Fachgebiet Audiokommunikation
Prof. Dr. Stefan Weinzierl

Master Thesis

Using BEM to calculate voice directivity patterns

The human voice is an essential means of communication between individuals. Among its characteristics, the directivity is a crucial point. It is the acoustical link between the performer and the environment in the sense that the voice directivity affects the distribution of acoustic energy in the room and thus the response of the room at the talker's ears. However, measurements and simulations of voice directivity have been seldom performed, especially not over the whole frequency range. The experience gained in the spatial audio community with successful simulations of the head related transfer functions (HRTF) is a promising way to calculate detailed voice directivity patterns.

Recent research [1] at the Audio Communication Group investigated how singers adapt to different rooms, or which influence room acoustics has on singing voice. Part of this study was conducted in an anechoic chamber, where the singers were presented with a collection of virtual rooms. These virtual acoustic scenes were created using measured data of 3D directivity of human voice. Because this measured data presents limited angular resolution, it would be interesting to obtain a finer spatial resolution.
In the spatial audio community, where the HRTFs are of primary importance for the listener, a recent study [2] has compared the resolution of several scanning system applied to the ears of an artificial head. The influence of those resolution levels on the quality of the HRTF calculated by a BEM solver [3] based on this scanned data, was analysed. This BEM solver yields robust HRTF calculation using the acoustic reciprocity principle, i.e. the sound sources are placed at the eardrums of the head 3D model and the radiated acoustic field is calculated all around the head. The obtained transfer functions are then considered the other way around, with sound sources distributed in space and a receiver at each eardrum.

The goal of this project is to estimate the influence of various mouth shapes on the radiated sound field and the obtained directivity patterns. In this perspective, different head meshes will be designed including different simplified or realistic mouth shapes. Directivity calculations will be performed for various mouth geometries, corresponding to various spoken phonemes. The MESH2HRTF BEM solver will be used to calculate the sound field radiated out of the heads designed with these different mouth shapes. Results will be analysed by means of comparisons to measured data if available, or to a reference mouth geometry.

Literature

[1] P. Luizard, J. Steffens, and S. Weinzierl, "Adaptation of singers to physical and virtual room acoustics," in *Proc. International Symposium on Room Acoustics, Amsterdam, The Netherlands, 15-17 September*, 2019.

[2] M. Dinakaran, F. Brinkmann, S. Harder, R. Pelzer, P. Grosche, R. R. Paulsen, and S. Weinzierl, "Perceptually motivated analysis of numerically simulated head-related transfer functions generated by various 3d surface scanning systems," in *2018 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, IEEE, 2018, pp. 551–555.

[3] H. Ziegelwanger, W. Kreuzer, and P. Majdak, "Mesh2hrtf: An open-source software package for the numerical calculation of head-related transfer functions," in *22nd International Congress on Sound and Vibration*, 2015.

Requirements

- Well grounded knowledge in signal processing
- Basic knowledge in virtual acoustics and spatial audio
- Interest for numerical experiment

Supervisors

Dr Paul Luizard	E-N 150	paul.luizard@campus.tu-berlin.de
Dr Fabian Brinckmann	E-N 150	fabian.brinckmann@tu-berlin.de