



Friedrich-Alexander-Universität
Erlangen-Nürnberg



MASTER THESIS

To students within
Medical Engineering / Medizintechnik,
Computer Science/ Informatik / Artificial Intelligence,
Data Science, LifeScience, Computational engineering

**Hals-Nasen-Ohren-Klinik
Kopf- und Halschirurgie**
Direktorin: Prof. Dr. med. Sarina Müller, MHBA
**Abteilung für
Phoniatrie und Pädaudiologie**
Prof. Dr.-Ing. Michael Döllinger

Telefon: 09131 85-33814
Fax: 09131 85-32687
Michael.doellinger@uk-erlangen.de
Waldstr. 1, 91054 Erlangen
CICERO-Gebäude: Raumerstr. 1a

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Title: Machine learning based modelling of vocal fold dynamics toward real-time voice simulation

Background: Modelling voice production is computationally expensive. One way to reduce the computational costs is to adopt an eigenmode-based formulation of the system equations, as described in Zhang (2015, 2017), which significantly improves computational efficiency. This formulation requires calculating the in vacuo eigenmodes of the vocal folds which then will be used in voice production simulation. To further reduce the computational costs toward real-time voice synthesis, it is desirable to develop a computationally efficient eigenvalue solver to calculate the in vacuo eigenmodes

Current state: In our past research project (i.e. the previous MA thesis: Khasawneh et al., 2026), we developed a physics-informed neural network (PINN) to predict in vacuo vocal fold eigenmodes and eigenfrequencies in a two-step process. This PINN was able to predict the lower-order eigenmodes accurately, but the accuracy decreases toward higher-order eigenmodes. Currently, a PINN was developed for every single eigenmode. As a result, the model does not provide information on the order of the eigenmodes, which can be a problem when potential eigenmode cross-over occurs. Also, the eigenmodes may not be orthogonal to each other.

Additionally, to improve the computational efficiency of calculating vocal fold eigenmodes, an open-source eigenvalue FEM solver with parallelization capability was developed. The accuracy of this model, however, needs to be further improved.

Research questions: The first goal is to improve the PINN performance by adding additional constraints on the eigenmode orthogonality, increasing the size of training data, and predicting multiple eigenmodes together instead of separately. A second goal of this project is to improve the FEM solver by implementing a higher-order grid mesh

Methods & goals:

1. Become familiar with laryngeal biomechanics and the mathematics of eigenvalue problems;
2. Read previous Master thesis (will be provided by us), published corresponding paper (Khasawneh et al., 2026) and become familiar with existing source code.
3. Implement higher-order mesh in the open-source FEM eigenvalue solver, and optimize the code for parallelization;

4. Perform FEM eigenvalue simulation to obtain additional training data for PINN training;
5. Modify the current PINN architecture to develop a single and comprehensive PINN to predict multiple eigenmodes;
6. Modify the PINN architecture to predict the eigenmodes and eigenfrequencies simultaneously;
7. Extend the loss function formulation in the PINN to include volumetric deformation patterns for improved accuracy;
8. Goal is to publish results in a peer-reviewed journal.

The work will be supervised by **Prof. Dr.-Ing. Michael Döllinger** (Member of Department Informatics & AIBE). The thesis is in close **cooperation with Prof. Zhaoyan Zhang** (University of California Los Angeles, UCLA) who will co-supervise the student.

We search for a dedicated and motivated student with

- Very good grades
- Experience in programming language (C++ and Python)
- Very good Mathematical understanding and solid mechanics
- Very good background and knowledge in Machine Learning
- Good written and verbal communication skills in English (cooperation partner is English speaking)

Application: Please send CV and current transcripts.

Contact person: Prof. Dr.-Ing. Michael Döllinger (michael.doellinger@uk-erlangen.de)

References:

1. Al Khasawneh, M., Döllinger, M., Zhang, Z. (2026). Physics-informed neural network for predicting in vacuo vocal fold eigenmodes: A proof of concept study, JASA Express Letters, 6(4), 045202.
2. Zhang, Z. (2015). Regulation of glottal closure and airflow in a three-dimensional phonation model: Implications for vocal intensity control, J. Acoust. Soc. Am., 137(2), 898-910.
3. Zhang, Z. (2017). Toward real-time physically-based voice simulation: An eigenmode-based approach, Proceedings of Meetings on Acoustics, vol. 30, pp. 060002.