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Toshio Sakata *Editor*

Applied Matrix and Tensor Variate Data Analysis



Springer

Applied Matrix And Tensor Variate Data Analysis Springerbriefs In Statistics

Nickolay Trendafilov, Michele Gallo



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Applied Matrix and Tensor Variate Data Analysis Toshio Sakata, 2016-02-02 This book provides comprehensive reviews of recent progress in matrix variate and tensor variate data analysis from applied points of view. Matrix and tensor approaches for data analysis are known to be extremely useful for recently emerging complex and high dimensional data in various applied fields. The reviews contained herein cover recent applications of these methods in psychology. Chap 1 audio signals, Chap 2 image analysis from tensor principal component analysis, Chap 3 and image analysis from decomposition, Chap 4 and genetic data, Chap 5. Readers will be able to understand the present status of these techniques as applicable to their own fields. In Chapter 5, especially a theory of tensor normal distributions which is a basic in statistical inference is developed and multi-way regression, classification, clustering, and principal component analysis are exemplified under tensor normal distributions. Chapter 6 treats one-sided tests under matrix variate and tensor variate normal distributions whose theory under multivariate normal distributions has been a popular topic in statistics since the books of Barlow et al 1972 and Robertson et al 1988. Chapters 1, 5, and 6 distinguish this book from ordinary engineering books on these topics.

Tensor (multidimensional Array) Decomposition, Regression and Software for Statistics and Machine Learning James Yi-Wei Li, 2014 This thesis illustrates connections between statistical models for tensors, introduces a novel linear model for tensors with 3 modes, and implements tensor software in the form of an R package. Tensors or multidimensional arrays are a natural generalization of the vectors and matrices that are ubiquitous in statistical modeling. However, while matrix algebra has been well studied and plays a crucial role in the interaction between data and the parameters of any given model, algebra of higher order arrays has been relatively overlooked in data analysis and statistical theory. The emergence of multilinear datasets where observations are vector variate, matrix variate, or even tensor variate only serve to emphasize the relative lack of statistical understanding around tensor data structures. In the first half of the thesis, we highlight classic tensor algebraic results and models used in image analysis, chemometrics, and psychometrics, as well as connect them to recent statistical models. The second half of the thesis features a linear model that is based off a recently introduced tensor multiplication. For this model, we prove some of the classic properties that we would expect from a 3-tensor generalization of the matrix ordinary least squares. We also apply our model to a functional dataset to demonstrate one possible usage. We conclude this thesis with an exposition of the software developed to facilitate tensor modeling and manipulation in R. This software implements many of the classic tensor decomposition models as well as our own linear model.

User-Defined Tensor Data Analysis Bin Dong, Kesheng Wu, Suren Byna, 2021-10-31 The SpringerBrief introduces FasTensor, a powerful parallel data programming model developed for big data applications. This book also provides a user's guide for installing and using FasTensor. FasTensor enables users to easily express many data analysis operations which may come from neural networks, scientific computing, or queries from traditional database management systems (DBMS). FasTensor frees users from all underlying and

tedious data management tasks such as data partitioning communication and parallel execution This SpringerBrief gives a high level overview of the state of the art in parallel data programming model and a motivation for the design of FasTensor It illustrates the FasTensor application programming interface API with an abundance of examples and two real use cases from cutting edge scientific applications FasTensor can achieve multiple orders of magnitude speedup over Spark and other peer systems in executing big data analysis operations FasTensor makes programming for data analysis operations at large scale on supercomputers as productively and efficiently as possible A complete reference of FasTensor includes its theoretical foundations C implementation and usage in applications Scientists in domains such as physical and geosciences who analyze large amounts of data will want to purchase this SpringerBrief Data engineers who design and develop data analysis software and data scientists and who use Spark or TensorFlow to perform data analyses such as training a deep neural network will also find this SpringerBrief useful as a reference tool

Tensor Methods in Statistics P. McCullagh, 2018-01-18 This book provides a systematic development of tensor methods in statistics beginning with the study of multivariate moments and cumulants The effect on moment arrays and on cumulant arrays of making linear or affine transformations of the variables is studied Because of their importance in statistical theory invariant functions of the cumulants are studied in some detail This is followed by an examination of the effect of making a polynomial transformation of the original variables The fundamental operation of summing over complementary set partitions is introduced at this stage This operation shapes the notation and pervades much of the remainder of the book The necessary lattice theory is discussed and suitable tables of complementary set partitions are provided Subsequent chapters deal with asymptotic approximations based on Edgeworth expansion and saddlepoint expansion The saddlepoint expansion is introduced via the Legendre transformation of the cumulant generating function also known as the conjugate function of the cumulant generating function A recurring theme is that with suitably chosen notation multivariate calculations are often simpler and more transparent than the corresponding univariate calculations The final two chapters deal with likelihood ratio statistics maximum likelihood estimation and the effect on inferences of conditioning on ancillary or approximately ancillary statistics The Bartlett adjustment factor is derived in the general case and simplified for certain types of generalized linear models Finally Barndorff Nielsen's formula for the conditional distribution of the maximum likelihood estimator is derived and discussed More than 200 Exercises are provided to illustrate the uses of tensor methodology

