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Database of single-channel and binaural room impulse responses of a 64-channel loudspeaker array

Abstract

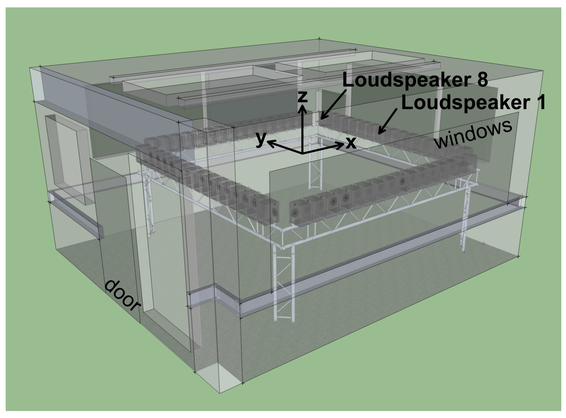
A freely available database of measured single-channel and binaural room impulse responses (RIRs and BRIRs) of a 64-channel loudspeaker array of rectangular shape under varying room acoustical conditions is presented. The RIRs have been measured at three receiver positions for four different room acoustic configurations. Corresponding BRIRs for head-orientations in the range of $\pm 80°$ in $2°$ steps with a KEMAR manikin have been captured for a subset of seven combinations of position and room acoustic configurations. The data is provided in the Spatially Oriented Format for Acoustics (SOFA). It can be used to study the influence of the listening room on multichannel audio reproduction. As an application, RIRs for the synthesis of a sound field by Wave Field Synthesis are shown.

Motivation

The influence of the listening room on audio reproduction is a topic of ongoing research [1]. Established reproduction techniques such as two-channel stereophonic or 5.1 surround sound are regularly subject to room-in-room situations. New multichannel techniques such as Wave Field Synthesis (WFS) [2, 3] require an anechoic environment. Perceptual consequences of the alteration of the sound field by reflections are not fully comprehended. The presented dataset allows for the study of the influence of the listening room on multichannel audio reproduction. Differing from recently published data [4], impulse responses have been captured for different room configurations by changing the setup of absorptive material in the room.

Room and loudspeaker array setup

- Audio Lab of the Institute of Communications Engineering, University of Rostock
- room of shoebox geometry, 5 m $\times$ 5.75 m and 3 m height
- room acoustic conditions:
  - no absorbers in the room,
  - broadband absorbers at walls and in front of the windows, in total: 15.48 m^2,
  - broadband absorbers at walls, ceiling and in front of the windows, in total 20.64 m^2,
  - additional absorbers of pyramid-shaped foam with 7 cm depth (total surface area 8 m^2) placed below the broadband absorbers at the walls and in front of the remaining window surfaces.
- loudspeaker array:
  - 64 loudspeakers Neumann KH 120 A
  - mounted on a square truss construction with edge length 4 m
  - mean loudspeaker spacing 23.4 cm



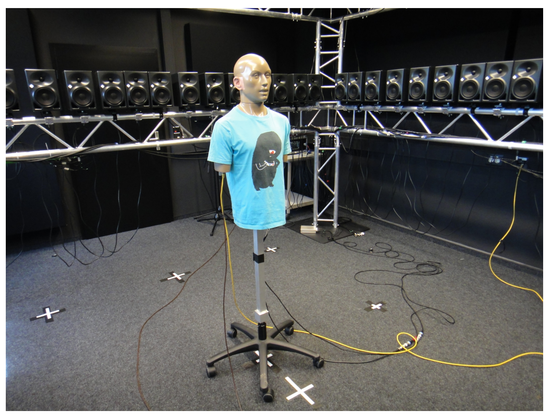


Figure: Left: Loudspeaker array in listening room with broadband absorbers (grey cuboids) at walls and ceiling. Right: KEMAR manikin during measurement.

Measurements

- BRIRs have been aquired with a KEMAR manikin 45BA with large ears (type KB0065 and KB0066) and G.R.A.S. 40AO pressure microphones. The head of the manikin was rotated horizontally above the torso from $\pm 80°$ in $2°$ steps.
- RIRs have been measured with an omnidirectional 1/4" microphone iSEMcon EMX-7150
- linear sine sweeps with bass emphasis of 2^{17} (BRIRs) and 2^{18} (RIRs) samples length at sampling rate 44.1 kHz
- receiver positions at array centre, room centre and one off-centre position
- RIRs available for all combinations of receiver position and absorber configuration, BRIRs only for a subset of these combinations
- additional measurement with an omnidirectional source: reverberation time of the room for all absorber setups

Table: Measured combinations of receiver positions and absorber configurations for BRIRs

	no absorbers	without ceiling absorbers	all broadband absorbers	additional absorbers
centre of room			×	
centre of array	×	×	×	×
off-centre position	×		×	

