Perception and evaluation of sound fields

Hagen Wierstorf[1], Sascha Spors[2], Alexander Raake[1]

[1] Assessment of IP-based Applications, Technische Universität Berlin
[2] Institute of Communications Engineering, Universität Rostock

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Introduction

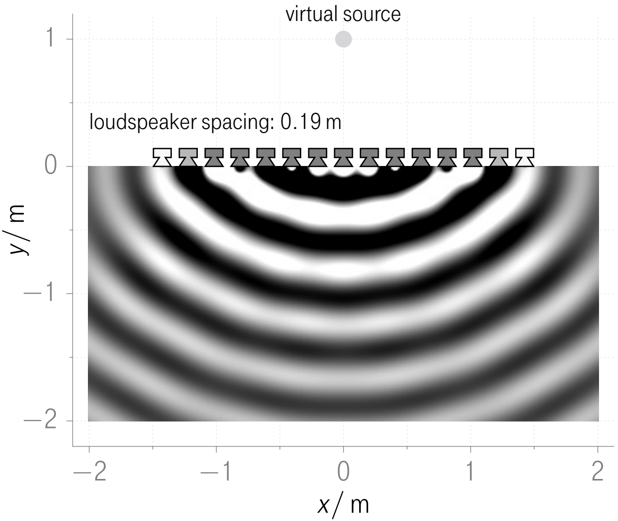
How to assess and model the perception of a sound field?

Why to assess and model the perception of a sound field?

