

Chapter 1

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

INTRODUCTION

In many experimental settings the information $z \in \mathbb{R}^n$ 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 $A : \mathbb{R}^m \rightarrow \mathbb{R}^n$ is known, may be inverted to recover the original data. A particularly common case (e.g. in image processing, dose computation 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

$$\min_{x \in \mathbb{R}^m} f(Ax), \quad (1.1)$$

where $f : \mathbb{R}^n \rightarrow \mathbb{R}$ 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

$$\nabla_x f(Ax) = A^T \cdot \nabla_z f(z), \quad (1.2)$$

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

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Numerical Solution of Algebraic Riccati Equations Dario A. Bini, Bruno Iannazzo, Beatrice Meini, 2012-03-31 This treatment of the basic theory of algebraic Riccati equations describes the classical as well as the more advanced algorithms for their solution in a manner that is accessible to both practitioners and scholars It is the first book in which nonsymmetric algebraic Riccati equations are treated in a clear and systematic way Some proofs of theoretical results have been simplified and a unified notation has been adopted Readers will find a unified discussion of doubling algorithms which are effective in solving algebraic Riccati equations as well as a detailed description of all classical and advanced algorithms for solving algebraic Riccati equations and their MATLAB codes This will help the reader gain an understanding of the computational issues and provide ready to use implementation of the different solution techniques

Matrix Algorithms G. W. Stewart, 2001-08-30 This is the second volume in a projected five volume survey of numerical linear algebra and matrix algorithms It treats the numerical solution of dense and large scale eigenvalue problems with an emphasis on algorithms and the theoretical background required to understand them The notes and reference sections contain pointers to other methods along with historical comments The book is divided into two parts dense eigenproblems and large eigenproblems The first part gives a full treatment of the widely used QR algorithm which is then applied to the solution of generalized eigenproblems and the computation of the singular value decomposition The second part treats Krylov sequence methods such as the Lanczos and Arnoldi algorithms and presents a new treatment of the Jacobi Davidson method These volumes are not intended to be encyclopedic but provide the reader with the theoretical and practical background to

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Computational Uncertainty Quantification for Inverse Problems Johnathan M. Bardsley, 2018-08-01 This book is an introduction to both computational inverse problems and uncertainty quantification UQ for inverse problems The book also presents more advanced material on Bayesian methods and UQ including Markov chain Monte Carlo sampling methods for UQ in inverse problems Each chapter contains MATLAB code that implements the algorithms and generates the figures as well as a large number of exercises accessible to both graduate students and researchers Computational Uncertainty Quantification for Inverse Problems is intended for graduate students researchers and applied scientists It is appropriate for courses on computational inverse problems Bayesian methods for inverse problems and UQ methods for inverse problems

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Table of Contents Fundamentals Of Matrix Computations Solutions

1. Understanding the eBook Fundamentals Of Matrix Computations Solutions
 - The Rise of Digital Reading Fundamentals Of Matrix Computations Solutions
 - Advantages of eBooks Over Traditional Books
2. Identifying Fundamentals Of Matrix Computations Solutions
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Fundamentals Of Matrix Computations Solutions
 - User-Friendly Interface
4. Exploring eBook Recommendations from Fundamentals Of Matrix Computations Solutions
 - Personalized Recommendations
 - Fundamentals Of Matrix Computations Solutions User Reviews and Ratings
 - Fundamentals Of Matrix Computations Solutions and Bestseller Lists
5. Accessing Fundamentals Of Matrix Computations Solutions Free and Paid eBooks
 - Fundamentals Of Matrix Computations Solutions Public Domain eBooks
 - Fundamentals Of Matrix Computations Solutions eBook Subscription Services

- Fundamentals Of Matrix Computations Solutions Budget-Friendly Options
- 6. Navigating Fundamentals Of Matrix Computations Solutions eBook Formats
 - ePub, PDF, MOBI, and More
 - Fundamentals Of Matrix Computations Solutions Compatibility with Devices
 - Fundamentals Of Matrix Computations Solutions Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Fundamentals Of Matrix Computations Solutions
 - Highlighting and Note-Taking Fundamentals Of Matrix Computations Solutions
 - Interactive Elements Fundamentals Of Matrix Computations Solutions
- 8. Staying Engaged with Fundamentals Of Matrix Computations Solutions
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Fundamentals Of Matrix Computations Solutions
- 9. Balancing eBooks and Physical Books Fundamentals Of Matrix Computations Solutions
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Fundamentals Of Matrix Computations Solutions
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Fundamentals Of Matrix Computations Solutions
 - Setting Reading Goals Fundamentals Of Matrix Computations Solutions
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Fundamentals Of Matrix Computations Solutions
 - Fact-Checking eBook Content of Fundamentals Of Matrix Computations Solutions
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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