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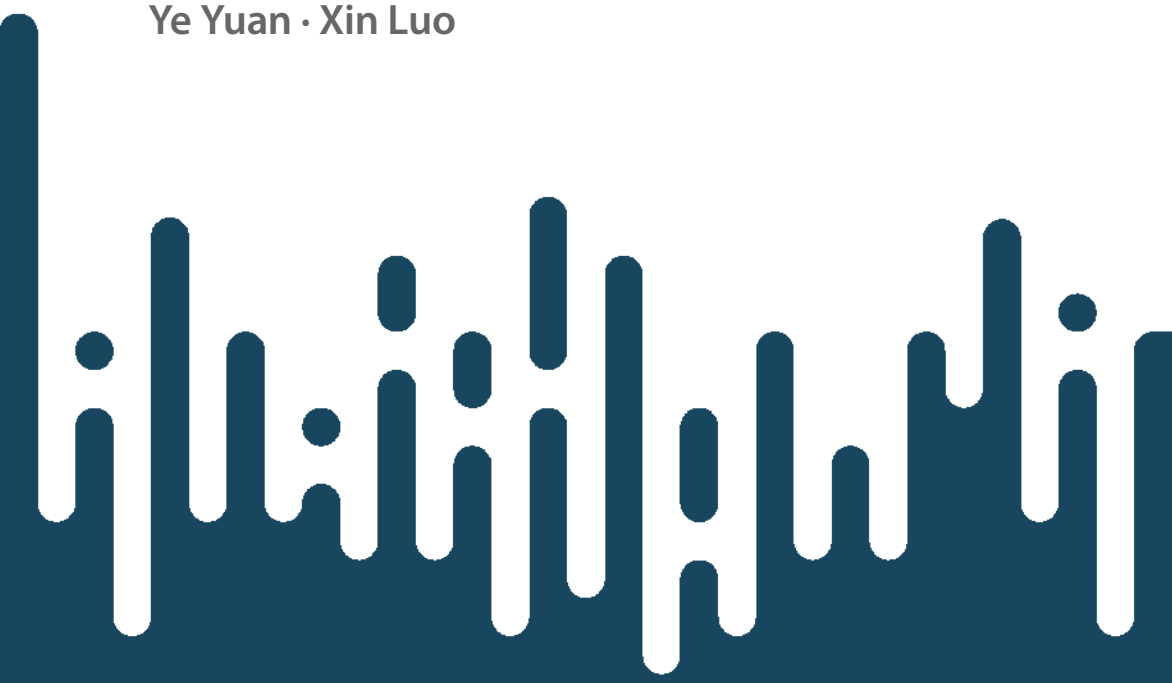
Ye Yuan · Xin Luo



Latent Factor Analysis for High-dimensional and Sparse Matrices

A particle swarm optimization-based approach

Springer

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Preface

High-dimensional and sparse (HiDS) matrices are commonly seen in many big data-related industrial applications like electronic commerce, cloud services, social networks, and wireless sensor networks. Despite its extreme sparse, an HiDS matrix contains rich knowledge regarding desired patterns like users' potential favorites, item clusters, and topological neighbors. Hence, how to efficiently and accurately extract desired knowledge from it for various data analysis tasks becomes a highly interesting issue.

Latent factor analysis (LFA) has proven to be highly efficient for addressing an HiDS matrix owing to its high scalability and efficiency. However, an LFA model's performance relies heavily on its hyper-parameters, which should be chosen with care. The common strategy is to employ grid-search to tune these hyper-parameters. However, it requires expensive computational cost to search the whole candidate space, especially when building an LFA model on an HiDS matrix. Hence, how to implement a hyper-parameter-free LFA model becomes a significant issue.

In this book, we incorporate the principle of particle swarm optimization (PSO) into latent factor analysis, thereby achieving four effective hyper-parameter-free latent factor analysis models. The first model is a Learning rate-free LFA (L^2FA) model, which utilizes a standard PSO algorithm into the learning process by building a swarm of learning rates applied to the same group. The second model is a *L*earning rate and *R*egularization coefficient-free *LFA* (LRLFA) model, which build a swarm by taking the learning rate and regularization coefficient of every single LFA-based model as particles, and then apply particle swarm optimization to make them adaptation according to a predefined fitness function. The third model is a *G*eneralized and *A*daptive *LFA* (GALFA) model, which implement self-adaptation of the regularization coefficient and momentum coefficient for excellent practicability via PSO. The last model is an *A*dvanced *L*earning rate-free *LFA* (AL^{2}FA) model. Before building this model, we first propose a novel position-transitional particle swarm optimization (P^{2}SO) algorithm by incorporate more dynamic information into the particle's evolution for preventing premature convergence. And then, a P^{2}SO algorithm is utilized into the training process to make the learning rate adaptation without

accuracy loss. Since hyper-parameter adaptation is done within only one full training process, thereby greatly reducing computational cost. Hence, it fits the need of real applications with high scalability and efficiency.

