Project Description: Parametric Model Reduction for Damping Optimization

Mechanical structures such a building or bridges are often modeled by control systems of the form

$$\begin{aligned} M\ddot{q}(t) + D\dot{q}(t) + Kq(t) &= B_2 u(t) + E_2 w(t), \\ y(t) &= C_2 \dot{q}(t), \\ z(t) &= H_1 q(t), \end{aligned}$$

where $q(\cdot)$ denotes the displacements of the the masses of the model, $u(\cdot)$ is a control input, and $y(\cdot)$ is an output containing measurements of the velocities. Moreover, $w(\cdot)$ is an input containing external noise, while $z(\cdot)$ is the performance output. Typically, the measurements in $y(\cdot)$ can be used to determine the control $u(\cdot)$ via a feedback law $y(t) = -Gu(t)$, where $G = \operatorname{diag}(g_1, \ldots, g_m)$. Here g_i, $i = 1, \ldots, m$, are the parameters of the controller (i. e., viscosities of the dampers to be placed) which have to be designed, typically in order to make the influence of the noise $w(\cdot)$ onto $z(\cdot)$ as small as possible. One optimization objective is the so-called $\mathcal{H}_\infty$-norm of the transfer function $F(s; g_1, \ldots, g_m) = H_1(s^2 M + s(D + B_2 G B_2^T) + K)^{-1} E_2$. Since the models are often of large size, model reduction techniques are of great importance to accelerate the optimization procedure. Usually, one first reduces the system and then optimizes this reduced system. In this project, I would like to follow a new idea in which the model reduction and optimization are carried out simultaneously. This idea consists of successively improving the reduced order model by incorporating the data obtained during the optimization phase which follows the lines of the method in [1].

Tasks for the intern:

- Make yourself familiar with damping optimization techniques.
- Implement the proposed algorithm and compare it with the other methods.
- Implement and test methods using different optimization criteria. (optional)
- Implement and test heuristics for optimal placement of the dampers. (optional)
- Write a short report of your findings.

References

[1] N. Aliyev, P. Benner, E. Mengi, and M. Voigt. Large-scale computation of $\mathcal{H}_\infty$-norms by a greedy subspace method, July 2016. Submitted for publication.

Contact

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