Algorithmic differentiation for FEM: 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 optimization 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) 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. Subsequently, I will sketch briefly a rounding error analysis and different implementation strategies. Then several aspects closely connected with the computation of sensitivity and adjoint information for finite element discretizations and related techniques are emphasized. This covers also the structure exploitation in time and space. Some examples stemming optimal flow control problems illustrate the presented aspects.

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