Schweizerische Gesellschaft für Akustik
Société Suisse d'Acoustique

Research Group for
Geometric Optimization
and Machine Learning

Detecting, Localizing, and Tracking Alarm Signals in Traffic using a Microphone Array

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Within the AAL project "Intelligible City For All"

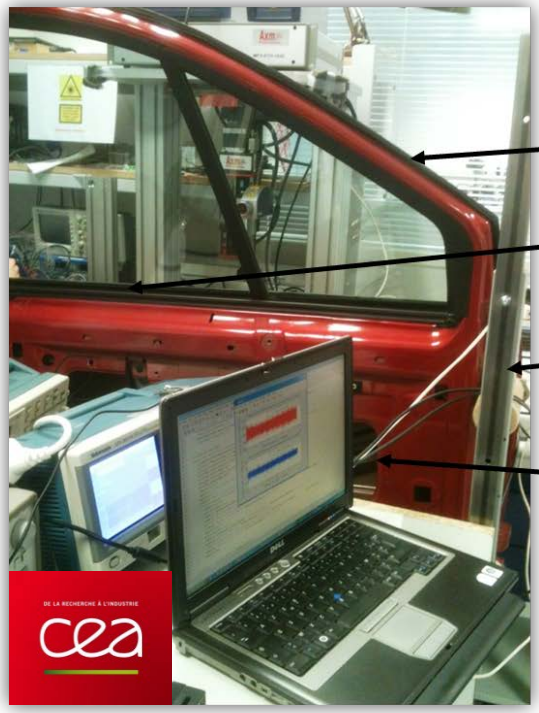
Project Milestones

Proof of concept for passive acoustic alarm signal localization on a moving vehicle

- **Hardware development (microphone array, carglass microphones)**
- **Database of recordings (alarm car maneuvers, ego noise)**
- Algorithm selection / development
- Software prototype implementation
- Evaluation on test data
- Human-Machine-Interface development

Developed Hardware

Wind-protected microphones / carglass microphones (work in progress)



Renault Scenic II front left door

Sealing and damping rubber

Door can rotate on hinges
Fixed to a rolling structure

12V door opening
DC motor

Database of recordings

Separate recordings of scenarios and disturbances

Alarm signals

- Police, Ambulance & Firefighters
- IT / FR / DE / AT

Alarm car maneuvers

- Lateral pass-by (e.g. straight road)
- Front pass-by (e.g. intersection)
- Circular pass-by (omnidirectionality test)

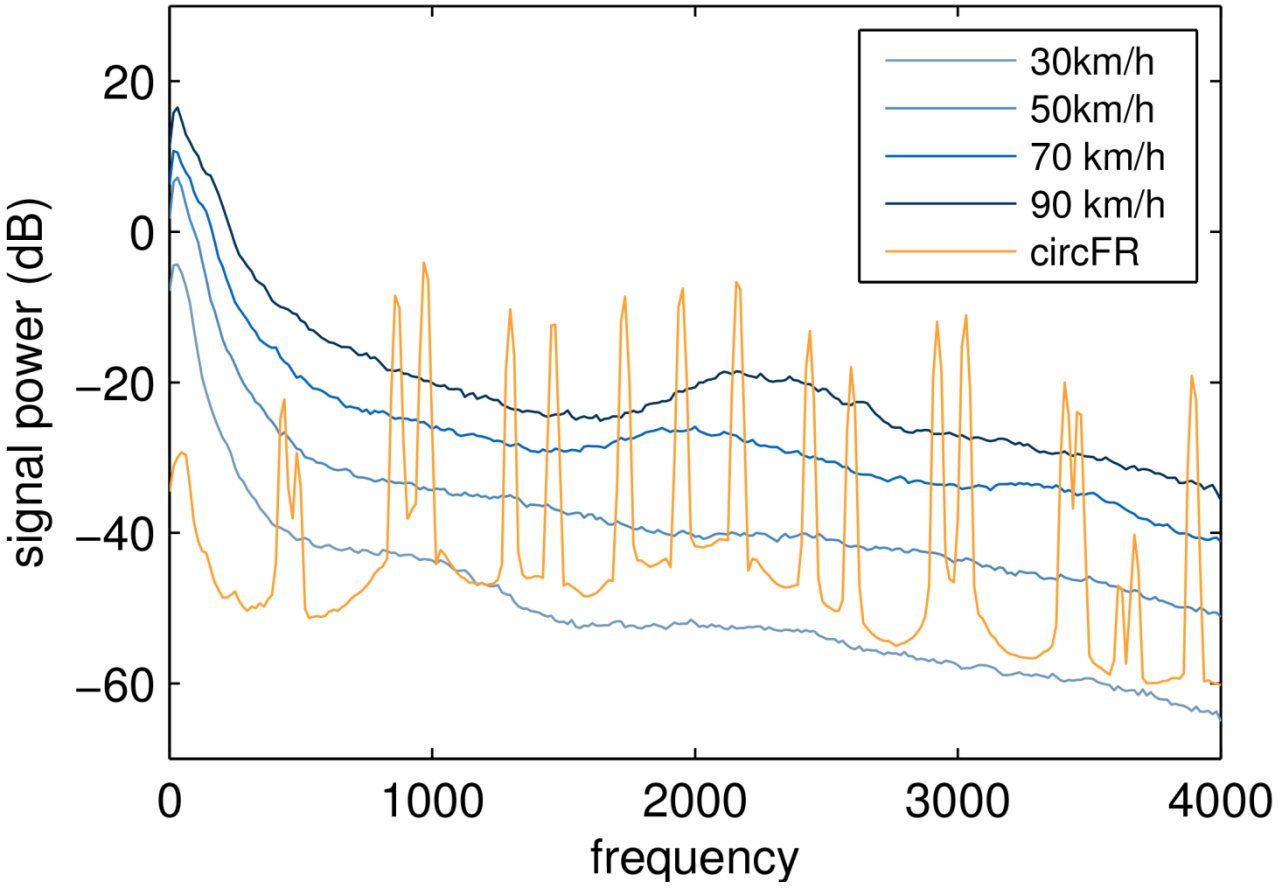
Ego noise (open and closed windows)

