Audio Communication Group

Prof. Dr. Stefan Weinzierl

Master Thesis

HRTF Measurements in Multi-Loudspeaker Setups

Recent advances in post-processing and interpolation (or spatial upsampling) of head-related transfer functions (HRTFs) have made it possible to obtain high-quality full-spherical HRTF sets based on sparse measurements in reverberant conditions, i.e., HRTF measurements with only a small number of captured directions in normal rooms [1-5]. However, most of the post-processing and interpolation methods have been evaluated in laboratory rather than real-world conditions.

This thesis aims to bridge the gap between laboratory setups and real-world applications. The recent industry-driven trend towards spatial music production in Dolby Atmos has led to a significant increase in the number of control rooms with multi-loudspeaker setups, and at the same time to a sharp increase in the demand for accurate headphone-based binaural reproduction of multichannel audio for mixing and mastering engineers, as consumers typically listen to spatial music over headphones. However, engineers often complain about missing spatial accuracy and externalization in the binaural decoding of Dolby Atmos productions, which could be due to the use of non-individual generic HRTFs. Therefore, several companies offer photogrammetry-based generation of individualized HRTFs that can be integrated into their binaural decoders and may improve the reproduction to some extent. However, the often-available multi-loudspeaker setup in the engineer's control room is an ideal starting point for *acoustic measurements* of sparse individual HRTFs, which can then be used to generate a full-spherical dense HRTF set for the engineer. The HRTF measurement could be seamlessly integrated into the calibration measurements, leaving the engineer with a calibrated multi-speaker setup and high quality individual HRTFs. The purpose of this thesis is to investigate the feasibility of obtaining dense individual HRTFs from measurements in control rooms with multi-loudspeaker setups, to compare the performance of different post-processing and interpolation approaches, and to recommend the best approach to use for optimal results.

Literature

[1] Pörschmann*, C., Arend*, J. M., & Brinkmann, F. (2019). Directional Equalization of Sparse Head-Related Transfer Function Sets for Spatial Upsampling. IEEE/ACM Transactions on Audio, Speech, and Language Processing, 27(6), 1060–1071, (*equal contributions). https://doi.org/10.1109/TASLP.2019.2908057

[2] Pörschmann, C., & Arend, J. M. (2019). Obtaining Dense HRTF Sets from Sparse Measurements in Reverberant Environments. Proc. of the AES International Conference on Immersive and Interactive Audio (IIA), York, UK, 1–10.

[3] Arend, J. M., Brinkmann, F., & Pörschmann, C. (2021). Assessing Spherical Harmonics Interpolation of Time-Aligned Head-Related Transfer Functions. Journal of the Audio Engineering Society, 69(1/2), 104–117. https://doi.org/10.17743/jaes.2020.0070

[4] Bau, D., Arend, J. M., & Pörschmann, C. (2022). Estimation of the Optimal Spherical Harmonics Order for the Interpolation of Head-Related Transfer Functions Sampled on Sparse Irregular Grids. Frontiers in Signal Processing, 2(884541), 1–13. https://doi.org/10.3389/frsip.2022.884541

[5] Arend, J. M., Pörschmann, C., Weinzierl, S., & Brinkmann, F. (2023). Magnitude-Corrected and Time-Aligned Interpolation of Head-Related Transfer Functions. arXiv. https://doi.org/10.48550/arXiv.2303.09966

Requirements

Basic knowledge of spatial hearing, HRTFs, and audio signal processing in Matlab and Python.

Supervision

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