Chapter 1

Singular Value Homogenization: a Simple Preconditioning Technique for Linearly Constrained Optimization and

INTRODUCTION

In many experimental settings the information[a] $z \in \mathbb{R}^n$ to be processed and analyzed computationally is obtained through measuring some real world data $x \in \mathbb{R}^m$. The action of performing such measurement oftentimes introduces distortions or errors in the real data which, given that the distortion $A : \mathbb{R}^m \to \mathbb{R}^n$ is known, may be inverted to recover the original data. A particularly common case (e.g. in image processing, dose computation[b] or convolution and deconvolution processes in general [1,2]) occurs when this relation A between measurements and data is in fact linear or easily linearizable, i.e. if $A \in \mathbb{R}^{m \times n}$.

It is thus natural to consider the following optimization problem

$$\min_{x \in \mathbb{R}^m} f(Ax),$$

$$(1.1)$$

where $f : \mathbb{R}^n \to \mathbb{R}$ is a continuously differentiable function and A is a real $m \times n$ matrix. Typical (first order) approaches for solving (1.1) involve estimates of the gradient, see for example the classical works of Levitin and Polyak [3], Goldstein and Tretyakov [4] and more recent and related results [5,6]. Hence there is the need to evaluate the term

$$\nabla_x f(Ax) = A^T \cdot \nabla_z f(z),$$

$$(1.2)$$

where $z = Ax$. In the case of ill-conditioned A, (1.2) gives only little information and hence long run-times ensue, see also [7,8].

The purpose of this paper is introduce a new preconditioning process through altering the singular value spectrum of A and then transforming (1.1) into a more benign problem. Our proposed algorithmic scheme can be used as a

Fundamentals Of Matrix Computations Solution

William S. Levine

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    Fundamentals of Matrix Computations David S. Watkins,2004-08-13 A significantly revised and improved introduction to a critical aspect of scientific computation Matrix computations lie at the heart of most scientific computational tasks For any scientist or engineer doing large scale simulations an understanding of the topic is essential Fundamentals of Matrix Computations Second Edition explains matrix computations and the accompanying theory clearly and in detail along with useful insights This Second Edition of a popular text has now been revised and improved to appeal to the needs of practicing scientists and graduate and advanced undergraduate students New to this edition is the use of MATLAB for many of the exercises and examples although the Fortran exercises in the First Edition have been kept for those who want to use them This new edition includes Numerous examples and exercises on applications including electrical circuits elasticity mass spring systems and simple partial differential equations Early introduction of the singular value decomposition A new chapter on iterative methods including the powerful preconditioned conjugate gradient method for solving symmetric positive definite systems An introduction to new methods for solving large sparse eigenvalue problems including the popular implicitly restarted Arnoldi and Jacobi Davidson methods With in depth discussions of such other topics as modern componentwise error analysis reorthogonalization and rank one updates of the QR decomposition Fundamentals of Matrix Computations Second Edition will prove to be a versatile companion to novice and practicing mathematicians who seek mastery of matrix computation *Matrix Computations* Gene H. Golub,Charles F. Van Loan,1996-10-15 Revised and updated the third edition of Golub and Van Loan s classic text in computer science provides essential information about the mathematical background and algorithmic skills required for the production of numerical software This new edition includes thoroughly revised chapters on matrix multiplication problems and parallel matrix computations expanded treatment of CS decomposition an updated overview of floating point arithmetic a more accurate rendition of the modified Gram Schmidt process and new material devoted to GMRES QMR and other methods designed to handle the sparse unsymmetric linear system problem **Matrix Computations** Gene Howard Golub,Charles F. Van Loan,2013-02-15 This revised edition provides the mathematical background and algorithmic skills required for the production of numerical software It includes rewritten and clarified proofs and derivations as well as new topics such as Arnoldi iteration and domain decomposition methods **Solutions Manual to Accompany Beginning Partial Differential Equations** Peter V. O'Neil,2014-10-13 Solutions Manual to Accompany Beginning Partial Differential Equations 3rd Edition Featuring a challenging yet accessible introduction to partial differential equations Beginning Partial Differential Equations provides a solid introduction to partial differential equations particularly methods of solution based on characteristics separation of variables as well as Fourier series integrals and transforms Thoroughly updated with novel applications such as Poe s pendulum and Kepler s problem in astronomy this third edition is updated to include the latest version of Maples which is integrated throughout the text New

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