- 30 km/h
- 50 km/h
- 70 km/h
- 90 km/h

Superposition of signal recordings and noise for evaluation

Spectral distribution

Alarm signal (French firefighters at 30m distance) is partly masked by ego noise



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Project Partners

Task: I'City Alarm – Array Signal Processing

Collaborating partners

- ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development)
- UPD/ LinkLab (Université Paris-Descartes / TELNET CEA-Linklab Tunisie)
- TUM (Technische Universität München)

Task dissemination

- Detection/ Identification: ENEA/UPD
- Localization: ENEA/TUM
- Tracking: ENEA/TUM

Alarm Signal Detection

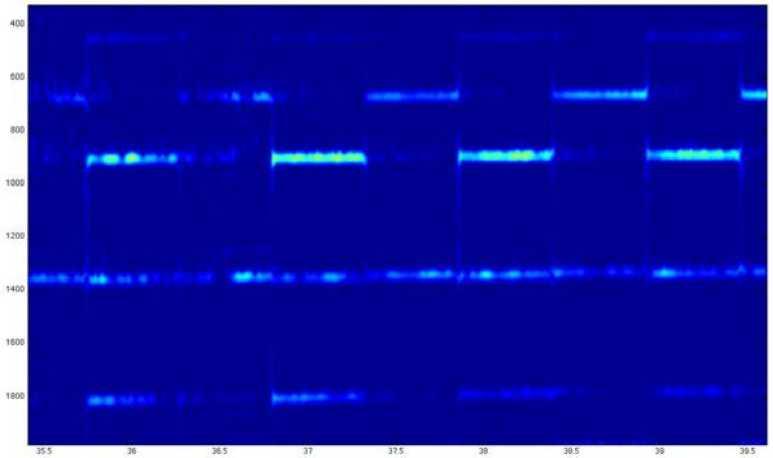
Initializes the processing chain

Current concept:

- Use the a priori known alarm signal specifications
- Several detection methods
  - Detect the fundamental frequency and harmonics in the signal with filterbanks
  - Short-Time-Fourier-Transform masks
  - Pulse detection in the STFT domain
- Binary decision (Alarm present or not)
- Alarm type recognition

Future development

- Signal-independent detection via tonal analysis



Alarm Signal Localization

Assumptions and concepts

Model assumptions

- 1D geometry (azimuth angle in cylindrical coordinates)
- Direct line-of-sight
- Free-field conditions (no reverberation)
- One source at a time

Steered beamforming approach (Delay-And-Sum-Beamformer / SRP-PHAT)

- Realtime processing
- Sufficient angular resolution (actually required resolution depends on HMI)
- Multiple sources can be detected

