Algebraic multigrid for solution of adjoint equations in compressible aerodynamics

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Abstract

Linear systems arising from linearization of second-order accurate discretizations of compressible Euler and Navier-Stokes equations are often very stiff and their efficient solution is a challenging task.

Based on the experience made with the linear counterpart of the DLR TAU code, available solution approaches, namely geometric multigrid and ILU-based approaches combined with Krylov methods, have certain disadvantages. Although the geometric multigrid approach is memory-efficient, it often demonstrates an unsatisfactory convergence behavior, especially for turbulent test cases. In the same time, the ILU-based approaches demonstrate rather good convergence rates as soon as a high enough ILU decomposition level is employed. However, they tend to become very memory intensive and thus are not always affordable in practice.

In this work, we offer an alternative solution approach based on algebraic multigrid (AMG). Unlike the geometric multigrid, AMG does not explicitely rely on the geometry of the grid. It is therefore a very attractive approach for problems dealing with unstructured grids. Originally developed for scalar elliptic problems, AMG needs to be extended and its components must be properly chosen and adjusted for the approach to be applicable to advection-dominated systems of PDEs. In collaboration with Fraunhofer SCAI, using their AMG software (the SAMG library), we develop a solution approach for the adjoint equations.

We demonstrate application of the suggested solution technique to a range of problems from subsonic Euler equations to transonic Reynolds-averaged Navier–Stokes equations.

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