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Navier-Stokes adjoint accuracy for aeroacoustic flow control and analysis RAMANATHAN VISHNAMPET, JONATHAN FREUND, DANIEL BODONY, University of Illinois at Urbana-Champaign — Optimal control based on discrete solutions of the continuous adjoint of the compressible Navier-Stokes equations has been successful for aeroacoustic flows despite discretization truncation errors, which result in an inconsistent sensitivity gradient. For finite resolution simulations, the truncation errors can limit the success of the optimization, especially for turbulent flows; recent evidence of this is presented. The gradient obtained from the discrete adjoint, which is more challenging to formulate but is insensitive to truncation errors, is consistent, and therefore, better suited to minimize our cost functional. We formulate the discrete adjoint of the compressible Navier-Stokes equations using high-order summation-by-parts operators with simultaneous-approximation-term boundary conditions and a high-fidelity time advancement scheme. We show that the continuous and discrete approaches lead to identical adjoint difference equations except near boundaries, at the last time step, and possibly the first few time steps, which affects the gradient accuracy. We evaluate the gradient from the two approaches and discuss the consequences of the errors in the continuous formulation for control optimization in aeroacoustic problems.

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