Real-valued stability analysis of Runge– Kutta–Chebyshev methods for delay differential equations

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Abstract

In the paper we consider first order stabilized Runge–Kutta–Chebyshev methods (RKCs) application to discrete delay differential equations and perform a linear stability analysis studying the equation

$$\dot{u}(t) = \lambda u(t) + \mu u(t - \tau)$$

with real values of λ and μ. We try two variants of RKCs extension for DDEs: first, suitable for constant delays τ and constant time-steps, and second, with linear interpolation between the time-mesh points. It is shown that delay-independent stability regions in $(\lambda h, \mu h)$ plane are larger if using interpolation. As for ordinary differential equations RKCs have points of stability vanishing along real λ axis. We use damped RKCs to improve the stability regions and find an "optimal" damping factor to maximize the numerical stabiity region coverage of the exact stability domain. All the results are confirmed with numerical simulations.