

Master Thesis

Sound Externalization: Influencing Factors and Enhancement Methods

Sound externalization, i.e., the perception that a sound source is outside of the head, is a psychoacoustic phenomenon that has been intensively researched, especially since the introduction of binaural technology and binaural reproduction [1]. Sound externalization is a key requirement for binaural rendering applications in music production, such as the virtual representation of multi-loudspeaker setups (e.g., 5.1 surround or Dolby Atmos) over headphones. However, perceived externalization is heavily influenced by various acoustic factors, such as spectral cues or reverberation [1-4], as well as by other non-acoustic multimodal factors, such as head movements or vision [1]. Distorted, impaired, or erroneous cues can lead to a decrease or collapse of perceived externalization, resulting in undesired in-head localization.

This master thesis is a cooperation with Dear Reality GmbH (Düsseldorf, Germany). The goal of the thesis is to (a) investigating acoustic factors that influence the perceived externalization of virtual multi-loudspeaker setups, (b) find out the importance of the different acoustic factors on perceived externalization, (c) develop methods and algorithms to enhance the perceived externalization of virtual multi-loudspeaker setups without temporal impairments or coloration artifacts (cf., [5]), and (d) perform a listening experiment investigating the externalization enhancement methods. The work is expected to contribute to the development of the dearVR MONITOR audio plugin [6], a tool for binaural reproduction of multi-loudspeaker setups in a virtual mixing room.

Literature

- [1] Best, V., Baumgartner, R., Lavandier, M., Majdak, P., & Kopco, N. (2020). Sound Externalization: A Review of Recent Research. *Trends in Hearing*, 24, 1–14. <https://doi.org/10.1177/2331216520948390>
- [2] Begault, D. R., Wenzel, E. M., & Anderson, M. R. (2001). Direct Comparison of the Impact of Head Tracking, Reverberation, and Individualized Head-Related Transfer Functions on the Spatial Perception of a Virtual Speech Source. *Journal of the Audio Engineering Society*, 49(10), 904–916.
- [3] Catic, J., Santurette, S., & Dau, T. (2015). The role of reverberation-related binaural cues in the externalization of speech. *Journal of the Acoustical Society of America*, 128(2), 1154–1167. <https://doi.org/10.1121/1.4928132>
- [4] Li, S., Schlieper, R., & Peissig, J. (2019). The Role of Reverberation and Magnitude Spectra of Direct Parts in Contralateral and Ipsilateral Ear Signals on Perceived Externalization. *Applied Sciences*, 9(3), 460. <https://doi.org/10.3390/app9030460>
- [5] *Colorless Binaural Externalization Processing Demonstration*. Retrieved April 14, 2023, from <https://www.chrislandschoot.com/binaural-externalization>
- [6] *dearVR MONITOR*. Retrieved April 14, 2023, from <https://www.dear-reality.com/products/dearvr-monitor>

Requirements

Basic knowledge of psychoacoustics of spatial hearing, (parametric) binaural rendering, and audio signal processing in Python or Matlab; Basic knowledge or willingness to learn tools such as py-BinSim, Unreal Engine, or Unity to implement the listening experiment.

Supervision

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