

DOCTORAL THESIS

Numerical methods for image restoration

Huang, Yumei

Date of Award:
2008

[Link to publication](#)

General rights

Copyright and intellectual property rights for the publications made accessible in HKBU Scholars are retained by the authors and/or other copyright owners. In addition to the restrictions prescribed by the Copyright Ordinance of Hong Kong, all users and readers must also observe the following terms of use:

- Users may download and print one copy of any publication from HKBU Scholars for the purpose of private study or research
- Users cannot further distribute the material or use it for any profit-making activity or commercial gain
- To share publications in HKBU Scholars with others, users are welcome to freely distribute the permanent URL assigned to the publication

Numerical Methods for Image Restoration

HUANG Yumei

A thesis submitted in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy

Principal Supervisor: Prof. Michael K. Ng

Hong Kong Baptist University

July 2008

Abstract

Numerical methods plays an important role in seeking various efficient numerical solvers for a great deal of real world mathematical applications. In this thesis, we concentrate on some numerical study on the digital image restoration problem.

The aim of image restoration is to realize an estimate of the original image by making use of the information of the observed image. Total variation regularization method is a very popular regularization method in image processing due to its excellent ability to preserve edges in the recovered images. This regularization method is used in all restoration problems we have considered. In our work, we first consider the total variation denoising problem. Based on the theory of semismooth operators, we develop semismooth Newton's methods for total variation denoising algorithm. Then the restoration of blurred images corrupted by additive Gaussian noise is studied and a fast restoration method is proposed. An efficient model for the restoration of color images is also constructed. In addition, a blurred image corrupted by impulse noise plus Gaussian noise is considered and an effective two step method is established for its restoration. Multiplicative noise usually can distort an image seriously and almost all the information of the original image may disappear in the observed image, the removal of multiplicative noise is also studied and an effective globally convex model is proposed. Since different noises take different ways to affect an image, different noises removal in the above problems are greatly different. After that, by assuming that an image can belong to a Lipschitz space, the blind deconvolution problem is considered. In blind deconvolution study, the unknown blur and image can be recovered simultaneously. For all cases, the experimental results show that the proposed models are very efficient.

Table of Contents

Declaration	i
Abstract	ii
Acknowledgements	iii
Table of Contents	iv
List of Tables	vii
Chapter 1 Introduction	1
1.1 Background	1
1.2 Total Variation Regularization and Its Solvers	2
1.2.1 Total Variation Regularization Model	2
1.2.2 Solvers for the Total Variation Minimization Problem	3
1.3 Boundary Condition	6
1.4 GMRES and Conjugate Gradient Method	7
1.5 Quasi-Newton Method	10
1.6 Organization of the Thesis	12
Chapter 2 On Semismooth Newton's Methods for Total Variation Min-	
imization	14
2.1 Introduction	14
2.2 The Main Results	14
2.2.1 Background Material	14
2.2.2 Semismooth Newton-type Methods	17

2.3	Numerical Results	22
Chapter 3 A Fast Total Variation Minimization Method for Image		
	Restoration	28
3.1	Introduction	28
3.2	Proposed Method	29
3.3	The Iterative Algorithm	30
3.3.1	The Convergence Analysis	32
3.4	Experimental Results	36
3.4.1	Image Restoration Results	38
3.4.2	Efficiency	38
3.5	Concluding Remarks	49
Chapter 4 Efficient Total Variation Minimization Methods for Color		
	Image Restoration	50
4.1	Introduction	50
4.2	Total Variation Regularization Methods	52
4.2.1	Grey-Level Images	52
4.2.2	Color Images	53
4.3	The Proposed Algorithm	53
4.3.1	The Iterative Algorithm	54
4.4	The Convergence of the Proposed Algorithm	56
4.5	Experimental Results	58
4.6	Conclusion	69
Chapter 5 Fast Image Restoration Methods for Impulse and Gaussian		
	Noises Removal	70
5.1	Introduction	70
5.2	The Proposed Model	72
5.2.1	The Minimization Model	72
5.2.2	Alternating Minimization Algorithm	73
5.2.3	Convergence Analysis	74
5.3	Experimental Results	75

5.3.1	Experiment 1	76
5.3.2	Experiment 2	80
5.3.3	Experiment 3	81
5.3.4	Experiment 4	82
5.3.5	Experiment 5	83
5.4	Concluding Remarks	84
5.5	Appendix	85
5.5.1	Algorithm for adaptive Median Filter(AMF)	85
5.5.2	Algorithm for adaptive Center-Weighted Median Filter(ACWMF)	86
Chapter 6 A New Total Variation Method for Multiplicative Noise Re-		
	moval	91
6.1	Introduction	91
6.2	The Proposed Model	93
6.2.1	Bayesian Formulation	94
6.2.2	The Alternating Iterative Algorithm	95
6.3	The Convergence Analysis	96
6.4	Numerical Results	100
6.5	Concluding Remarks	112
Chapter 7 Lipschitz and Total-Variational Regularization for Blind De-		
	convolution	113
7.1	Introduction	113
7.2	Blind Deconvolution by Lipschitz Regularization	114
7.3	Numerical Results	117
7.4	Concluding Remarks	124
Chapter 8 Conclusion		125
Bibliography		127
Curriculum Vitae		134