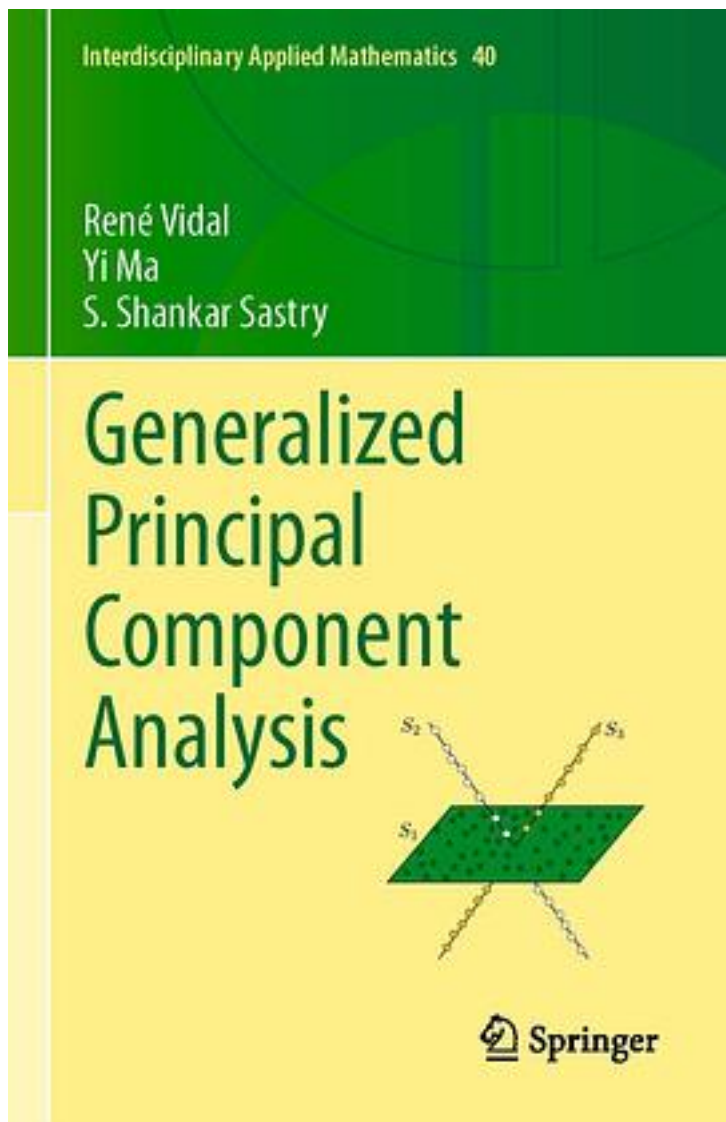


Generalized Principal Component Analysis



[Generalized Principal Component Analysis_ 下载链接1](#)

著者:René Vidal

出版者:Springer

出版时间:2016-4-12

装帧:精装

isbn:9780387878102

This book provides a comprehensive introduction to the latest advances in the mathematical theory and computational tools for modeling high-dimensional data drawn from one or multiple low-dimensional subspaces (or manifolds) and potentially corrupted by noise, gross errors, or outliers. This challenging task requires the development of new algebraic, geometric, statistical, and computational methods for efficient and robust estimation and segmentation of one or multiple subspaces. The book also presents interesting real-world applications of these new methods in image processing, image and video segmentation, face recognition and clustering, and hybrid system identification etc.

This book is intended to serve as a textbook for graduate students and beginning researchers in data science, machine learning, computer vision, image and signal processing, and systems theory. It contains ample illustrations, examples, and exercises and is made largely self-contained with three Appendices which survey basic concepts and principles from statistics, optimization, and algebraic-geometry used in this book.

作者介绍:

René Vidal is a Professor of Biomedical Engineering and Director of the Vision Dynamics and Learning Lab at The Johns Hopkins University.

Yi Ma is Executive Dean and Professor at the School of Information Science and Technology at ShanghaiTech University.

S. Shankar Sastry is Dean of the College of Engineering, Professor of Electrical Engineering and Computer Science and Professor of Bioengineering at the University of California, Berkeley.

