Final Progress Report
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NEW APPROACHES TO LINEAR
AND NONLINEAR PROGRAMMING

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Subj: RETURNED GRANTEE/CONTRACTOR TECHNICAL REPORTS

1. This confirms our conversations of 27 Feb 97 and 11 Jul 97. Enclosed are a number of technical reports which were returned to our agency for lack of clear distribution availability statement. This confirms that all reports are unclassified and are “APPROVED FOR PUBLIC RELEASE” with no restrictions.

2. Please contact me if you require additional information. My e-mail is silverr@onr.navy.mil and my phone is (206) 625-3196.

ROBERT J. SILVERMAN
SUMMARY OF COMPLETED PROJECT

The project explored the theoretical properties and computational performance of algorithms for solving constrained optimization problems (linear and nonlinear programs). Particular emphasis was placed on algorithms for solving large problems.

The practical applications of optimization are innumerable. For example, mathematical models of the economy (to analyze the optimal use of natural resources) are typically large linear or nonlinear programs. Areas in which we have been actively involved include optimal generation and transmission of electricity, optimization of aircraft and spacecraft trajectories, optimal structural design, and financial modeling such as portfolio optimization.

Progress on solution algorithms and software for such applications is ultimately reflected in improved techniques in many other areas of science and industry.

TECHNICAL INFORMATION

The research described was conducted by the Principal Investigators and their students (Meredith Goldsmith, Erik Boman, Sam Eldersveld, Dulce Ponceleón) whose work was supported by the grant. The main achievements during the grant period are listed below in various categories.

SQP Methods

In Sequential Quadratic Programming (SQP) methods for constrained optimization, most of the computational effort goes into solving QP subproblems to generate each search direction.

- Theoretical and practical results were obtained for SQP algorithms based on incomplete solution of the QP subproblems [MP95].

- A large-scale SQP algorithm and its implementation LSSQP [Eld92] demonstrated the feasibility of working with reduced Hessians and sparse Jacobians.

- A new large-scale SQP algorithm and its implementation SNOPT [GMS93, GMS96b] underwent continuous development. The application of this new software to the important class of trajectory optimization problems has invoked considerable interest in the U.S. and European aerospace communities. It is compatible with our existing general-purpose optimizer MINOS [MS95], and will be more efficient for problems whose nonlinear functions and gradients are expensive to evaluate. It also has a more reliable mechanism for ensuring convergence on problems with nonlinear constraints.

Interior-Point Methods

- Primal-dual interior-point algorithms for linear programming were developed and implemented [GMPS94, GMPS95].

- A primal interior-point algorithm for convex programming was developed and implemented in prototype (MATLAB) form [JS95].
• Special linesearch procedures were developed for use with logarithmic barrier functions [MW94].

• A series of papers [GSS96, Sau95, Sau96] explored the stability of \( LDL^T \) factorizations for solving large indefinite systems of equations—notably, the augmented systems arising in sparse least-squares problems and in barrier methods for linear and quadratic programming [GMPS94].

Other Optimization Methods

• A new second-derivative method for unconstrained optimization was formulated [FGM95]. The method is based on finding a partial Cholesky factorization of the Hessian. The new method is one of the most efficient available for practical computation.

• A Newton approach to large-scale optimization with linear inequality constraints was developed in [FM94].

• An intriguing new simplex-type method for linear programming was developed in [CPS93]. This bears resemblance to Lemke’s method, but is at least four times as efficient in terms of work per iteration.

• A new dense quadratic programming code QPOPT was completed and documented [GMS95b].

• The large-scale optimizer MINOS underwent continual development, including the implementation of a callable subroutine [MS95].

Publications

The following papers were referred to above. They have been published by the Principal Investigators during the review period.


