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Collocation Time Stepping Methods via Flux Reconstruction Approach

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Recently, there has been a significant international effort to develop high-order Computational Fluid Dynamics (CFD) methods with the goal of incorporating them into design tools for aerospace industries as evidenced by the series of International Workshop on High-Order CFD methods I-V, the TILDA project (Towards Industrial LES/DNS in Aeronautics) supported by European Commission, and various similar projects at universities and research institutions worldwide.

Among these high-order CFD methods for spatial discretization, the flux reconstruction (FR) schemes introduced by this author (Huynh 2007, 2009) have the advantage of simplicity and economy, and have gained significant traction as reviewed in (Huynh, Wang, and Vincent, 2014). For unsteady problems, time stepping methods employed with popular high-order schemes such as discontinuous Galerkin (DG) or FR are typically of explicit Runge-Kutta type.

In this paper, a family of collocation time stepping methods derived via the FR approach is introduced and analysed. These methods are of one-step type, i.e., the solution at time t_n is known and that at t_{n+1} is to be calculated. They are derived using the theory of orthogonal functions and include the well-known Gauss and Radau collocation. The result is a family of time stepping schemes with adjustable dissipation (chosen by the user). Accuracy and stability of these methods are also studied. All schemes discussed are of implicit Runge-Kutta type. These methods have the potential of reducing computing time for the numerical solutions of industrial flow problems.

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