The Lanczos Tau Framework for Time-Delay Systems

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When modelling a system with internal transport phenomena, a commonly used class of models are time-invariant, linear, dynamical systems subject to delay. As such a model not only depends on its current state, but also on its history, studying its dynamics requires the use of a functional differential equation. For the development of numerical methods, this complication generally implies a need for a discretization scheme. Although Lanczos tau methods were already proposed for FDEs in the 80s, their use appears only limited compared to the collocation strategies popularized in the early 2000s. In this work, we revisit the former by reinterpreting it as a pencil of operators. In doing so, we can make novel connections between this approach, Padé approximation, collocation methods, and ultraspherical methods. To demonstrate the importance of the used discretization scheme, we conclude with an application to the approximation of the H^2-norm, an important system measure in robust control and model order reduction. We note significantly improved convergence rates, and sometimes super convergence, when using certain Lanczos tau methods, motivating our renewed interest in this technique.