This will be discussed with the example of localization

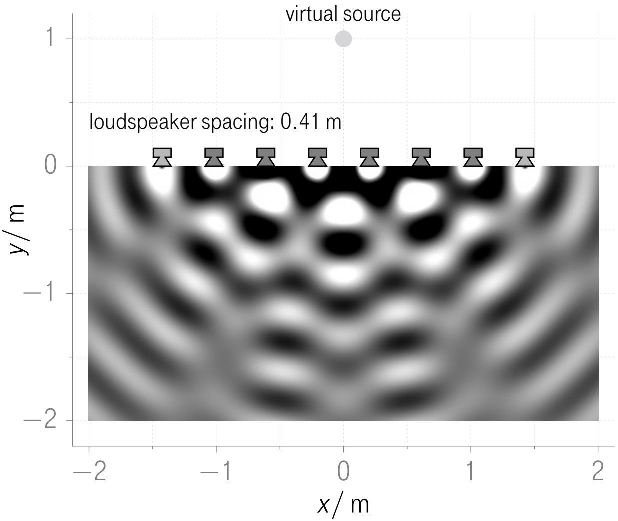
Sound Field Synthesis

physically motivated synthesis



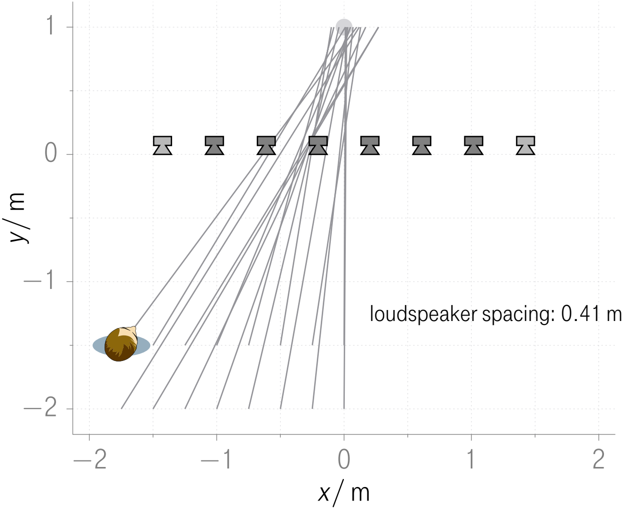
Sound Field Synthesis

psychoacoustically motivated synthesis



Localization within a sound field

listener experiments



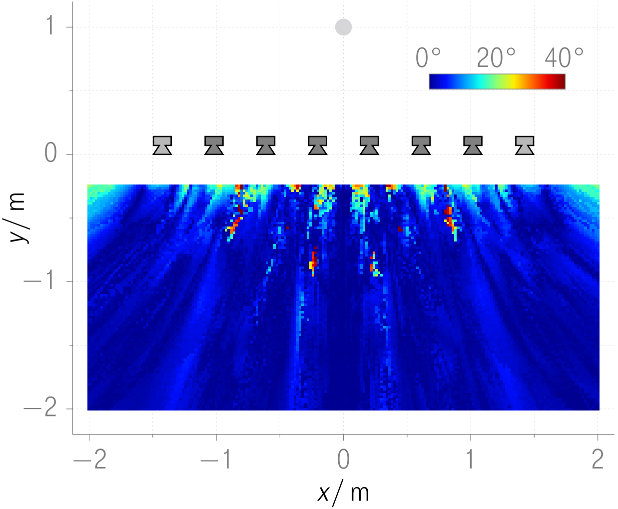
Localization within a sound field

definition

localization error := deviation of the direction of the auditory event from the direction of the sound event

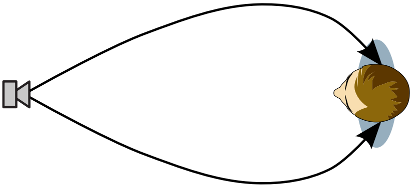
Localization within a sound field

binaural modelling



Binaural synthesis

virtual sources



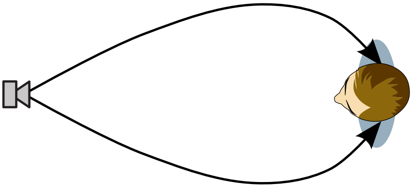
- connection between sound field synthesis and psychoacoustics (Völk, 2008)
- dynamic binaural synthesis via head tracker
- transparent with individual HRTFs (Langendijk, 2000)

Völk et al. (2008), *Simulation of wave field synthesis*, Acoustics

Langendijk und Bronkhorst (2000), *Fidelity of three-dimensional-sound reproduction using a virtual auditory display*, JASA

Binaural synthesis

virtual sources



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Binaural synthesis

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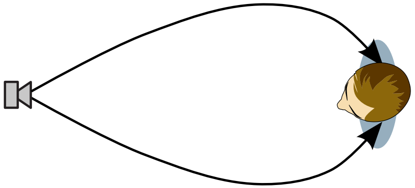

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Binaural synthesis

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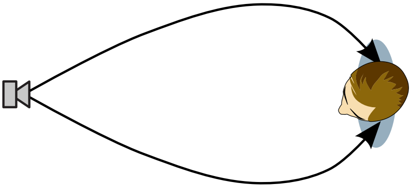

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Binaural synthesis and localization

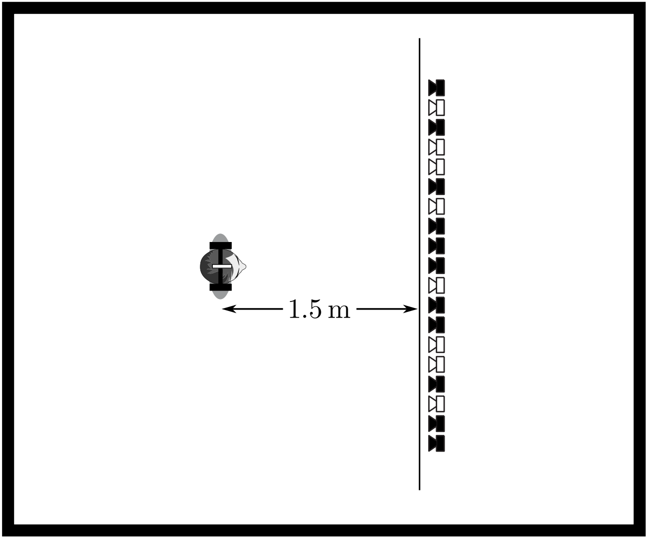
real vs. virtual sources

- localization error is between 1°-5° for the horizontal plane for real and virtual sources (Makous 1990, Hess 2004, Bronkhorst 1995, ...)
- it varies with different experimental methods (Majdak 2008)
- it is the same with individual HRTFs as for real sources, but slightly larger for non-individual HRTFs (Seeber 2003)

