Dissertation

Numerical simulation method for a precise calculation of the human phonation under realistic conditions

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Univ.Prof. Dipl.-Ing. Dr.techn. Manfred Kaltenbacher
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by

Dipl.-Math. Stefan Zörner
Mat.Nr. 0861599
Wilhelminenstr. 34/6
1160 Wien

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Stefan Zörner

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Abstract

The human voice is essential for day-to-day communication. Consequently, impairment of speech, known as dysphonia, may have a significant impact on a person's career and possible even their social life. To understand the mechanisms and effects that distinguish a healthy voice from an unhealthy one, the phonation process itself must be understood. In the case of human phonation, computer aided simulation is a useful tool, as it is non-invasive. However, if the target is to achieve an exact replica, the complex nature of the phonation process pushes the bounds of current research and also demands high computational capacities. Simplifications in the model are therefore necessary to counteract these problems. This thesis analyses different kinds of simplifications and the error which is caused by the corresponding model. These investigations were carried out with the simulation tool *CFS++*, and extended to allow for a precise simulation of the interaction between air flow and structural (vocal fold) vibration. Furthermore, it is also capable of determining the acoustic sources and propagation of aeroacoustical and vibration-induced sound.

Firstly, the impact of the geometrical shape of the vocal folds is studied. Thereby, a fully coupled fluid-structure simulation is employed to compare two different kinds of vocal fold models. Moreover, investigations have been performed if the coupling of fluid and structure can be reduced to a pure flow simulation. The vocal fold vibration is thereby imitated by special boundary conditions. In addition, different aeroacoustic analogies are analysed and compared. These acoustic methods also permit a precise location of the sound sources during phonation. We also present and enhancement of the model, which integrates and considers the acoustic impact of the vocal tract, to calculate for instance the sound field of a vowel.

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