4aAAd2

Binaural reproduction of self-generated sound in virtual acoustic environments

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MOTIVATION

- Interaction between the user and the virtual acoustic environment (VAE) is of increasing interest (e.g. [1])
- But what about interaction by means of self-generated sound?

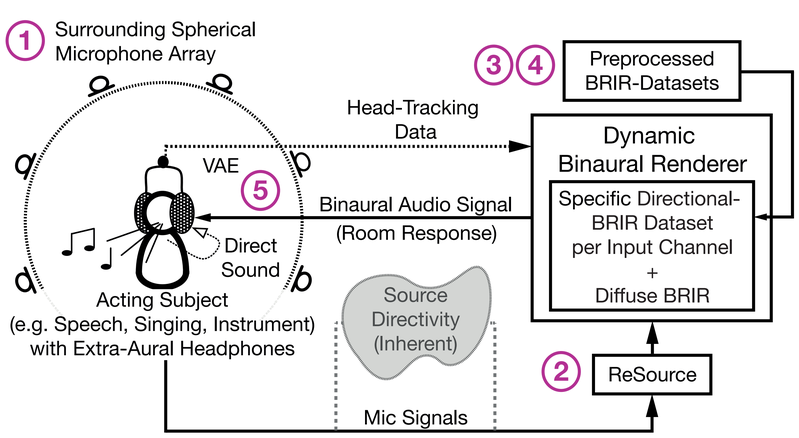
Self-generated sound

- Organic signals (speech, singing, handclaps)
- Interactive sound (playing an instrument)

Benefits for VAEs

- New possibilities for natural interaction with the VAE
- Possibly enhanced presence and immersion [2][3]

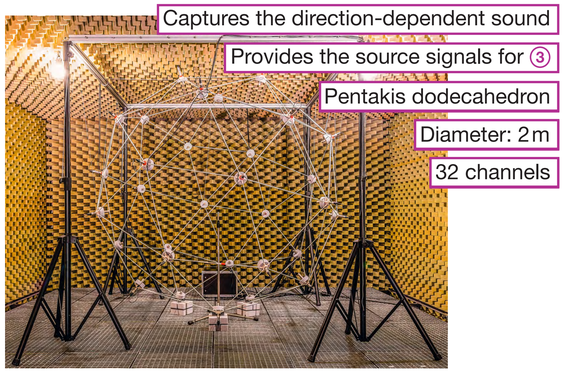
BASIC IDEA



- **Reactive VAE:** Real-time system which captures the self-generated sound, feeds it back into the virtual room, and provides the acoustic response to the actions of the user
- **Key features of the reactive VAE:**
  - Room-related reproduction of self-generated sound
  - Considers the dynamic directivity of the sound source
  - Generally works with any arbitrary sound source
- **Technical conditions:**
  - Headphone-based (extra-aural headphones)
  - Dynamic binaural synthesis

IMPLEMENTATION

① Surrounding spherical microphone array



② ReSource module

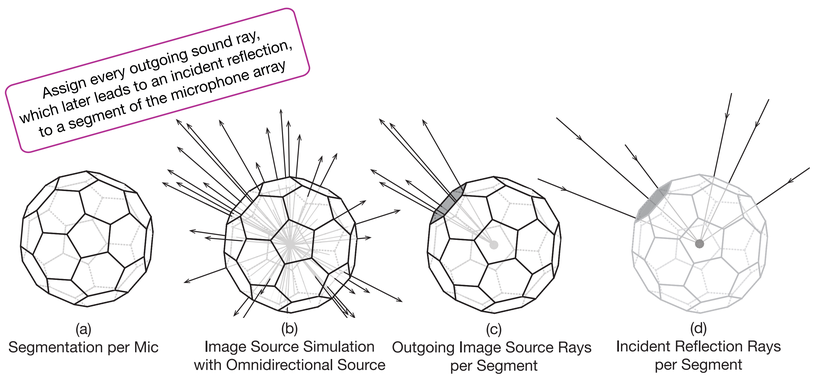
- C++ module providing the source signal for ④
- Averages the power spectra of all microphone signals

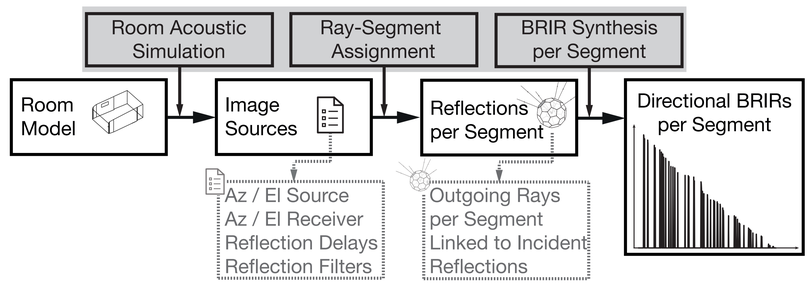
$$S(n,k) = \sqrt{\sum_{i=1}^{N} w_i |(X_i(n,k)|^2}$$

- Derives an adaptive filter by comparing $S(n,k)$ with $X_i(n,k)$
- Continually filters the signal from microphone i so that it matches the spectrum $S(n,k)$ and sends this to the output

③ Directional BRIRs

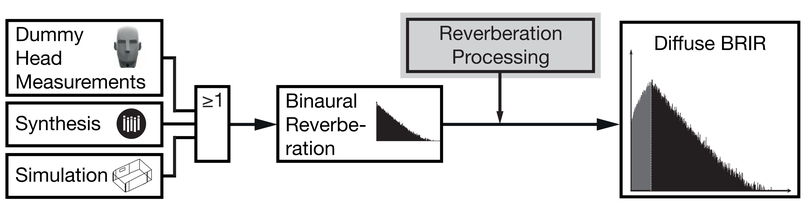
- Set of direction-dependent room responses per channel
- Based on image-source simulation with RAVEN [4]
- Matlab toolbox for assignment and actual synthesis





④ Diffuse BRIR

- One specific BRIR describing the diffuse sound field
- Based on measurements, synthesis, or simulation
- Matlab toolbox for reverberation processing



⑤ Further signal processing

- Headphone and microphone compensation filters
- Level calibration (ratio direct sound / synthesized response)

CONCLUSION

- Reactive VAE for binaural reproduction of self-generated sound
- Captures and processes the dynamic directivity of the source
- Possible uses: practice room, interactive VR, research tool
- Recent work: technical evaluation, improvement of ReSource
- Future work: experiments concerning the influence of self-generated sound on human perceptual processes

REFERENCES

[1] S. Pelzer, L. Aspöck, D. Schröder, and M. Vorländer, "Interactive Real-Time Simulation and Auralization for Modifiable Rooms," Building Acoustics, 21(1), 65–74 (2014).
[2] C. Pörschmann and R. S. Pellegrini, "3-D Audio in Mobile Communication Devices: Effects of Self-Created and External Sounds on Presence in Auditory Virtual Environments," Journal of Virtual Reality and Broadcasting, 7(11), 3–11 (2010).
[3] R. Nordahl and N. C. Nilsson, "The Sound of Being There: Presence and Interactive Audio in Immersive Virtual Reality," in The Oxford Handbook of Interactive Audio, New York, USA: Oxford University Press, (2014).
[4] D. Schröder and M. Vorländer, "RAVEN: A Real-Time Framework for the Auralization of Interactive Virtual Environments," in Proceedings of Forum Acusticum, 1541–1546 (2011).

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