目录: 1 Introduction 1

1.1 Modeling Data with a Parametric Model..... 2

1.1.1 The Choice of a Model Class 3

1.1.2 Statistical Models versus Geometric Models 4

1.2 Modeling Mixed Data with a Mixture Model 6

1.2.1 Examples of Mixed Data Modeling 7

1.2.2 Mathematical Representations of Mixture Models 12

1.3 Clustering via Discriminative or Nonparametric Methods 16

1.4 Noise, Errors, Outliers, and Model Selection 18

Part I Modeling Data with a Single Subspace

2 Principal Component Analysis 25

2.1 Classical Principal Component Analysis (PCA) 25

2.1.1 A Statistical View of PCA. 26

2.1.2 A Geometric View of PCA. 30

2.1.3 A Rank Minimization View of PCA. 34

2.2 Probabilistic Principal Component Analysis (PPCA) 38

2.2.1 PPCA from Population Mean and Covariance 39

2.2.2 PPCA by Maximum Likelihood 40

2.3 Model Selection for Principal Component Analysis..... 45

2.3.1 Model Selection by Information-Theoretic Criteria 46

2.3.2 Model Selection by Rank Minimization	49
2.3.3 Model Selection by Asymptotic Mean Square Error	51
2.4 Bibliographic Notes	53
2.5 Exercises	54
3 Robust Principal Component Analysis	63
3.1 PCA with Robustness to Missing Entries	64
3.1.1 Incomplete PCA by Mean and Covariance Completion ..	68
3.1.2 Incomplete PPCA by Expectation Maximization	69
3.1.3 Matrix Completion by Convex Optimization	73
3.1.4 Incomplete PCA by Alternating Minimization.....	78
3.2 PCA with Robustness to Corrupted Entries	87
3.2.1 Robust PCA by Iteratively Reweighted Least Squares ...	89
3.2.2 Robust PCA by Convex Optimization	92
3.3 PCA with Robustness to Outliers	99
3.3.1 Outlier Detection by Robust Statistics	101
3.3.2 Outlier Detection by Convex Optimization	107
3.4 Bibliographic Notes	113
3.5 Exercises	115
4 Nonlinear and Nonparametric Extensions.....	123
4.1 Nonlinear and Kernel PCA	126
4.1.1 Nonlinear Principal Component Analysis (NLPCA)	126
4.1.2 NLPCA in a High-dimensional Feature Space	128
4.1.3 Kernel PCA (KPCA)	129
4.2 Nonparametric Manifold Learning	133
4.2.1 Multidimensional Scaling (MDS)	134
4.2.2 Locally Linear Embedding (LLE)	135
4.2.3 Laplacian Eigenmaps (LE)	138
4.3 K-Means and Spectral Clustering	143
4.3.1 K-Means Clustering	145
4.3.2 Spectral Clustering	148
4.4 Bibliographic Notes	160
4.5 Exercises	161
4.A Laplacian Eigenmaps: Continuous Formulation ..	166
Part II Modeling Data with Multiple Subspaces	171
5 Algebraic-Geometric Methods	171
5.1 Problem Formulation of Subspace Clustering	172
5.1.1 Projectivization of Affine Subspaces	172
5.1.2 Subspace Projection and Minimum Representation	174
5.2 Introductory Cases of Subspace Clustering	176
5.2.1 Clustering Points on a Line	176
5.2.2 Clustering Lines in a Plane	179
5.2.3 Clustering Hyperplanes	181
5.3 Subspace Clustering Knowing the Number of Subspaces.....	184
5.3.1 An Introductory Example	184
5.3.2 Fitting Polynomials to Subspaces	186
5.3.3 Subspaces from Polynomial Differentiation	188
5.3.4 Point Selection via Polynomial Division	190
5.3.5 The Basic Algebraic Subspace Clustering Algorithm	193
5.4 Subspace Clustering not Knowing the Number of Subspaces	196
5.4.1 Introductory Examples	196
5.4.2 Clustering Subspaces of Equal Dimension	198
5.4.3 Clustering Subspaces of Different Dimensions	200
5.5 Model Selection for Multiple Subspaces	201
5.5.1 Effective Dimension of Samples of Multiple Subspaces .	202

