Sherman, Laura L.; **Taylor, Arthur C. III**; **Green, Larry L.**; **Newman, Perry A.**; **Hou, Gene W.**; **Korivi, Vamshi Mohan**

First- and second-order aerodynamic sensitivity derivatives via automatic differentiation with incremental iterative methods. (English) Zbl 0933.76070

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The straightforward automatic-differentiation and hand-differentiated incremental iterative methods are interwoven to produce a hybrid scheme that captures some of the strengths of each strategy. With this compromise, discrete aerodynamic sensitivity derivatives are calculated with the efficient incremental iterative solution algorithm of the original flow code. Moreover, the principal advantage of automatic differentiation is retained (i.e., all complicated source codes for the derivative calculations can be constructed quickly and with accuracy). The basic equations for second-order sensitivity derivatives are presented, which results in a comparison of four different methods. Each of these four schemes for second-order derivatives requires that large systems are solved first for the first-order derivatives and, in all but one method, for the first-order adjoint variables. Of these latter three schemes, two require no solutions of large systems thereafter. For the other two for which additional systems are solved, the equations and solution procedures are analogous to those for the first-order derivatives.

From a practical viewpoint, implementation of the second-order methods is feasible only with software tools such as automatic differentiation, because of the extreme complexity and large number of terms. First- and second-order sensitivities are calculated accurately for two airfoil problems, including a turbulent flow example. In each of these two sample problems, three dependent variables (coefficients of lift, drag, and pitching moment) and six independent variables (three geometric-shape and three flow-condition design variables) are considered. Several different procedures are tested, and results are compared on the basis of accuracy, computational time, and computer memory. For first-order derivatives, the hybrid incremental iterative scheme obtained with automatic differentiation is competitive with the best hand-differentiated method. Furthermore, it is at least two to four times faster than central finite differences, without an overwhelming penalty in computer memory.

Reviewer: V.P.Tyagi (Bombay)

MSC:

76M25 Other numerical methods (fluid mechanics) (MSC2010)
76G25 General aerodynamics and subsonic flows
65D25 Numerical differentiation

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