Signal characteristics well-known

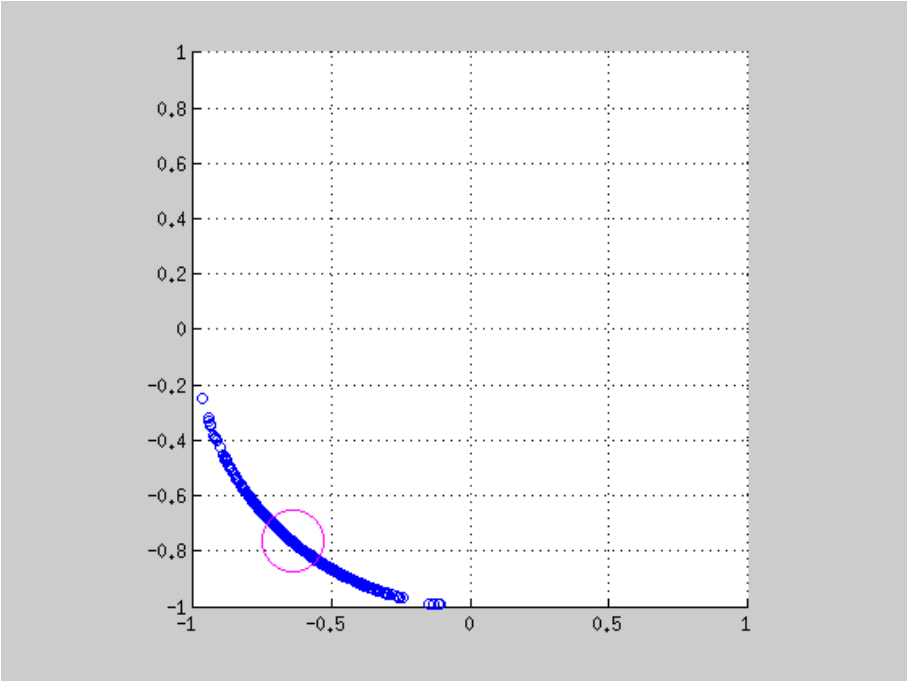
- Evaluate significant frequency range only

