CNLS/DX-Div. Seminar
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Large-Scale Optimization Algorithms for Inverse Problems in Atmospheric Imaging

Curt Vogel
Department of Mathematical Sciences
Montana State University
Bozeman, MT 59717-2400
E-mail: vogel@math.montana.edu
Web Site: www.math.montana.edu/~vogel

The physical problem of interest is to estimate both the *phase* (or *wave-front aberration*) and the *object* (or true image) from atmospheric image data modeled by

$$d = s[\phi] \star f + \text{noise}, \tag{1}$$

where $\star$ denotes 2-D convolution product and the *point spread function* $s[\phi] = |\mathcal{F}^{-1}\{pe^{\imath\phi}\}|^2$. The obvious nonuniqueness issues arising in (1) can be dealt with by taking new image data generated by a technique known as *phase diversity.*

The phase/object estimation problem presents some interesting mathematical and computational challenges. The problem is ill-posed, so regularization must be incorporated to obtain stable, accurate parameter estimates. We employ a penalty approach known as *Tikhonov regularization*, which requires the minimization of a function of the form

$$J[\phi, f] = J_{data}[\phi, f; d] + \gamma ||f||^2 + \alpha \phi^T L \phi, \tag{2}$$

where J_{data} is a nonquadratic fit-to-data function, L is a symmetric positive definite matrix, and γ and α are small parameters. After discretization, the number of unknows is quite large ($> 10^5$).

We apply a pair of algorithms, (i) the *limited memory BFGS method* (l-BFGS) with line search globalization; and (ii) the Newton/CG algorithm with trust region globalization due to Steihaug. We will present numerical results and point out some interesting parallels between preconditioners for Newton/CG and the initial Hessian for l-BFGS.

Contact: Ken Hanson, 7-1402, kmh@lanl.gov