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PII: S0045-7825(14)00480-0
DOI: http://dx.doi.org/10.1016/j.cma.2014.12.001
Reference: CMA 10496

To appear in: *Comput. Methods Appl. Mech. Engrg.*

Towards Efficient Backward-in-time Adjoint Computations using Data Compression Techniques

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Abstract

In the context of a posteriori error estimation for nonlinear time-dependent partial differential equations, the state-of-the-practice is to use adjoint approaches which require the solution of a backward-in-time problem defined by a linearization of the forward problem. One of the major obstacles in the practical application of these approaches is the need to store, or recompute, the forward solution to define the adjoint problem and to evaluate the error representation. This study considers the use of data compression techniques to approximate forward solutions employed in the backward-in-time integration. The development derives an error representation that accounts for the difference between the standard-approach and the compressed approximation of the forward solution. This representation is algorithmically similar to the standard representation and only requires the computation of the quantity of interest for the forward solution and the data-compressed reconstructed solution (i.e. scalar quantities that can be evaluated as the forward problem is integrated). This approach is then compared with existing techniques, such as checkpointing and time-averaged adjoints. Finally, we provide numerical results indicating the potential efficiency of our approach on a transient diffusion-reaction equation and on the Navier-Stokes equations. These results demonstrate memory compression ratios up to 450× while maintaining reasonable accuracy in the error-estimates.

Keywords: data compression, adjoint problem, error analysis, Navier-Stokes

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[1]Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energys National Nuclear Security Administration under contract DE-AC04-94AL85000.