Assessment of Simulations in FAUST and TASCAR for the Development of Audio Algorithms in Acoustic Environments

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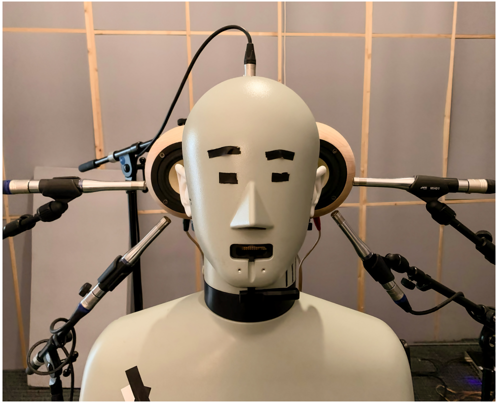
Introduction

- Research on active noise control (ANC) in time-variant environments
- ANC $\rightarrow$ hard real-time constraints
- Difficult to evaluate & validate algorithms
  - Offline evaluation often not possible
  - Evaluation on hardware (DSP/FPGA)



Introduction

Evaluation on hardware

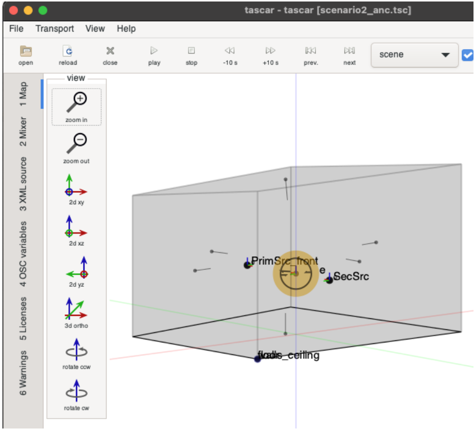
- Bare metal programming
  → hardware-bound, time consuming, hard to adapt
- Conversion from higher language (Syfala/dSPACE/SpeedGoat)
  → costly, dedicated hardware

- General disadvantages
  - Hardware availability/costs
  - Limited repeatability
  - Measurement space

→ Real-time simulation of acoustic scenarios

TASCAR

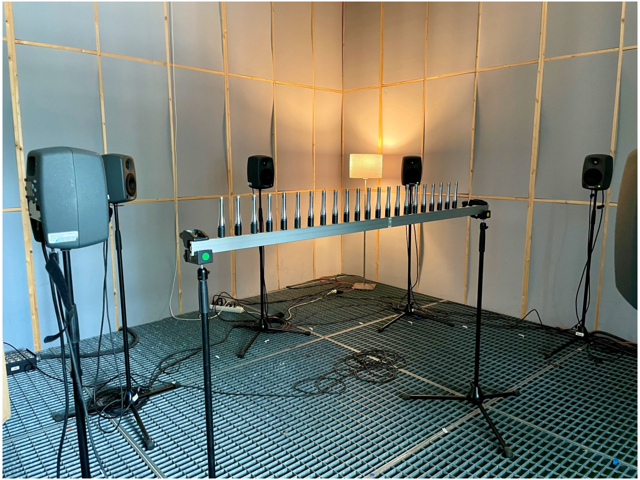
- “Toolbox for Acoustic Scene Creation and Rendering”
- Open-source audio virtualization tool (University of Oldenburg)
- Widespread use for hearing-aid research, audiology, and deep learning
- Offline & real-time sample-based auralization of acoustic scenes
- Using Jack Audio Connection Kit (I/O, time-line)
- Direct user-interaction via OSC

