Tensor Techniques In Physics Learning Development Institute

Designing molecules and materials with desired properties is an important prerequisite for advancing technology in our modern societies. This requires both the ability to calculate accurate microscopic properties, such as energies, forces and electrostatic multipoles of specific configurations, as well as efficient sampling of potential energy surfaces to obtain corresponding macroscopic properties. Tools that can provide this are accurate first-principles calculations rooted in quantum mechanics, and statistical mechanics, respectively. Unfortunately, they come at a high computational cost that prohibits calculations for large systems and long time-scales, thus presenting a severe bottleneck both for searching the vast chemical compound space and the stupendously many dynamical configurations that a molecule can assume. To overcome this challenge, recently there have been increased efforts to accelerate quantum simulations with machine learning (ML). This emerging interdisciplinary community encompasses chemists, material scientists, physicists, mathematicians and computer scientists, joining forces to contribute to the exciting hot topic of progressing machine learning and AI for molecules and materials. The book that has emerged from a series of workshops provides a snapshot of this rapidly developing field. It contains tutorial material explaining the relevant foundations needed in chemistry, physics as well as machine learning to give an easy starting point for interested readers. In addition, a number of research papers defining the current state-of-the-art are included. The book has five parts (Fundamentals, Incorporating Prior Knowledge, Deep Learning of Atomistic Representations, Atomistic Simulations and Discovery and Design), each prefaced by editorial commentary that puts the respective parts into a broader scientific context.

Tensor network is a fundamental mathematical tool with a huge range of applications in physics, such as condensed matter physics, statistic physics, high energy physics, and quantum information sciences. This open access book aims to explain the tensor network contraction approaches in a systematic way, from the basic definitions to the important applications. This book is also useful to those who apply tensor networks in areas beyond physics, such as machine learning and the big-data analysis. Tensor network originates from the numerical renormalization group approach proposed by K.G. Wilson in 1975. Through a rapid development in the last two decades, tensor network has become a powerful numerical tool that can efficiently simulate a wide range of scientific problems, with particular success in quantum many-body physics. Varieties of tensor network algorithms have been proposed for different problems. However, the connections among different algorithms are not well discussed or reviewed. To fill this gap, this book explains the fundamental concepts and basic ideas that connect and/or unify different strategies of the tensor network contraction algorithms. In addition, some of the recent progresses in dealing with tensor decomposition techniques and quantum simulations are also represented in this book to help the readers to better understand tensor network. This open access book is intended for graduated students, but can also be used as a professional book for researchers in the related fields. To understand most of the contents in the book, only basic knowledge of quantum mechanics and linear algebra is required. In order to fully understand some advanced parts, the reader will need to be familiar with notion of condensed matter physics and quantum information, that however are not necessary to understand the main parts of the book. This book is a good source for non-specialists on quantum physics to understand tensor network algorithms and the related mathematics.

Volume 1: General Introduction to Molecular Sciences Volume 2: Physical Aspects of Molecular Systems Volume 3: Electronic Structure and Chemical Reactivity Volume 4: Molecular Phenomena in Biological Sciences

This book constitutes the refereed proceedings of the artificial intelligence in intelligent systems section of the 10th Computer Science Online Conference 2021 (CSOC 2021), held online in April 2021. Artificial intelligence in intelligent systems topics are presented in this book. Modern hybrid and bio-inspired algorithms and their application are discussed in selected papers.

Tensor calculus is a prerequisite for many tasks in physics and engineering. This book introduces the symbolic and the index notation side by side and offers easy access to techniques in the field by focusing on algorithms in index notation. It explains the required algebraic tools and contains numerous exercises with answers, making it suitable for self study for students and researchers in areas such as solid mechanics, fluid mechanics, and electrodynamics. ContentsAlgebraic ToolsTensor Analysis in Symbolic Notation and in Cartesian CoordinatesAlgebra of Second Order TensorsTensor Analysis in Curvilinear CoordinatesRepresentation of Tensor FunctionsAppendices: Solutions to the Problems; Cylindrical Coordinates and Spherical Coordinates

Tensor Network ContractionsMethods and Applications to Quantum Many-Body SystemsSpringer Nature

Graduate students receive a stimulating introduction to analytical approximation techniques for solving differential equations in this text, which introduces scientifically significant problems and indicates useful solutions. 1966 edition.

