Table of Contents

Deep Learning and Neural Nets Preface and Acknowledgments			
I.	Multiplication Ax Using Columns of A	2	
I.:	Matrix-Matrix Multiplication AB	9	
I.:	The Four Fundamental Subspaces	14	
Ι.	Elimination and $A = LU$	21	
I.:	5 Orthogonal Matrices and Subspaces	29	
I.	6 Eigenvalues and Eigenvectors	36	
I.	7 Symmetric Positive Definite Matrices	44	
I.	Singular Values and Singular Vectors in the SVD	56	
Ι.	Principal Components and the Best Low Rank Matrix	71	
I.	Rayleigh Quotients and Generalized Eigenvalues	81	
I.	Norms of Vectors and Functions and Matrices	88	
I.	12 Factoring Matrices and Tensors: Positive and Sparse	97	
Part II : Computations with Large Matrices			
II	.1 Numerical Linear Algebra	115	
II	.2 Least Squares: Four Ways	124	
II	.3 Three Bases for the Column Space	138	
II	4 Randomized Linear Algebra	146	

Part III: Low Rank and Compressed Sensing				
III.1	Changes in A^{-1} from Changes in A	160		
III.2	Interlacing Eigenvalues and Low Rank Signals	168		
III.3	Rapidly Decaying Singular Values	178		
III.4	Split Algorithms for $\ell^2 + \ell^1$	184		
III.5	Compressed Sensing and Matrix Completion	195		
Part IV:	Special Matrices	203		
IV.1	Fourier Transforms: Discrete and Continuous	204		
IV.2	Shift Matrices and Circulant Matrices	213		
IV.3	The Kronecker Product $A\otimes B$	221		
IV.4	Sine and Cosine Transforms from Kronecker Sums	228		
IV.5	Toeplitz Matrices and Shift Invariant Filters	232		
IV.6	Graphs and Laplacians and Kirchhoff's Laws	239		
IV.7	Clustering by Spectral Methods and k-means	245		
IV.8	Completing Rank One Matrices	255		
IV.9	The Orthogonal Procrustes Problem	257		
IV.10	Distance Matrices	259		
Part V:	Probability and Statistics	263		
V.1	Mean, Variance, and Probability	264		
V.2	Probability Distributions	275		
V.3	Moments, Cumulants, and Inequalities of Statistics	284		
V.4	Covariance Matrices and Joint Probabilities	294		
V.5	Multivariate Gaussian and Weighted Least Squares	304		
V.6	Markov Chains	311		

Table of Contents				
Part VI: Optimization 3				
VI.1 Minimum Problems: Convexity and Newton's Method	324			
VI.2 Lagrange Multipliers = Derivatives of the Cost	333			
VI.3 Linear Programming, Game Theory, and Duality	338			
VI.4 Gradient Descent Toward the Minimum	344			
VI.5 Stochastic Gradient Descent and ADAM	359			
Part VII: Learning from Data				
VII.1 The Construction of Deep Neural Networks	375			
VII.2 Convolutional Neural Nets	387			
VII.3 Backpropagation and the Chain Rule	397			
VII.4 Hyperparameters: The Fateful Decisions	407			
VII.5 The World of Machine Learning	413			
Books on Machine Learning				
Eigenvalues and Singular Values : Rank One				
Codes and Algorithms for Numerical Linear Algebra				
Counting Parameters in the Basic Factorizations				
Index of Authors				
Index				
Index of Symbols				