Universität Stuttgart

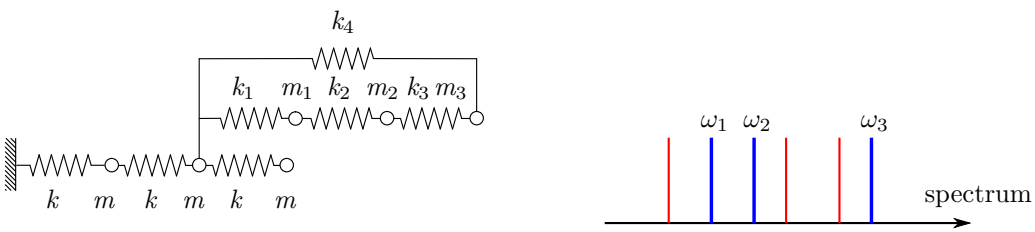
Baustatik und Baudynamik

Master Thesis

Structural design via inverse eigenvalue problems

Prescribing several lowest eigenfrequencies of a structure may be beneficial for avoiding or exploiting resonances. The design of such a structure can be formulated as an inverse eigenvalue problem (IEP), which is a well-known and tractable problem of linear algebra. Newton and semi-smooth Newton methods for the error in the spectrum are popular algorithms among them. Unfortunately, the known methods for IEP may suffer from ill-conditioning and bad convergence. Especially, ill-conditioning is pronounced in the case of two similar eigenfrequencies in the spectrum or when only of partial information about the spectrum is available (number of adjustable parameters is greater than the number of the prescribed eigenfrequencies). Therefore, skillful usage and implementation of the algorithms are important for obtaining robust convergence.

The aim of the thesis is implementation and testing of different methods for inverse eigenvalue problems in structural design. The focus lies in the robustness of fully and partially inverse eigenvalue problems with prescribed system topology.



parameter vector $\mathbf{s} = [k_1, k_2, k_3, k_4, m_1, m_2, m_3]^{\mathrm{T}}$

residual $\mathbf{R}(\mathbf{s}) = [\omega_1 - \omega_1^*, \omega_2 - \omega_2^*, \omega_3 - \omega_3^*]^{\mathrm{T}}$

A mechanical system with current lowest eigenfrequencies $\omega_{1,2,3}$ and the target values $\omega_{1,2,3}^*$. Seven adjustable parameters and a possible residual for a Newton like method are given.

The specific tasks are

- Study of literature
- Implementation of Newton and semi-smooth Newton algorithms for IEP in MATLAB
- Testing and extension of algorithms for better robustness
- Interpretation and documenting of results

Areas of interest

Dynamics, Inverse problems, MATLAB

Literature

Joseph, K. T.: *Inverse Eigenvalue Problem in Structural Design.* In: AIAA journal 30 (1992), pp. 2890–2896.

Shen, W. P., Li, C., & Jin, X. Q.: *A Ulm-like method for inverse eigenvalue problems.* In: Applied Numerical Mathematics (2011), 61, pp. 356–367.