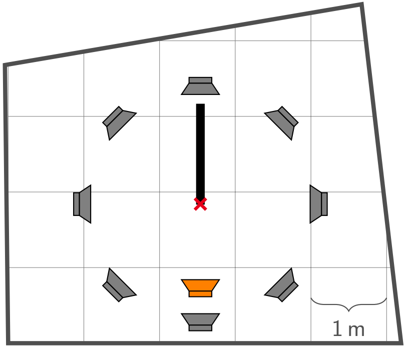


Experiment Setup

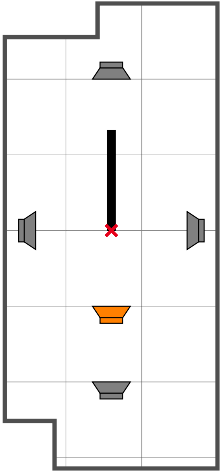
- Compare accuracy of simulation to measurements/co-simulations
  - Soundfield properties
  - Behavior of acoustic algorithms
- Two different rooms
  - Semi-anaechoic measurement room
  - Anisotropic meeting room
- Different source configurations (1/4/8 sources)
- Reference recording with linear microphone arrangement

Measurement setup - measurement chamber





Measurement setup - meeting room



Simulation setup

- Remodel simplified room model in TASCAR based on high-precision 3D scan
- Estimated absorption coefficients for each surface

- Varying simulation accuracy
  0. Free-field conditions
  1. 2^{nd} order image source model (ISM)
  2. 2^{nd} order ISM + modeled source directivity
  3. 2^{nd} order ISM + directivity + FDN reverb

- Rendered offline (roomacoustic parameters) or online (RT signal processing)

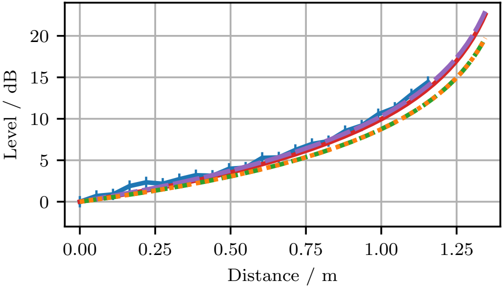
Soundfield analysis

Analyzed properties

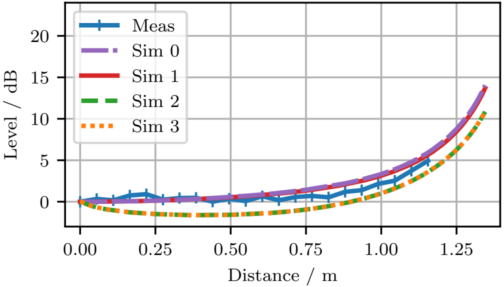
- Level distribution along array

- Spatial coherence/correlation to central position
  - Spatial correlation widely used measure for description of sound fields
  - Correlation only valid for test signal → time consuming
  - Spatial coherence with broadband excitation for fast/easier measurement

