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

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