This is the first book about how to incorporate particle swarm optimization into latent factor analysis for implementing effective hyper-parameter adaptation. It is intended for professionals and graduate students involved in LFA on HiDS data. It is assumed that the reader has a basic knowledge of mathematics, as well as a certain background in data mining. The reader can get an overview on how to implement efficient hyper-parameter adaptation in an LFA model. We hope this monograph will be a useful reference for students, researchers, and professionals to understand the basic methodologies of hyper-parameter adaptation via PSO. The readers can immediately conduct extensive researches and experiments on the real applications HiDS data involved in this book.

Chongqing, China Ye Yuan
June 2022 Xin Luo

Contents

1 Introduction 1
1.1 Background 1
1.2 Preliminaries 2
1.2.1 Symbol and Abbreviation Appointment 2
1.2.2 An LFA Model 3
1.2.3 Particle Swarm Optimization 6
1.3 Book Organization 6
References 7

2 Learning Rate-Free Latent Factor Analysis via PSO 11
2.1 Overview 11
2.2 An LFA Model with SGD Algorithm 12
2.3 The Proposed L^{2}FA Model 14
2.3.1 Learning Rate Adaptation via PSO 14
2.3.2 Algorithm Design and Analysis 15
2.4 Experimental Results and Analysis 17
2.4.1 General Settings 17
2.4.2 Performance Comparison 18
2.4.3 Effect of Swarm Size 20
2.4.4 Summary 22
2.5 Conclusions 22
References 25

3 Learning Rate and Regularization Coefficient-Free Latent Factor Analysis via PSO 29
3.1 Overview 29
3.2 An SGD-Based LFA Model 31
3.3 The Proposed LRLFA Model 32
3.3.1 Learning Rate and Regularization Coefficient Adaptation via PSO 32
3.3.2 Linearly Decreasing Inertia Weight Incorporation 35

3.3.3 Algorithm Design and Analysis . . . 36
3.4 Experimental Results and Analysis . . . 37
3.4.1 General Settings . . . 37
3.4.2 Effect of Swarm Size . . . 39
3.4.3 Performance Comparison . . . 41
3.4.4 Summary . . . 45
3.5 Conclusions . . . 45
References . . . 45

4 Regularization and Momentum Coefficient-Free Non-negative Latent Factor Analysis via PSO . . . 51
4.1 Overview . . . 51
4.2 An SLF-NMU-Based NLFA Model . . . 53
4.3 The Proposed GALFA Model . . . 54
4.3.1 A Generalized Learning Objective . . . 54
4.3.2 A Generalized SLF-NMU-Based Learning Rule . . . 55
4.3.3 Generalized-Momentum Incorporation . . . 56
4.3.4 Regularization and Momentum Coefficient Adaptation via PSO . . . 58
4.3.5 Algorithm Design and Analysis . . . 60
4.4 Experimental Results and Analysis . . . 63
4.4.1 General Settings . . . 63
4.4.2 Parameter Sensitivity . . . 64
4.4.3 Comparison with State-of-the-Art Models . . . 68
4.4.4 Summary . . . 71
4.5 Conclusions . . . 71
References . . . 72

5 Advanced Learning Rate-Free Latent Factor Analysis via P^2SO . . . 75
5.1 Overview . . . 75
5.2 An SGD-Based LFA Model . . . 76
5.3 The Proposed AL^2FA Model . . . 78
5.3.1 A P^2SO Algorithm . . . 78
5.3.2 Learning Rate Adaptation via P^2SO . . . 80
5.3.3 Algorithm Design and Analysis . . . 81
5.4 Experimental Results and Analysis . . . 83
5.4.1 General Settings . . . 83
5.4.2 Effect of ρ . . . 84
5.4.3 Comparison Results . . . 85
5.4.4 Summary . . . 87
5.5 Conclusions . . . 87
References . . . 88

6 Conclusion and Future Directions . . . 91
6.1 Conclusion . . . 91
6.2 Discussion . . . 92
References . . . 92