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AERODYNAMIC SHAPE OPTIMIZATION  
USING DISCRETE SENSITIVITY ANALYSIS  
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## ABSTRACT

THREE-DIMENSIONAL AERODYNAMIC SHAPE OPTIMIZATION  
USING DISCRETE SENSITIVITY ANALYSIS

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An aerodynamic shape optimization procedure based on discrete sensitivity analysis is extended to treat three-dimensional geometries. The function of sensitivity analysis is to directly couple computational fluid dynamics (CFD) with numerical optimization techniques, which facilitates the construction of efficient direct-design methods. The development of a practical three-dimensional design procedures entails many challenges, such as: 1) the demand for significant efficiency improvements over current design methods; 2) a general and flexible three-dimensional surface representation; and 3) the efficient solution of very large systems of linear algebraic equations. It is demonstrated that each of these challenges is overcome by: 1) employing fully implicit (Newton) methods for the CFD analyses; 2) adopting a Bezier-Bernstein polynomial parameterization of two- and three-dimensional surfaces; and 3) using preconditioned conjugate gradient-like linear system solvers. Whereas each of these extensions independently yields an improvement in computational efficiency, the combined effect of implementing all the extensions simultaneously results in a significant factor of 50 decrease in computational time and a factor of eight reduction in memory over the most efficient design strategies in current use. The new aerodynamic shape optimization procedure is demonstrated in the design of both two- and three-dimensional inviscid aerodynamic problems including a two-dimensional

supersonic internal/external nozzle, two-dimensional transonic airfoils (resulting in supercritical shapes), three-dimensional transonic transport wings, and three-dimensional supersonic delta wings. Each design application results in realistic and useful optimized shapes.