5.5.2 Minimum Effective Dimension of Noisy Samples	204
5.5.3 Recursive Algebraic Subspace Clustering	205
5.6 Bibliographic Notes	207
5.7 Exercises	210
6 Statistical Methods	217
6.1 K-Subspaces	219
6.1.1 K-Subspaces Model	219
6.1.2 K-Subspaces Algorithm	220
6.1.3 Convergence of the K-Subspaces Algorithm	221
6.1.4 Advantages and Disadvantages of K-Subspaces	222
6.2 Mixture of Probabilistic PCA (MPPCA)	222
6.2.1 MPPCA Model	223
6.2.2 Maximum Likelihood Estimation for MPPCA	223
6.2.3 Maximum a Posteriori (MAP) Estimation for MPPCA ..	226
6.2.4 Relationship between K-Subspaces and MPPCA	228
6.3 Compression-Based Subspace Clustering	231
6.3.1 Model Estimation and Data Compression	231
6.3.2 Minimum Coding Length via Agglomerative Clustering	233
6.3.3 Lossy Coding of Multivariate Data	238
6.3.4 Coding Length of Mixed Gaussian Data	242
6.4 Simulations and Applications	247
6.4.1 Statistical Methods on Synthetic Data	247
6.4.2 Statistical Methods on Gene Expression Clustering, Image Segmentation, and Face Clustering ...	254
6.5 Bibliographic Notes	258
6.6 Exercises	261
6.A Lossy Coding Length for Subspace-like Data	263
7 Spectral Methods	267
7.1 Spectral Subspace Clustering	268
7.2 Local Subspace Affinity (LSA) and Spectral Local Best-Fit Flats (SLBF)	270
7.3 Locally Linear Manifold Clustering (LLMC)	274
7.4 Spectral Curvature Clustering (SCC)	276
7.5 Spectral Algebraic Subspace Clustering (SASC)	279
7.6 Simulations and Applications	281
7.6.1 Spectral Methods on Synthetic Data	281
7.6.2 Spectral Methods on Face Clustering	285
7.7 Exercises	289
8 Sparse and Low-Rank Methods	291
8.1 Self-Expressiveness and Subspace-Preserving Representations ...	294
8.1.1 Self-Expressiveness Property	294
8.1.2 Subspace-Preserving Representation	296
8.2 Low-Rank Subspace Clustering (LRSC)	297
8.2.1 LRSC with Uncorrupted Data	297
8.2.2 LRSC with Robustness to Noise	302
8.2.3 LRSC with Robustness to Corruptions	308
8.3 Sparse Subspace Clustering (SSC)	310
8.3.1 SSC with Uncorrupted Data	310
8.3.2 SSC with Robustness to Outliers	324
8.3.3 SSC with Robustness to Noise	326
8.3.4 SSC with Robustness to Corrupted Entries	330
8.3.5 SSC for Affine Subspaces	332
8.4 Simulations and Applications	333
8.4.1 Low-Rank and Sparse Methods on Synthetic Data	333

8.4.2 Low-Rank and Sparse Methods on Face Clustering	336
8.5 Bibliographic Notes	344
8.6 Exercises	345
Part III Applications	
9 Image Representation	349
9.1 Seeking Compact and Sparse Image Representations	349
9.1.1 Prefixed Linear Transformations.....	350
9.1.2 Adaptive, Overcomplete, and Hybrid Representations ...	351
9.1.3 Hierarchical Models for Multiscale Structures.....	353
9.2 Image Representation with Multiscale Hybrid Linear Models	354
9.2.1 Linear versus Hybrid Linear Models	354
9.2.2 Multiscale Hybrid Linear Models.....	361
9.2.3 Experiments and Comparisons.....	365
9.3 Multiscale Hybrid Linear Models in Wavelet Domain	369
9.3.1 Imagery Data Vectors in the Wavelet Domain	369
9.3.2 Hybrid Linear Models in the Wavelet Domain	371
9.3.3 Comparison with Other Lossy Representations	372
9.4 Bibliographic Notes	376
10 Image Segmentation	377
10.1 Basic Models and Principles	378
10.1.1 Problem Formulation	378
10.1.2 Image Segmentation as Subspace Clustering	380
10.1.3 Minimum Coding Length Principle	381
10.2 Encoding Image Textures and Boundaries	382
10.2.1 Construction of Texture Features	382
10.2.2 Texture Encoding	383
10.2.3 Boundary Encoding	384
10.3 Compression-Based Image Segmentation.....	386
10.3.1 Minimizing Total Coding Length	386
10.3.2 Hierarchical Implementation	387
10.3.3 Choosing the Proper Distortion Level	389
10.4 Experimental Evaluation	392
10.4.1 Color Spaces and Compressibility	392
10.4.2 Experimental Setup	394
10.4.3 Results and Discussions	395
10.5 Bibliographic Notes	399
11 Motion Segmentation.....	401
11.1 The 3D Motion Segmentation Problem	402
11.2 Motion Segmentation from Multiple Affine Views	405
11.2.1 Affine Projection of a Rigid-Body Motion	405
11.2.2 Motion Subspace of a Rigid-Body Motion	406
11.2.3 Segmentation of Multiple Rigid-Body Motions.....	406
11.2.4 Experiments on Multiview Motion Segmentation	407
11.3 Motion Segmentation from Two Perspective Views	413
11.3.1 Perspective Projection of a Rigid-Body Motion	414
11.3.2 Segmentation of 3D Translational Motions	415
11.3.3 Segmentation of Rigid-Body Motions	416
11.3.4 Segmentation of Rotational Motions or Planar Scenes ...	417
11.3.5 Experiments on Two-View Motion Segmentation	418
11.4 Temporal Motion Segmentation	421
11.4.1 Dynamical Models of Time-Series Data	422
11.4.2 Experiments on Temporal Video Segmentation	423
11.4.3 Experiments on Segmentation of Human Motion Data.....	425

