Preface

Statisticians encounter many types of complex data, and among them matrix and tensor data are currently popular data forms that play a vital role in various analyses. Matrix data constitute an essential data form of multivariate analysis and tensor data are comprised of a multi-way datum with which statisticians are familiar in analyzing contingency tables. The difference between matrix and tensor data forms and contingency tables is that the entries in the tensor data are real values and that the entries in the contingency tables are integers. Furthermore, tensor data can treat complex data in more flexible ways.

In this expository book we present both foundations and applications of matrix and tensor data analysis in six chapters.

Chapter 1 deals with the principal component analysis (PCA) for 3-way tensor data, popularly referred to as 3WPCA. The author of this chapter, Prof. Adachi of Osaka University, has conducted extensive research in this field and published papers in respected journals like Psychometrika and Computational Statistics. His research emphasizes hierarchical relationships among Tucker2, Tucker3, Parafac, and the common PCA. He illustrates the theory by applying it to psychological data.

Chapter 2 discusses nonnegative matrix factorization (NMF) and its application to audio signal data. After the basics, including algorithms, of NMF are explained, remarkable applications to audio signal data are given. The author of this chapter, Dr. Kameoka, is a promising award winning young researcher who works at NTT Communication Science Laboratories and is an adjunct associate professor at the Graduate School of Information Science and Technology of the University of Tokyo.

Chapter 3 introduces an application of tensor PCA to image data. The author of this chapter, Associate Prof. Inoue of Kyushu University, is a specialist of tensor principal components analysis to image data and has written many papers related to these topics in journals like Lecture Note of Computer Sciences and others. He formulated a generalized tensor PCA (GTPCA) and derived multi-linear PCA (MPCA), robust MPCA, simultaneous low-rank approximation of tensors (SLART), and robust SLART from GTPCA. Applications for image analysis are presented in this chapter such as outlier removal, image compression, and face recognition.

Chapter 4 focuses on sparse coding theory of image data. The author of this chapter, Prof. Murata of Waseda University, is one of the founders of Independent Components Analysis in Japan and has published books about the topic. He has developed unified treatments of several principles in matrix factorizations. He shows that the difference between PCA, independent component analysis (ICA), nonnegative matrix factorization (NMF), and sparse representations are understood as different constraints when a data matrix is decomposed into a product of two matrices. Applications to image processing are also given.

Chapter 5 centers on the application of tensor normal distribution to genetic data. The author of this chapter, Dr. Akdemir, Research Associate at Cornell University, has published a pioneering paper about tensor normal distribution in the Journal of Algebraic Statistics. He expounded the estimation of mean and covariance of array (tensor) under normal distributions with missing data. Applications to real-life data involving the estimation of genotype and environment interaction and effects on possible correlated traits are detailed.

Chapter 6 introduces one-sided tests for the mean matrix of a matrix normal distribution. The late Prof. Kudo of Kyushu University, who was a pioneer of multivariate one-sided tests in Japan, taught the authors of this chapter, Associate Prof. Iwasa of Kumamoto University and Prof. Sakata of Kyushu University. Both authors have published several papers about one-sided tests in statistical journals such as the Journal of Multivariate Analysis and the Journal of Institute of Statistical Mathematics. They developed a one-sided test for mean matrix of matrix normal distributions and constructed a class of similar test statistics that includes similar tests previously obtained by Sasabuchi, Hu, and Banerjee. These works are positioned as the starting point to one-sided tests for the mean tensor of a tensor normal distribution.

All the chapters in this book distinctly develop interesting application fields for matrix and tensor data. Finally, the authors would like to express their sincere appreciation to Prof. Akimichi Takemura for his encouragment to write this book, and to Japan Statistical Society for giving us this opportunity to publish it.

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