Applied Matrix and Tensor Analysis John A. Eisele, Robert M. Mason, 1970

Tensor Computation for Data Analysis Yipeng Liu, Jiani Liu, Zhen Long, Ce Zhu, 2021-08-31 Tensor is a natural representation for multi dimensional data and tensor computation can avoid possible multi linear data structure loss in classical matrix computation based data analysis This book is intended to provide non specialists an overall understanding of tensor computation and its applications in data analysis and benefits researchers engineers and students with theoretical computational technical and experimental details It presents a systematic and up to date overview of tensor decompositions

from the engineer's point of view and comprehensive coverage of tensor computation based data analysis techniques. In addition, some practical examples in machine learning, signal processing, data mining, computer vision, remote sensing, and biomedical engineering are also presented for easy understanding and implementation. These data analysis techniques may be further applied in other applications on neuroscience, communication, psychometrics, chemometrics, biometrics, quantum physics, quantum chemistry, etc. The discussion begins with basic coverage of notations, preliminary operations in tensor computations, main tensor decompositions, and their properties. Based on them, a series of tensor based data analysis techniques are presented as the tensor extensions of their classical matrix counterparts, including tensor dictionary learning, low rank tensor recovery, tensor completion, coupled tensor analysis, robust principal tensor component analysis, tensor regression, logistical tensor regression, support tensor machine, multilinear discriminate analysis, tensor subspace clustering, tensor based deep learning, tensor graphical model, and tensor sketch. The discussion also includes a number of typical applications with experimental results, such as image reconstruction, image enhancement, data fusion, signal recovery, recommendation system, knowledge graph acquisition, traffic flow prediction, link prediction, environmental prediction, weather forecasting, background extraction, human pose estimation, cognitive state classification from fMRI, infrared small target detection, heterogeneous information networks clustering, multi view image clustering, and deep neural network compression.

Algebraic and Computational Aspects of Real Tensor Ranks Toshio Sakata, Toshio Sumi, Mitsuhiro Miyazaki, 2016-03-18. This book provides comprehensive summaries of theoretical algebraic and computational aspects of tensor ranks, maximal ranks, and typical ranks over the real number field. Although tensor ranks have been often argued in the complex number field, it should be emphasized that this book treats real tensor ranks which have direct applications in statistics. The book provides several interesting ideas, including determinant polynomials, determinantal ideals, absolutely nonsingular tensors, absolutely full column rank tensors, and their connection to bilinear maps and Hurwitz-Radon numbers. In addition to reviews of methods to determine real tensor ranks in details, global theories such as the Jacobian method are also reviewed in details. The book includes as well an accessible and comprehensive introduction of mathematical backgrounds with basics of positive polynomials and calculations by using the Groebner basis. Furthermore, this book provides insights into numerical methods of finding tensor ranks through simultaneous singular value decompositions.

Multivariate Data Analysis on Matrix Manifolds Nickolay Trendafilov, Michele Gallo, 2021-09-15. This graduate level textbook aims to give a unified presentation and solution of several commonly used techniques for multivariate data analysis (MDA). Unlike similar texts, it treats the MDA problems as optimization problems on matrix manifolds defined by the MDA model parameters, allowing them to be solved using free optimization software Manopt. The book includes numerous in-text examples as well as Manopt codes and software guides which can be applied directly or used as templates for solving similar and new problems. The first two chapters provide an overview and essential background for studying MDA, giving basic information and

notations Next it considers several sets of matrices routinely used in MDA as parameter spaces along with their basic topological properties A brief introduction to matrix Riemannian manifolds and optimization methods on them with Manopt complete the MDA prerequisite The remaining chapters study individual MDA techniques in depth The number of exercises complement the main text with additional information and occasionally involve open and or challenging research questions Suitable fields include computational statistics data analysis data mining and data science as well as theoretical computer science machine learning and optimization It is assumed that the readers have some familiarity with MDA and some experience with matrix analysis computing and optimization

Matrix and Tensor Factorization Techniques for Recommender Systems Panagiotis Symeonidis, Andreas Zioupos, 2017-02-06 This book presents the algorithms used to provide recommendations by exploiting matrix factorization and tensor decomposition techniques It highlights well known decomposition methods for recommender systems such as Singular Value Decomposition SVD UV decomposition Non negative Matrix Factorization NMF etc and describes in detail the pros and cons of each method for matrices and tensors This book provides a detailed theoretical mathematical background of matrix tensor factorization techniques and a step by step analysis of each method on the basis of an integrated toy example that runs throughout all its chapters and helps the reader to understand the key differences among methods It also contains two chapters where different matrix and tensor methods are compared experimentally on real data sets such as Epinions GeoSocialRec Last fm BibSonomy etc and provides further insights into the advantages and disadvantages of each method The book offers a rich blend of theory and practice making it suitable for students researchers and practitioners interested in both recommenders and factorization methods Lecturers can also use it for classes on data mining recommender systems and dimensionality reduction methods

Vector and tensor analysis Eutiquio C. Young, 1980

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