Audio Communication Group / Numerical Fluid Dynamics Group

Prof. Dr. Stefan Weinzierl / Dr. Mathias Lemke

Master Thesis

Modeling of head-related transfer functions using an immersed boundary method in finite difference time domain simulations

Head-related transfer functions describe the free-field sound transmission to the ears and thus contain all cues that are needed to simulate spatial hearing. HRTFs are thus one of the fundamental ingredients in most virtual and augmented reality systems. One possible way of obtaining HRTFs is to numerically solve the Euler or wave equation in the time or frequency domain based on a 3D mesh of a head.
Finite difference time domain (FDTD) simulations are a suitable method to simulate acoustic environments with high accuracy. One of the most challenging parts of FDTD is the modeling of accurate acoustic boundary conditions. Recently, immersed boundary (IB) methods have shown good results to approximate realistic boundaries (Reiss 2022, Lemke and Reiss 2022). The developed IB method manipulates the governing equation by adding a volume fraction and a linear friction term (Darcy's law).
In this project, a simulation within an existing FDTD code to model HRTFs shall be developed. Models of human heads are present. The models must be included in the FDTD framework and the parameters of the immersed boundaries fitted to receive realistic acoustic impedances. The results will be compared with BEM simulations (mesh2HRTF, https://github.com/Any2HRTF/Mesh2HRTF) and measured HRTFs.

Literature

Reiss, J. (2022): “Pressure-tight and non-stiff volume penalization for compressible flows.” In: Journal of Scientific Computing, 90(86):1–29.
Lemke, M.; Reiss, J. (2022), “Approximate acoustic boundary conditions in the time-domain using volume penalization.” arXiv.org.

Requirements

Knowledge of acoustics and wave-based numerical simulations. Programming knowledge, preferably in Fortran and Python or Matlab. Basic Linux knowledge.

Supervision

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