Challenges for adjoint compiler technology

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Given a program for evaluating a multivariate vector function $y = F(x)$, where $F : R^n \to R^m$, an adjoint compiler transforms the source code into a program that computes $\bar{x}+ = F'(x)^T \cdot \bar{y}$ at a computational complexity of $O(m)$ and where $F'(x)$ denotes the Jacobian of F at x. Adjoint compilers for both C/C++ and Fortran are developed by our group. A number of successful applications, including various finite element codes, have been reported on. Users include the Max-Planck-Institute for Meteorology in Hamburg (adjoint error correction), QinetiQ Group plc in the UK (shape optimization), and oceanographers at MIT in the US (data assimilation).

We have been collaborating with colleagues at Argonne National Laboratory, US, and INRIA, France, to tackle some of the many open challenges for developers of adjoint compilers. Various hard combinatorial and static program analysis problems need to be faced. They range from approximate solutions for the NP-hard DATA-FLOW REVERSAL problem to the definition of adjoint communication patterns for programs using MPI. Re-applicability of the compilers to their own outputs with the aim to generate higher derivative codes is highly desirable.

The talk aims to set the stage for further off-line discussions with potential users of adjoint compiler technology. A large fraction of the audience is expected to belong to this category. We plan to give a survey of our activities in this area giving people an impression of why adjoint compilers are useful tools for computational science and engineering and what makes their development theoretically and practically challenging.

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