Automatic Differentiation with the TAPENADE Tool: Development Status and Applications

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Abstract: We present TAPENADE, a tool for Automatic Differentiation (AD). AD transforms a program that computes or simulates a mathematical vector function into a new program that computes derivatives of this function. Specifically, TAPENADE can produce tangent programs that compute directional derivatives, and adjoint programs that compute gradients. Gradients are among the most useful derivatives, for optimization, data-assimilation, and inverse problems. Therefore, they receive a particular attention and development effort in TAPENADE.

After recalling the AD principles behind TAPENADE, we show how they are reflected in TAPENADE's differentiation model, internal algorithms and output. We pay particular attention to the static data-flow analyses that are required to produce efficient differentiated code, comparable with hand-written adjoint codes. The memory consumption of adjoint codes is a major problem. It can be addressed through time-memory tradeoffs known as "checkpointing" that require interesting novel data-flow analyses. Most data-flow analyses in TAPENADE are unknown in classical compiler technology, and use the particular structure of adjoint programs.

TAPENADE is still undergoing major developments. We describe the new pointer analysis that will allow us to differentiate programs that use pointers, for example in Fortran95. At the same time, we are experimenting with second-order derivatives using the "tangent-on-reverse" approach.

We shall show some successful applications of TAPENADE to large scale applications. The first example is gradient-based shape optimization in CFD. The second example is variational data-assimilation in Earth sciences.

TAPENADE can be used either as a server on our site http://www-sop.inria.fr/tropics, or downloaded locally and called from the command line or from a makefile.

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