Alarm Signal Tracking

Post processing

Goal: Stable direction estimate from noisy localization output

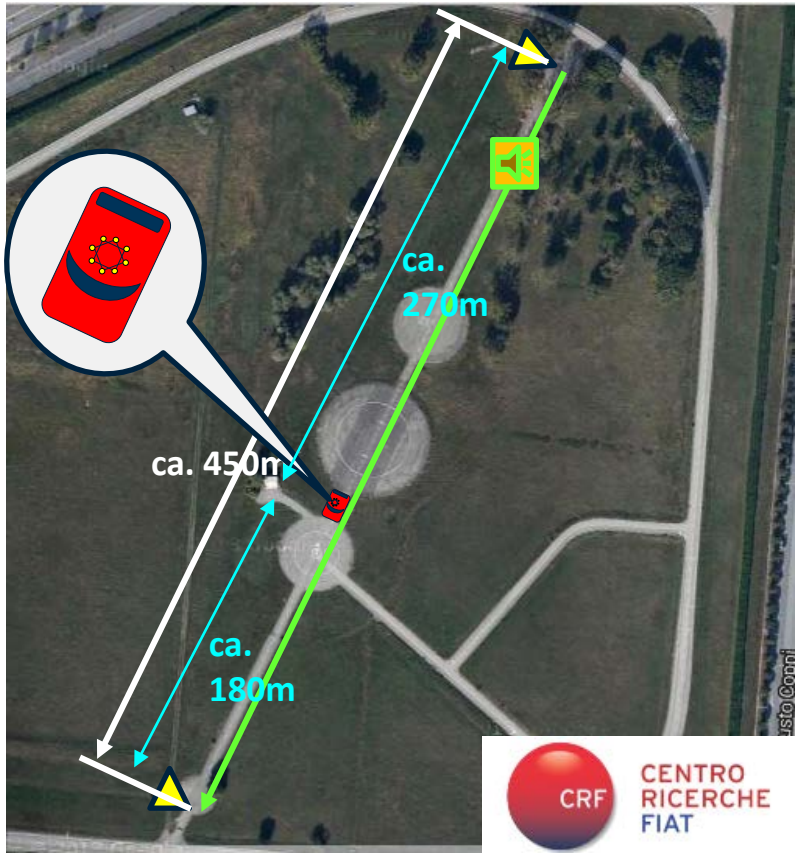
Particle filtering



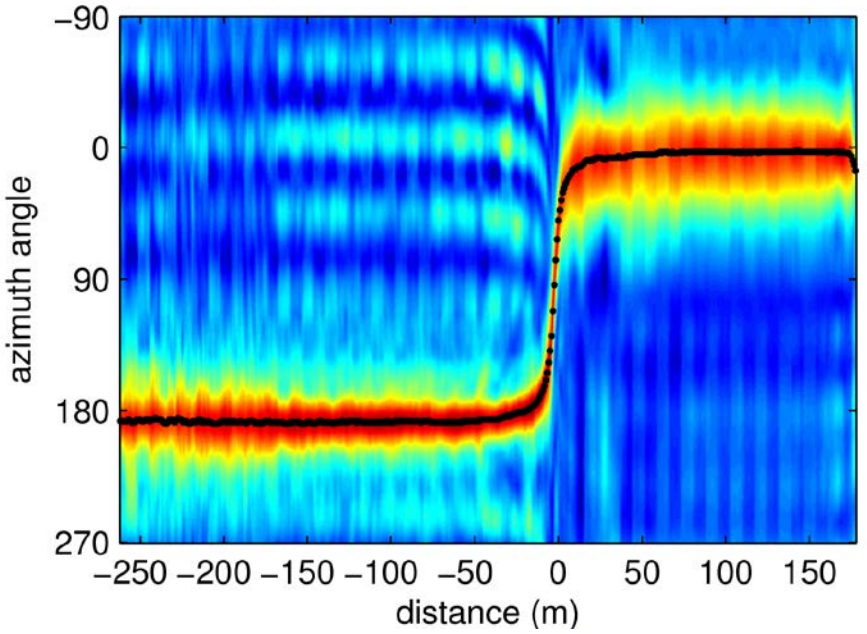
Preliminary Localization Results

Example scenario: Lateral pass-by

Experimental Setup



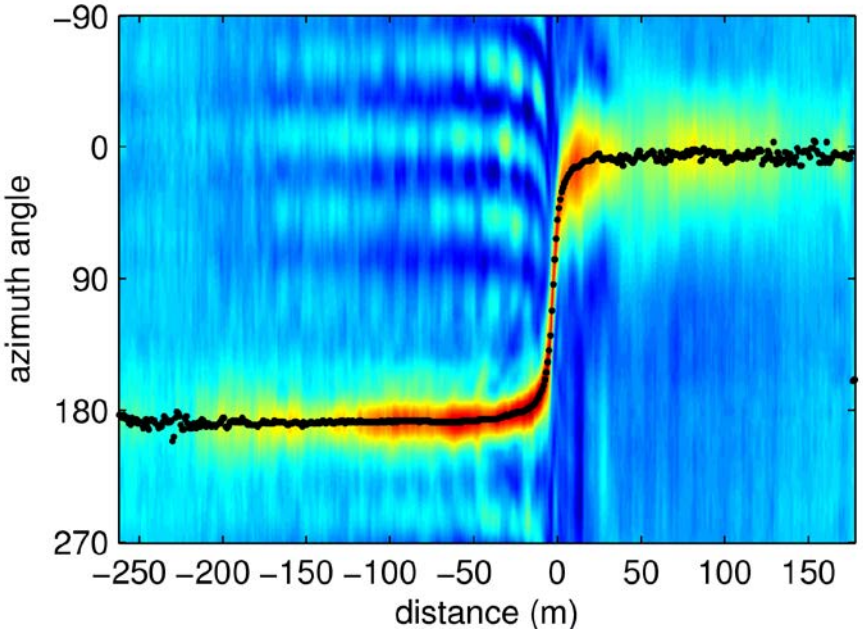
Localization result (DSB) without additive noise, frequency range: 600Hz – 4kHz



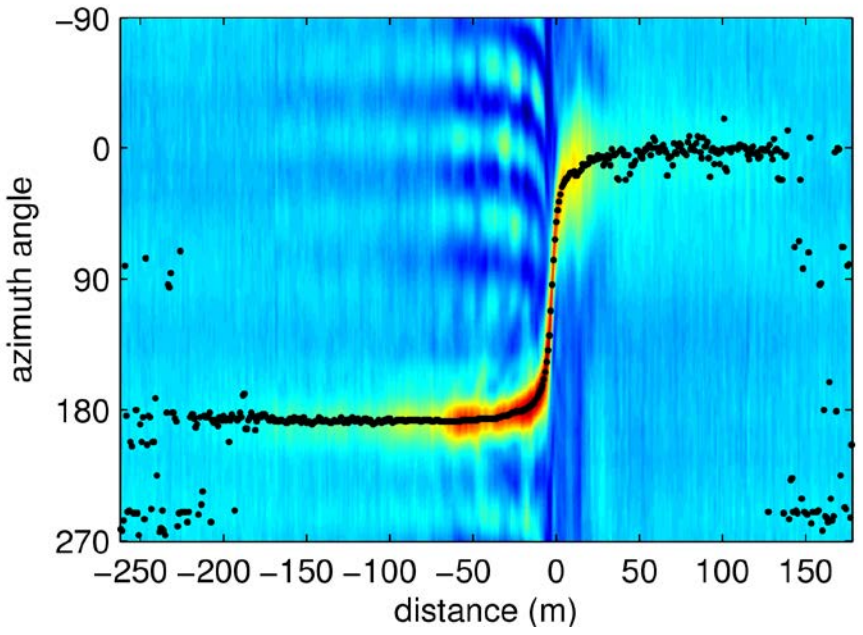
Preliminary Localization Results

Lateral pass-by scenario with ego noise (urban traffic speed)

