ADMAT™: Automatic Differentiation for MATLAB Codes

A fundamental need that occurs across the fields of scientific, engineering, and financial computing is the calculation of partial derivatives. ADMAT is an advanced MATLAB tool that allows for the efficient and accurate computation of first and, if requested, second derivatives. ADMAT has a number of distinguishing features.

1. **Fast gradient computation**
   ADMAT can calculate gradients of multi-dimensional functions fast – in fact, in time proportional to the time required to evaluate the function itself. Moreover, ADMAT increases real-time efficiency by exploiting code structure.

2. **Efficient Jacobian determination, including sparse Jacobians**
   A common need for nonlinear vector function is to obtain the Jacobian matrix, i.e., the matrix of first derivatives, at a current iterate. ADMAT will do this efficiently and accurately. If the requested Jacobian is sparse, the sparsity pattern can be automatically determined by ADMAT and used at subsequent iterates for increased productivity. In addition, if the vector function is structured (beyond sparsity) then ADMAT can be applied in a tailored fashion for even greater efficiency.

3. **The Newton step**
   Many engineering and scientific codes require the computation of the Newton step. It is possible to do this by first computing the Jacobian matrix and then solving a linear system. ADMAT can improve this process by computing the Newton step directly, and accurately, without requiring the full determination of the Jacobian matrix. This can be significantly more efficient than the standard (“Jacobian first”) approach.

4. **2nd Derivatives: the Hessian matrix**
   ADMAT will compute, accurately and efficiently, first and second derivatives of a scalar-valued function. The second derivatives form the symmetric Hessian.
matrix. If there is sparsity then ADMAT can automatically determine the sparsity pattern and re-use it at subsequent iterates, for greater efficiency.

5. **MATLAB with C and/or Fortran calls**
   ADMAT generally requires MATLAB source code for differentiation. However, some MATLAB user codes have function calls to executable C or Fortran subroutines. Assuming differentiability, ADMAT handles this situation by applying automatic differentiation techniques combined with finite-differencing for the C (or Fortran) subroutine calls.

6. **Newton steps for optimization**
   The minimization of a twice differentiable function may appear to require the determination of the second derivatives, i.e., the Hessian matrix to determine the Newton step. However, ADMAT is able to more effectively determine the Newton step without fully determining the Hessian matrix.

7. **Platforms**
   ADMAT is freely available and easy to install, under Windows, Unix, and Linux.

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**About Cayuga Research**

Cayuga Research is a consulting company focused on the development and implementation of advanced optimization methods. Our firm is composed of experienced research analysts and developers based in Waterloo, Ontario. We have broad experience in basic applied optimization research with over 100 research publications and several published software packages, as well as years of experience in industrial consulting and collaboration.

We are experts in the design and application of optimization strategies to increase process efficiency and provide predictive analytic tools to help in both decision making and the identification of unusual, perhaps fraudulent, patterns of activity. We are accomplished in designing complex optimization systems, and we are experienced in increasing the efficiency and accuracy of current optimization procedures.