Level distribution - measurement room

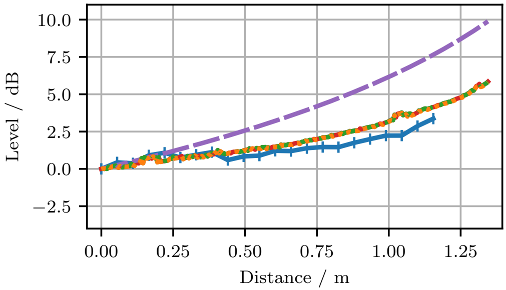


1 source

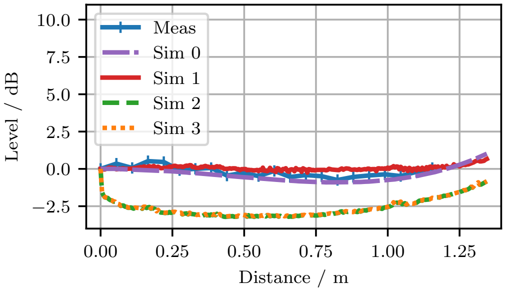


8 sources

Level distribution - meeting room

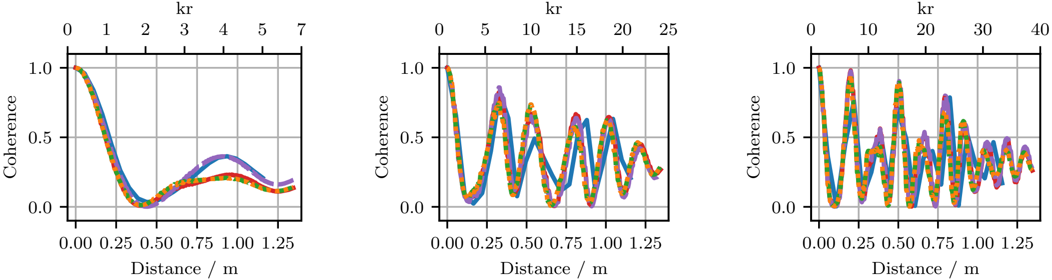


1 source



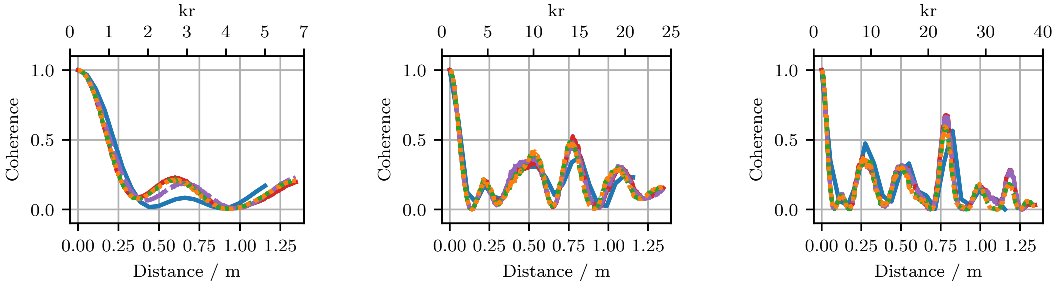
4 sources

Spatial coherence - measurement room (4ch)



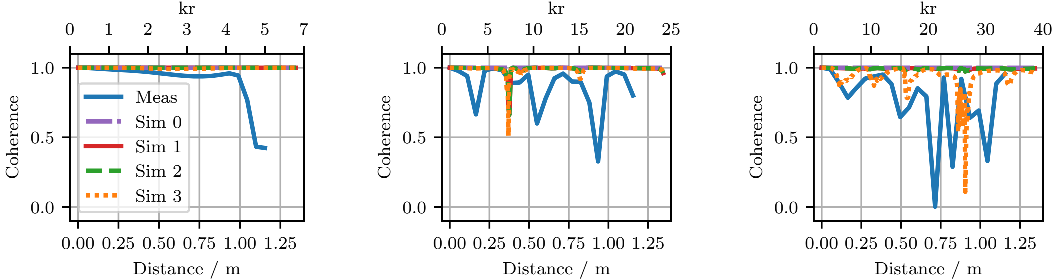
$f = 300\,\text{Hz}$ $f = 1000\,\text{Hz}$ $f = 1700\,\text{Hz}$

Spatial coherence - measurement room (8ch)



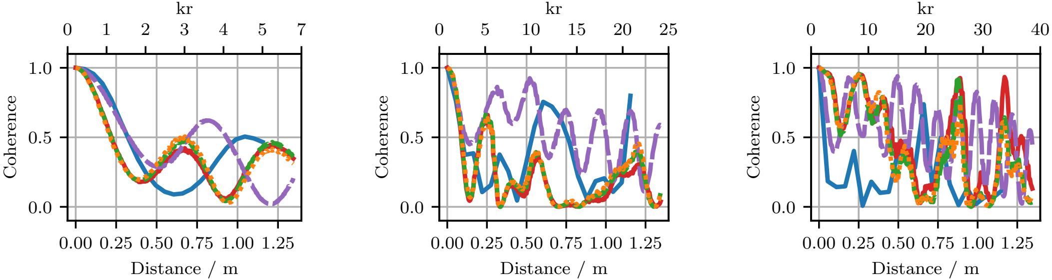
$f = 300\,\text{Hz}$ $f = 1000\,\text{Hz}$ $f = 1700\,\text{Hz}$

