

Contents

Certificate	ii
Declaration by the Candidate	iii
Copyright Transfer Certificate	iv
Acknowledgements	iv
Contents	vii
List of Figures	xi
List of Tables	xv
Abbreviations	xvii
Symbols	xix
Preface	xxi
1 Introduction	1
1.1 Literature Review	2
1.1.1 First-order Methods	3
1.1.2 Fixed point theory	8
1.2 Motivation	11
1.3 Research Contributions	12
1.4 Layout of Thesis	14
2 Background	17

2.1	Operator Splitting Techniques	17
2.2	Forward-backward Splitting Techniques	18
2.3	Proximal Gradient Methods	19
2.3.1	Backtracking Line Search	21
2.4	Accelerated Gradient Methods	22
2.5	General Assumptions	24
2.6	Viscosity-Approximation Fixed-point Scheme	24
2.7	Extra-gradient Methods	25
3	NAGA: New Accelerated Gradient Algorithm with Convergence and Stability Guarantees and Applications	27
3.1	Introduction	27
3.1.1	Contributions	29
3.1.2	Outline	30
3.2	Related Concepts	30
3.3	NAGA	32
3.4	Analysis of NAGA	34
3.4.1	Boundedness of $\{x_n\}$ from NAGA	35
3.4.2	Convergence with Contraction Mappings	37
3.4.3	Convergence with Non-expansive Mappings	38
3.4.4	Stability Analysis of NAGA	40
3.5	Applications, Experiments and Result Analysis	41
3.5.1	Machine Learning with high-dimensional datasets	42
3.5.2	Unified Sparse Representation Learning	53
3.5.2.1	Problem Formulation and Proposed Approach	53
3.5.2.2	Experiments and Result Analysis	55
3.5.3	Logistic Regression with Extended Lasso Frameworks	57
3.5.3.1	Overlapping group Lasso	58
3.5.3.2	Fused Lasso	59
3.5.3.3	Experimental Results	61
3.6	Conclusions	66
4	VAGA: Viscosity-based Accelerated Gradient Algorithm for Regularized Multitask Learning Framework with Convergence Guarantee and Applications	69
4.1	Introduction	69
4.1.1	Contributions	72
4.1.2	Outline	72
4.2	Preliminaries	73
4.2.1	Viscosity-based Forward-backward Splitting Method (VFBA)	73
4.2.2	Joint Splice-site Recognition	74
4.3	VAGA	76
4.4	Analysis of VAGA	78

4.4.1	Boundedness of $\{x_n\}$ from VAGA	78
4.4.2	Convergence Analysis	80
4.5	Experimental Results and Analysis	83
4.5.1	Multitask Regression	83
4.5.2	Joint Splice-site Recognition	88
4.6	Conclusions	91
5	A New Operator Splitting Algorithm and its Accelerated Variant with Convergence Guarantees and Application to Microarray Gene Analysis	93
5.1	Introduction	93
5.1.1	Contributions	95
5.1.2	Outline	95
5.2	Related Concepts and Background	96
5.2.1	Peaceman-Rachford Operator Splitting Algorithm	96
5.2.2	Douglas Rachford Operator Splitting Algorithm	97
5.3	Proposed Operator Splitting Algorithms	98
5.3.1	EOSA	98
5.3.2	Convergence Analysis of EOSA	100
5.3.3	AEOSA	102
5.3.4	Convergence Analysis of AEOSA	103
5.4	Experiments and Result analysis	104
5.5	Conclusion	111
6	Conclusions and Future Work	113
6.1	Summary	113
6.2	Future Work	115
A	Definitions	117
B	List of Publications	123
	Bibliography	125