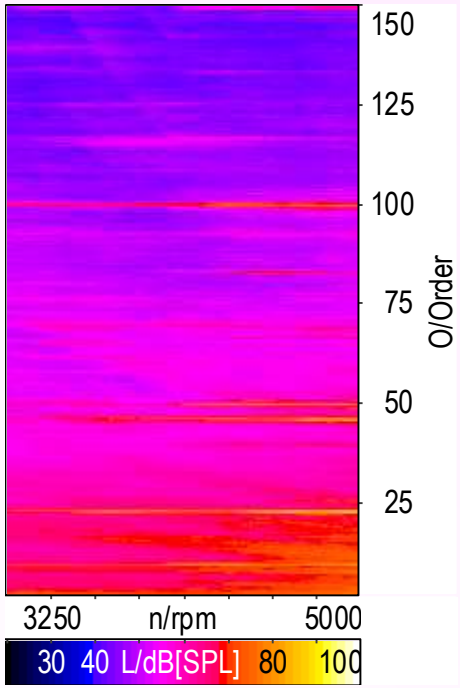
Data flow of the traffic noise synthesizer



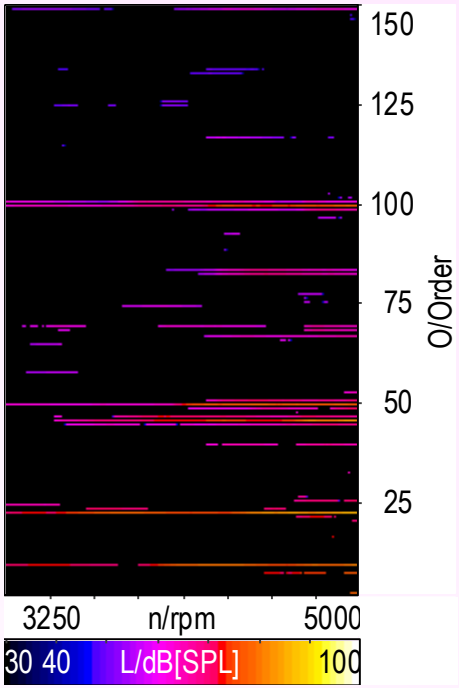
Example of Synthesis: Order analysis and synthesis



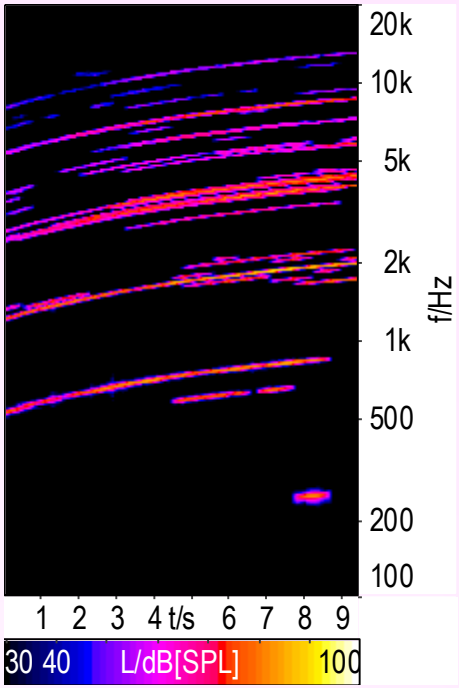
Spectrogram of a near-field engine measurement