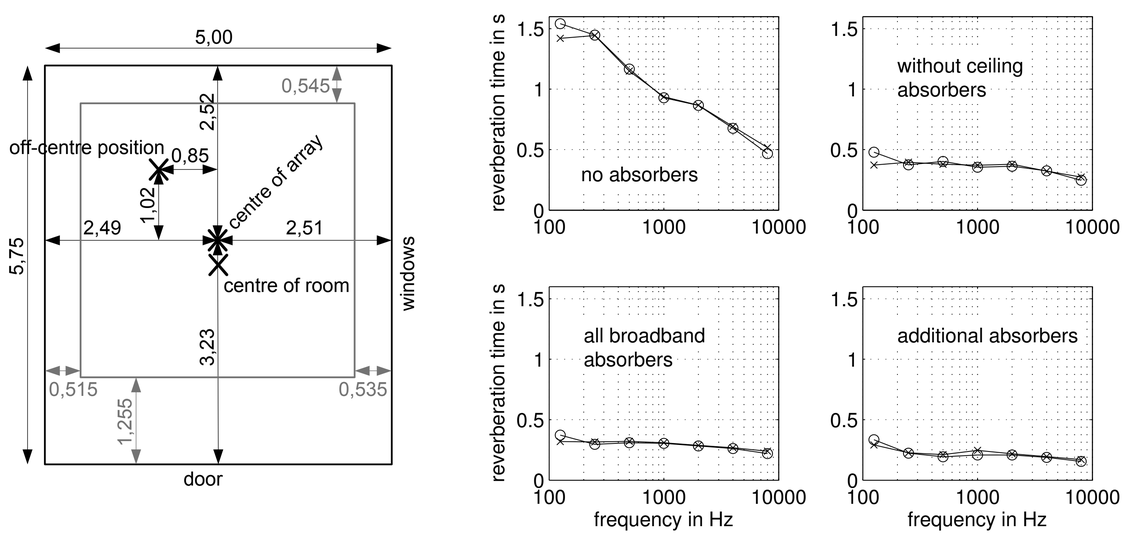


Figure: Left: Loudspeaker array in room (grey lines) and measurement positions, all distances in metres. Right: Reverberation times (RT) in octave bands for different absorber configurations. Crosses: RT obtained with an omnidirectional source, circles: RT for the synthesised room impulse response at the array centre for a WFS point source at $\mathbf{x}_{\text{ps}} = (-2.72,\ 0.09,\ 0)$ m.

Application example

The measured RIRs have been used to synthesise a point source with WFS. The discretisation of the array leads to spatial aliasing artefacts that arrive after the first wave front. Each additional pulse can be attributed to one of the loudspeakers involved in the synthesis.

Synthesised RIRs for the room configurations without absorbers and with broadband plus additional absorbers exhibit considerably different decay rates. Close inspection of the waveform for the setup with additional absorbers reveals an amplitude modulation of 8 Hz in the lower part of the decay caused by a beat of two room modes (60 and 68 Hz).

The reverberation times of the synthesised RIRs do not differ considerably from the reverberation time of the room acquired with an omnidirectional source except for a slight increase at low frequencies.

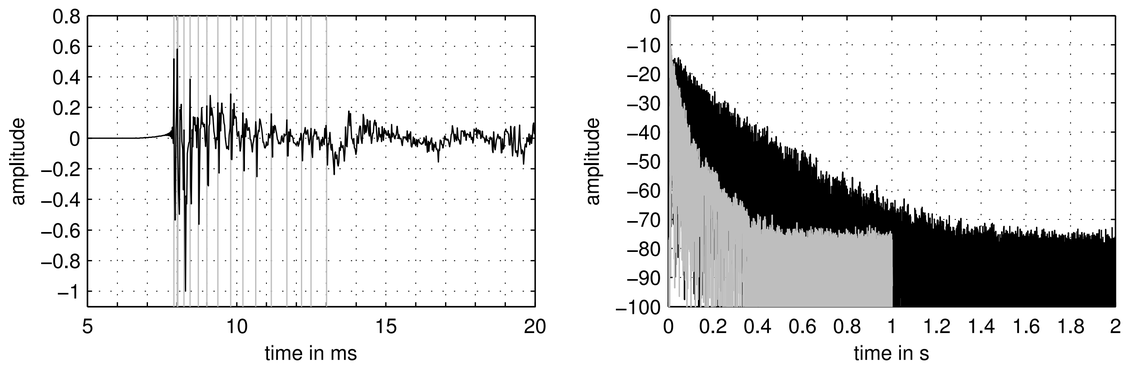


Figure: Synthesised RIRs at the array centre for a virtual point source by WFS at $\mathbf{x}_{\text{ps}} = (-2.72,\ 0.09,\ 0)$ m. Left: Start of synthesised RIR with all broadband absorbers installed. Grey lines indicate arrival times of spatial aliasing artefacts. Right: Complete synthesised RIRs. Black: without absorbers at walls or ceiling, grey: with broadband and additional absorbers

Free database

The data is freely available for download at

http://dx.doi.org/10.14279/depositonce-87

under the *Creative Commons Attribution-NonCommercial-ShareAlike 4.0* license. It is published in the Spatially Oriented Format for Acoustics (SOFA) [5].

References

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[3] Sascha Spors, Rudolf Rabenstein, and Jens Ahrens. The theory of wave field synthesis revisited. In *Proc. 124th AES Conv.*, Amsterdam, the Netherlands, 2008.

[4] Frank Melchior, David Marston, Chris Pike, Darius Satongar, and Yiu W. Lam. A library of binaural room impulse responses and sound scenes for evaluation of spatial audio systems. In *Proc. 40th German Annual Conf. on Acoustics (DAGA)*, Oldenburg, Germany, 2014.

[5] AES69. *AES standard for file exchange - Spatial acoustic data file format.* Audio Engineering Society, 2015.