Spatial coherence - meeting room (1ch)



$f = 300\,\text{Hz}$ $f = 1000\,\text{Hz}$ $f = 1700\,\text{Hz}$

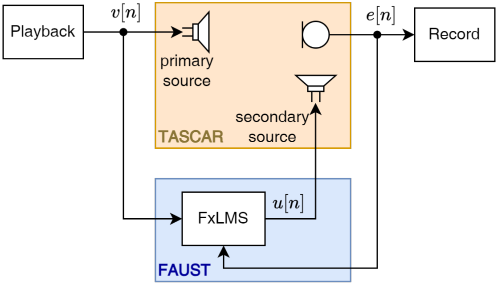
Spatial coherence - meeting room (4ch)



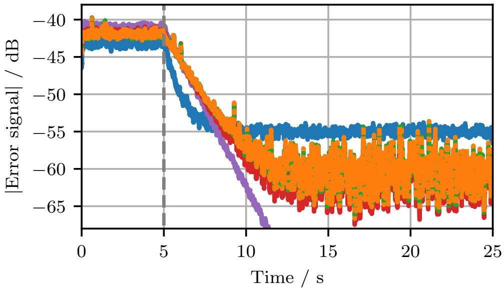
$f = 300\,\mathrm{Hz}$ $f = 1000\,\mathrm{Hz}$ $f = 1700\,\mathrm{Hz}$

Real-time simulation

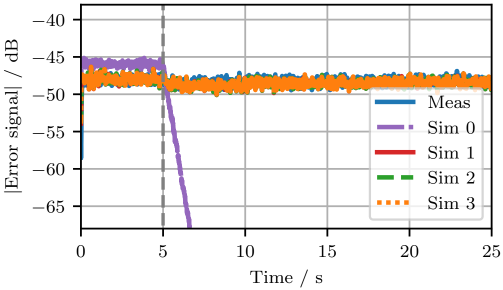
- Feedforward ANC as example
  - Disturbances emitted by primary source
  - Play antinoise signal to cancel noise at listening position
  - Antinoise generated by adaptive filter
- Acoustic simulation in TASCAR
- Signal processing in FAUST (`faust2jack`)
- Latency defined by JACK settings
- Compare adaptation properties to measurement-based co-simulation



Adaptation speed

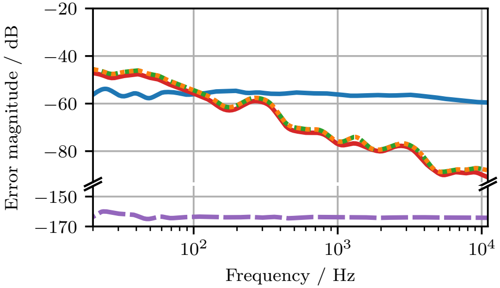


Measurement room

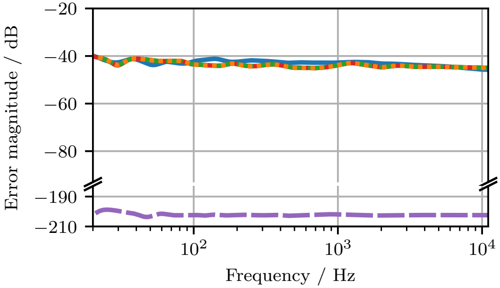


Meeting room

Steady state spectrum



Measurement room



Meeting room

Conclusion

- FAUST and TASCAR can be used in combination to evaluate audio algorithms
- Good accuracy in low reflective environments
- Limited validity in diffuse settings
- Handy tool for quick experiments and pre-studies
- Can't replace physical measurements completely

Outlook

- Time-variant virtualization by using external sensors
- faust2tascar

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Paper

Slides

Code