Probabilistic Runge-Kutta methods for uncertainty quantification of numerical errors in geometric integration

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Abstract:

A novel geometric probabilistic Runge-Kutta method for the integration of dynamical systems is introduced [1]. A careful randomisation of the time steps allows to construct a probability measure over the numerical solution, which provides uncertainty quantification of the error while collapsing to the true solution consistently with respect to traditional error estimates. Being this randomisation of the method intrinsic in the scheme, some geometric properties of Runge-Kutta methods are proved to be conserved in the mean sense by their probabilistic counterpart.

Finally, we show how the new probabilistic integrator qualitatively enhances the solution of an inferential Bayesian inverse problem involving dynamical systems thanks to the uncertainty introduced in the forward solver.

References

[1] A. Abdulle and G. Garegnani, *Random time step probabilistic methods for uncertainty quantification in chaotic and geometric numerical integration*, arXiv preprint arXiv:1801.01340.