Optimal Unsteady Flow Control and One-Shot Aerodynamic Shape Optimization using AD

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For efficient detailed aerodynamic design as well as optimal unsteady flow control, the use of adjoint approaches is a first essential ingredient. We compare continuous and discrete adjoint approaches. For the generation of discrete adjoint solvers, we discuss the use of Automatic Differentiation (AD) and for unsteady optimal flow control its combination with checkpointing techniques. In the case of detailed aerodynamic shape optimization, we discuss so-called one-shot methods. Here, one achieves simultaneously convergence of the primal state equation, the adjoint state equation as well as the design equation. The direction and size of the one-shot optimization steps are determined by a carefully selected design space preconditioner. It turns out, that one-shot methods enable aerodynamic shape designs for the computational effort of a small, constant multiple of the effort of an aerodynamic simulation. Integral part of these approaches are, next to suitable preconditioners for the coupled one-shot loop, gradient smoothing and shape derivatives.