Fachgebiet Audiokommunikation
Prof. Dr. Stefan Weinzierl

Master Thesis

Development and evaluation of a speaking and listening artificial head to study the directivity of human voice

In the framework of a research project going on at the Audio Communication Group of TU-Berlin on the faculty of adaptation of singers to different room acoustics, the directivity of human voice 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 to the singer's ears. Studying this relationship in a systematic manner involves rigorous, repeatable measurements which can be achieved by means of an artificial head.

Previous research investigated sound radiation from human and artificial mouths. The human directivity for various vowels at different sound levels was investigated [1] by recording a professional singer in an anechoic chamber with a circular microphone array in the horizontal plane. In the context of lyrical performance [2], opera singers were recorded in an anechoic chamber and a recital hall using different singing styles. Results show that the singers are able to change their directivity by changing the spectral emphasis of their voices through their formants. The sound directivity of a replica of the human vocal tract has been measured in the horizontal plane and modeled by means of the multimodal theory which allows for modeling the propagation of higher order acoustical modes with respect to the waveguide geometry [3]. This shows that it is possible to build a model of sound directivity according to the vowel that is pronounced by the speaker, i.e. rearranging the formants. Finally, certain artificial heads provide the possibility to change their ears, as the FABIAN head [4] developed at TU-Berlin.

The first step of this project is the construction of the artificial head, based on a well documented piece (e.g. Neumann KU100), including the ability to change its mouth and ears. Several mouth geometries representing different vowels will be built and the ears will be borrowed among the collection of the Audio Communication Group so that various HRTF can be considered. The materials to be employed will be discussed, with the possibility to use 3D-printing. The second step is the assessment and documentation of the device. Directivity measurements will be performed for each mouth in the horizontal plane (varying azimuth angle) and possibly for various elevation angle values. In addition, an analytical model of the sound directivity can be developed, e.g. based on the multimodal theory, and further compared to the measurements.

Literature

[1] B. Katz and C. d'Alessandro, "Directivity measurements of the singing voice," in *International Congress on Acoustics, Madrid, Spain*, 2007, 6p.

[2] D. Cabrera, P. J. Davis, and A. Connolly, "Long-term horizontal vocal directivity of opera singers: Effects of singing projection and acoustic environment," *Journal of Voice*, vol. 25, no. 6, e291–e303, 2011.

[3] R. Blandin, A. Van Hirtum, X. Pelorson, and R. Laboissière, "Influence of higher order acoustical propagation modes on variable section waveguide directivity: Application to vowel[α]," *Acta Acustica united with Acustica*, vol. 102, no. 5, pp. 918–929, 2016.

[4] A. Lindau, S. Weinzierl, and H. Maempel, "Fabian-an instrument for software-based measurement of binaural room impulse responses in multiple degrees of freedom," *24. Tonmeistertagung*, 2006.

Requirements

- Well grounded knowledge in acoustics
- Basic knowledge in sound radiation and spatial hearing
- Experience with Matlab software
- Will and skills in hand-working

Supervisors

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