30 km/h noise added



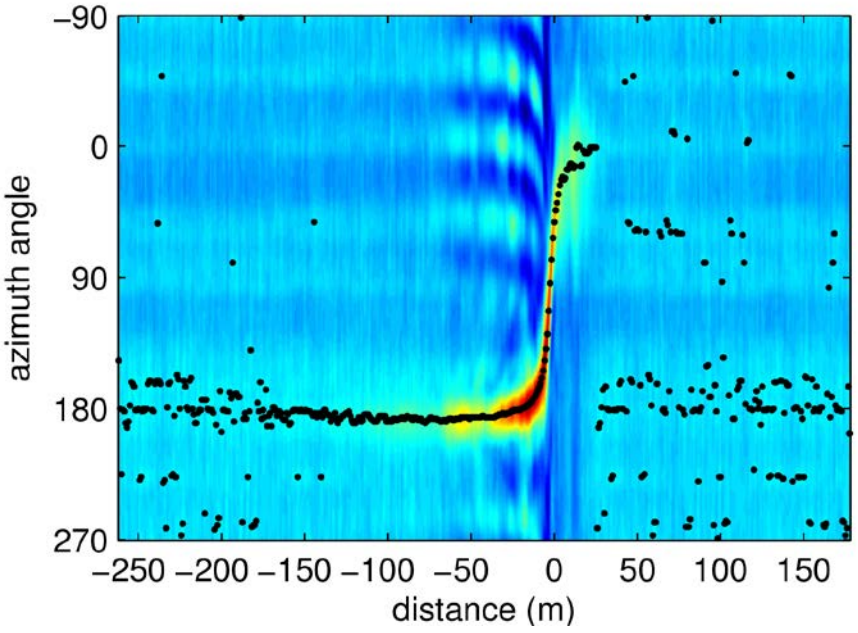
50 km/h noise added



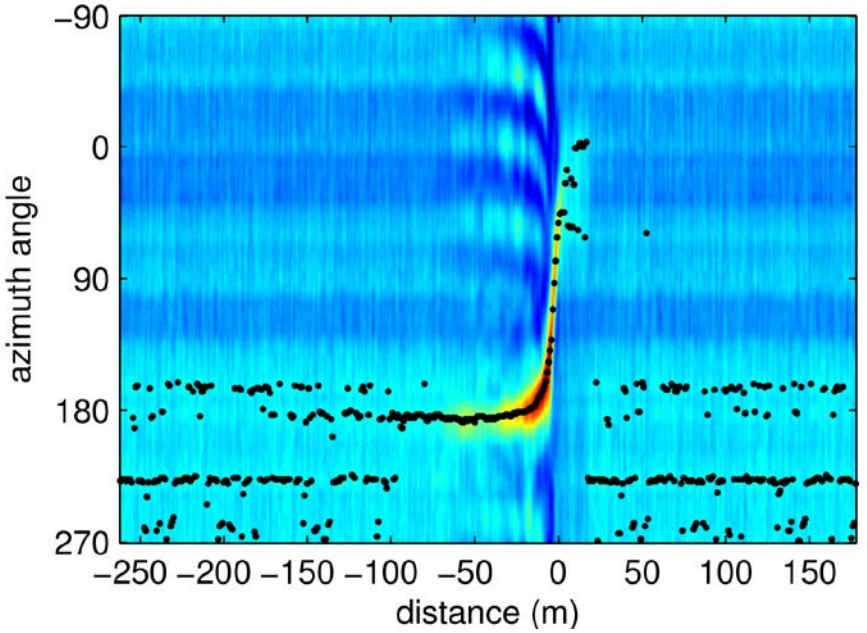
Preliminary Localization Results

Lateral pass-by scenario with ego noise (overland speed)

70 km/h noise added



90 km/h noise added



Conclusion

How promising is such a system?

As an early warning system

- at low speed (urban traffic)
- in good conditions (little reverberation)
- Need further comparison against human drivers

As an immediate warning system (~3-5 seconds TTC)

- Signal is always detected if distance goes below 50m and direct line-of sight
- Valuable warning system for presbyacusic people

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