11.5 Bibliographical Notes	428
12 Hybrid System Identification	431
12.1 Problem Statement	433
12.2 Identification of a Single ARX System	434
12.3 Identification of Hybrid ARX Systems	438
12.3.1 The Hybrid Decoupling Polynomial	439
12.3.2 Identifying the Hybrid Decoupling Polynomial	440
12.3.3 Identifying System Parameters and Discrete States	443
12.3.4 The Basic Algorithm and Its Extensions	445
12.4 Simulations and Experiments	446
12.4.1 Error in the Estimation of the Model Parameters	447
12.4.2 Error as a Function of the Model Orders	447
12.4.3 Error as a Function of Noise	448
12.4.4 Experimental Results on Test Data Sets	449
12.5 Bibliographic Notes	450
13 Final Words	453
13.1 Unbalanced and Multimodal Data	454
13.2 Unsupervised and Semisupervised Learning	454
13.3 Data Acquisition and Online Data Analysis	455
13.4 Other Low-Dimensional Models	456
13.5 Computability and Scalability	457
13.6 Theory, Algorithms, Systems, and Applications	459
A Basic Facts from Optimization	461
A.1 Unconstrained Optimization	461
A.1.1 Optimality Conditions	462
A.1.2 Convex Set and Convex Function	462
A.1.3 Subgradient	464
A.1.4 Gradient Descent Algorithm	465
A.1.5 Alternating Direction Minimization	466
A.2 Constrained Optimization	468
A.2.1 Optimality Conditions and Lagrangian Multipliers	468
A.2.2 Augmented Lagrange Multiplier Methods	470
A.2.3 Alternating Direction Method of Multipliers	471
A.3 Exercises	474
B Basic Facts from Mathematical Statistics	475
B.1 Estimation of Parametric Models	475
B.1.1 Sufficient Statistics	476
B.1.2 Mean Square Error, Efficiency, and Fisher Information ..	477
B.1.3 The Rao–Blackwell Theorem and Uniformly Minimum-Variance Unbiased Estimator	479
B.1.4 Maximum Likelihood (ML) Estimator	480
B.1.5 Consistency and Asymptotic Efficiency of the ML Estimator	481
B.2 ML Estimation for Models with Latent Variables	485
B.2.1 Expectation Maximization (EM)	486
B.2.2 Maximum a Posteriori Expectation Maximization (MAP-EM)	488
B.3 Estimation of Mixture Models	490
B.3.1 EM for Mixture Models	490
B.3.2 MAP-EM for Mixture Models	492
B.3.3 A Case in Which EM Fails	494
B.4 Model-Selection Criteria	496
B.4.1 Akaike Information Criterion	497
B.4.2 Bayesian Information Criterion	498

B.5 Robust Statistical Methods.....	498
B.5.1 Influence-Based Outlier Detection	499
B.5.2 Probability-Based Outlier Detection	501
B.5.3 Random-Sampling-Based Outlier Detection	503
B.6 Exercises	506
C Basic Facts from Algebraic Geometry	509
C.1 Abstract Algebra Basics	509
C.1.1 Polynomial Rings	509
C.1.2 Ideals and Algebraic Sets	511
C.1.3 Algebra and Geometry: Hilbert's Nullstellensatz	513
C.1.4 Algebraic Sampling Theory	514
C.1.5 Decomposition of Ideals and Algebraic Sets	516
C.1.6 Hilbert Function, Polynomial, and Series	517
C.2 Ideals of Subspace Arrangements	519
C.3 Subspace Embedding and PL-Generated Ideals	522
C.4 Hilbert Functions of Subspace Arrangements	524
C.4.1 Hilbert Function and Algebraic Subspace Clustering.....	525
C.4.2 Special Cases of the Hilbert Function	528
C.4.3 Formulas for the Hilbert Function	530
C.5 Bibliographic Notes	534
References.....	535
Index	553
• • • • •	(收起)

[Generalized Principal Component Analysis_下载链接1](#)

标签

计算机

机器学习

Optimization

数学科学

unsupervised

clustering

MachineLearning

评论

[Generalized Principal Component Analysis 下载链接1](#)

书评

[Generalized Principal Component Analysis 下载链接1](#)