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Contour integral methods and model order reduction for parametric linear control systems

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In this talk, I present a contour integral method (CIM) for the efficient computation of outputs from parametric linear systems in control form over specified time intervals and under a user-prescribed accuracy. The CIM framework utilises a quadrature rule to approximate the inverse Laplace transform, which is executed along a modified integration contour. First, I discuss the non-parametric case and show how an accurate and extremely fast approximation of the output function can be achieved, without using any reduction approach, just by a suitable construction of the integration contour and the precomputation of small-size matrices. Then I discuss the parametric case and demonstrate how this method integrates effectively with projection-based model order reduction (MOR), where the projection spaces are constructed via a greedy-type algorithm guided by an appropriately derived error estimate, which relies on a suitably defined adjoint problem, and adhering to Hermite interpolation conditions. This methodology significantly reduces computational expenses when evaluating the input-output relations for varied parameters across the parametric domain, as well as for a wide class of input functions and initial conditions sufficiently captured by a low-dimensional subspace. The natural selection of the frequency points and interpolation parameters, together with the ability to target a prescribed time interval for different initial conditions, represents a distinctive feature compared with state-of-the-art methodologies. Finally, the precision and efficacy of the approach are demonstrated by numerical experiments on a range of benchmark test problems for both non-parametric and parametric linear control systems.

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