Algorithmic differentiation:
Sensitivity analysis and the computation of adjoints

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The provision of exact and consistent derivative information is important for numerous applications arising from optimisation purposes as for example optimal control problems. However, even the pure simulation of complex systems may require the computation of derivative information. Implicit integration methods are prominent examples for this case.

The talk will present the technique of algorithmic (or automatic) differentiation (AD) [1] to compute exact derivative information for function evaluations given as computer programs. This includes a short overview of the history of AD and a description of the main variants of AD, namely the forward mode to compute sensitivities and the reverse mode for the provision of adjoints. A discussion of complexity estimates follows yielding the important cheap gradient result.

To illustrate the importance of structure exploitation also for the use of AD an example from an industrial application will be presented, see [2]. It covers the complete design chain in Computational Fluid Dynamics (CFD), i.e., incorporates the parameterization of the object to be optimized like, e.g., a turbine blade, the usage of a Computer Aided Design (CAD) tool to actually construct the air foil and a flow solver to compute the flow around the air foil. The optimization of such a complete design chain that includes a CAD tool is still a severe challenge. We discuss how AD can be applied to the CAD kernel and a suitable flow solver taking also the complexity of the derivative information into account. We will see that a gradient-based optimization using adjoint information is the only tractable way. Numerical results for the optimization of the TU Berlin stator as one example from turbo machinery are shown. This includes also a verification of the computed derivatives.

References

[1] A Griewank and A Walther: *Evaluating Derivatives: Principles and Techniques of Algorithmic Differentiation, Second Edition. SIAM (2008).*.

[2] M Banović, I Vasilopoulos, A Walther, and M Meyer: *Algorithmic differentiation of an industrial airfoil design tool coupled with the adjoint CFD method*. Optimization and Engineering, to appear.