Makous and Middlebrooks (1990), *Two-dimensional sound localization by human listeners*, JASA
Hess (2004), *Influence of head-tracking on spatial perception*, 117th AES
Bronkhorst (1995), *Localization of real and virtual sound sources*, JASA
Majdak et al. (2008), *The Accuracy of Localizing Virtual Sound Sources: Effects of Pointing Method and Visual Environment*, 124th AES
Seeber (2004), *Untersuchung der auditiven Lokalisation mit einer Lichtzeigermethode*, Technische Universität München

Localization of real and virtual sources

apparatus



Localization of real and virtual sources

apparatus

Localization of real and virtual sources

method

- head-pointing method with laser pointer mounted on the head (Makous 1990)
  $\Rightarrow$ listener has to face the source, smallest human lateralisation error (Mills 1958)
  $\Rightarrow$ laser pointer gives visual feedback and enhances the cooperation with the motor system (Lewald 2000)
- white noise pulses 700 ms long, 300 ms pause
- 11 subjects, 11 loudspeakers
- 5 repetitons for each condition and loudspeaker position
- 3 conditions: real loudspeaker, anechoic HRTF, room HRTF

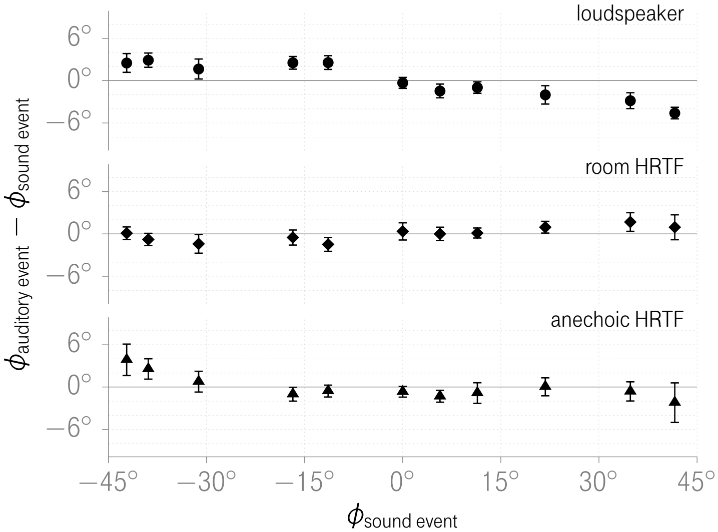
Makous and Middlebrooks (1990), *Two-dimensional sound localization by human listeners*, JASA
Mills (1958), *On the minimum audible angle*, JASA
Lewald et al. (2000), *Sound localization with eccentric head position*, Behav Brain Res

Localization of real and virtual sources

room HRTFs

Results

mean signed error + 95% confidence interval



Results

summary

	Loudspeaker	room HRTF	anechoic HRTF
unsigned error / °	2.4 ±0.59	1.5 ±0.26	2.0 ±0.56
standard deviation / °	2.2 ±0.15	2.4 ±0.28	3.8 ±0.30
time / s	3.5 ±0.65	3.7 ±0.55	5.5 ±1.72

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Conclusion

Why to assess and model the perception of a sound field?

Sound field synthesis methods are more psychoacoustically motivated than considered.

Localization and coloration still not fully understand.

How to assess and model the perception of a sound field?

With binaural synthesis.

- full control of stimuli reaching the listener or a auditory model
- every position and loudspeaker array possible
- not fully transparent, but localization with anechoic HRTFs feasible

Questions?

http://audio.qu.tu-berlin.de/