Order analysis

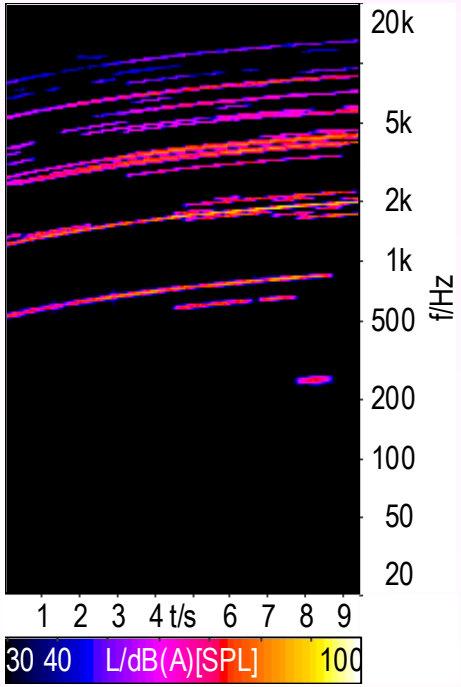


Order analysis with detected orders

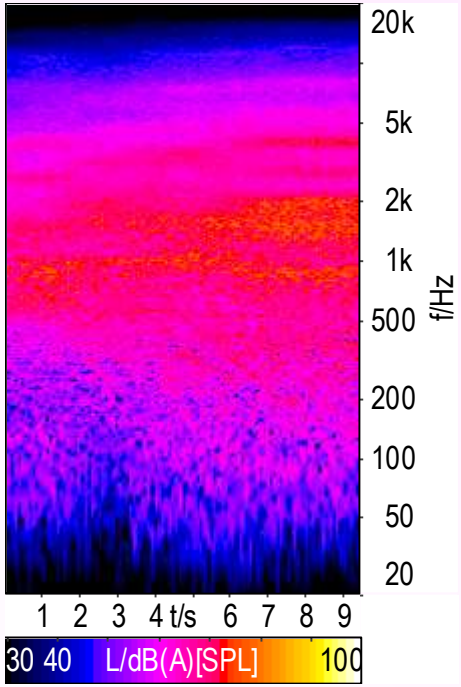


Re-synthesis of orders

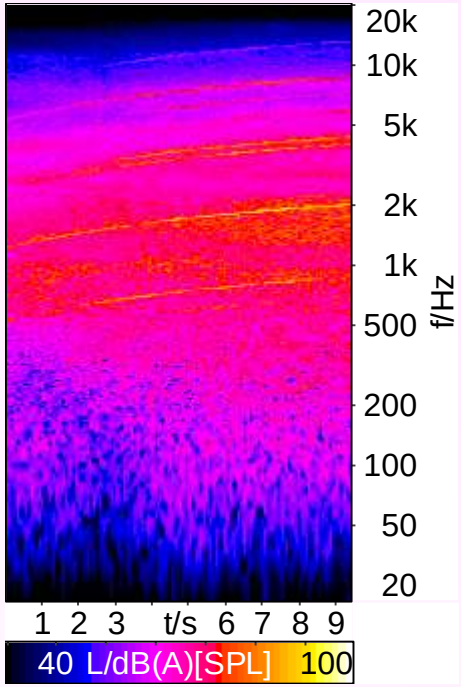
Example of Synthesis: Sound synthesis of an electric vehicle



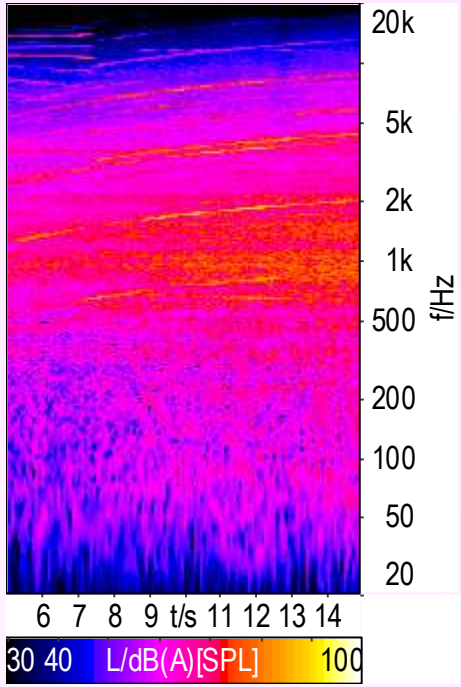
Order synthesis



Noise synthesis



Synthesis (superposition)



Near-field measurement

Sound example: Mitsubishi iMIEV

Single pass-by sound events during full-load acceleration

iMIEV E-motor

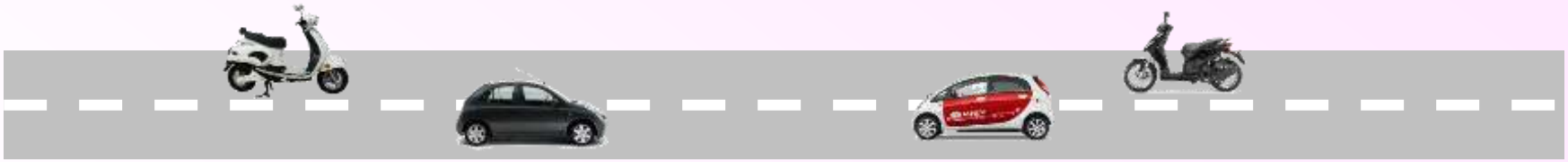
iMIEV E-motor + tires

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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