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Identification of Second-Order Systems from Frequency Response Data

In this talk, we present a data-driven approach to identify second-order systems of the form
\begin{equation}
\begin{array}{rcl}
\mathbf{M}\ddot{\mathbf{x}}(t) + \mathbf{D}\dot{\mathbf{x}}(t)+ \mathbf{K}\mathbf{x}(t) &=& \mathbf{B}\mathbf{u}(t),\qquad
\mathbf{x}(0) = 0,~\dot{\mathbf{x}}(0) = 0, \\
\mathbf{y}(t) &=& \mathbf{C}\mathbf{x}(t).
\end{array}
\end{equation}
These systems typically appear in order to perform various engineering studies, e.g., vibration analysis. The frequency response of the system can be given by the following rational structured function:
H(s) = C$\left(s^2\mathbf{M} + s\mathbf{D} + \mathbf{K}\right)^{-1}\mathbf{B}, which is also known as the transfer function. The frequency response of a system can be measured$
= $\alpha\mathbf{M} + \beta\mathbf{K}$. As a consequence, the identification problem is solved analytically using the frequency data. In the second approach, the Rayleigh damping hypothesis is no longer assumed, and the problem is solved finding low-rank matrices that best fit the given data ensuring the second order structure. Finally, the efficiency of the proposed methods is demonstrated by means of various numerical benchmarks.

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