This comprehensive and well-organized book focusses on the phenomeno-logical aspects of Particle Physics. It strikes a fine balance between those texts that require sophisticated mathematical physics and those that are too elementary. For, unlike in many books on the subject, which give prominence to gauge theories, the attempt here is to lay stress on phenomenology _ an aspect that needs exposure among students of high energy physics.

A pioneering monograph on tensor methods applied to distributional problems arising in statistics, this work begins with the study of multivariate moments and cumulants. An invaluable reference for graduate students and professional statisticians. 1987 edition.

This book is about tensor analysis. It consists of 169 pages. The language and method used in presenting the ideas and techniques of tensors make it very suitable as a textbook or as a reference for an introductory course on tensor algebra and calculus or as a guide for self-studying and learning.

It is an ideal companion for courses such as mathematical methods of physics, classical mechanics, electricity and magnetism, and relativity.

Today, information technology plays a pivotal role in financial control and audit: most financial data is now digitally recorded and dispersed among servers, clouds and networks over which the audited firm has no control. Additionally, a firm's data—particularly in the case of finance, software, insurance and biotech firms— comprises most of the audited value of the firm. Financial audits are critical mechanisms for ensuring the integrity of information systems and the reporting of organizational finances. They help avoid the abuses that led to passage of legislation such as the Foreign Corrupt Practices Act (1977), and the Sarbanes-Oxley Act (2002). Audit effectiveness has declined over the past two decades as auditor skillsets have failed to keep up with advances in information technology. Information and communication technology lie at the core of commerce today and are integrated in business processes around the world. This book is designed to meet the increasing need of audit professionals to understand information technology and the controls required to manage it. The material included focuses on the requirements for annual Securities and Exchange Commission audits (10-K) for listed corporations. These represent the benchmark auditing procedures for specialized audits, such as internal, governmental, and attestation audits. Using R and RStudio, the book demonstrates how to render an audit opinion that is legally and statistically defensible; analyze, extract, and manipulate accounting data; build a risk assessment matrix to inform the conduct of a cost-effective audit program;

and more.

Clustering has emerged as one of the more fertile fields within data analytics, widely adopted by companies, research institutions, and educational entities as a tool to describe similar/different groups. The book Recent Applications in Data Clustering aims to provide an outlook of recent contributions to the vast clustering literature that offers useful insights within the context of modern applications for professionals, academics, and students. The book spans the domains of clustering in image analysis, lexical analysis of texts, replacement of missing values in data, temporal clustering in smart cities, comparison of artificial neural network variations, graph theoretical approaches, spectral clustering, multiview clustering, and model-based clustering in an R package. Applications of image, text, face recognition, speech (synthetic and simulated), and smart city datasets are presented.

This book introduces machine learning methods in finance. It presents a unified treatment of machine learning and various statistical and computational disciplines in quantitative finance, such as financial econometrics and discrete time stochastic control, with an emphasis on how theory and hypothesis tests inform the choice of algorithm for financial data modeling and decision making. With the trend towards increasing computational resources and larger datasets, machine learning has grown into an important skillset for the finance industry. This book is written for advanced graduate students and academics in financial econometrics, mathematical finance and applied statistics, in addition to quants and data scientists in the field of quantitative finance. Machine Learning in Finance: From Theory to Practice is divided into three parts, each part covering theory and applications. The first presents supervised learning for cross-sectional data from both a Bayesian and frequentist perspective. The more advanced material places a firm emphasis on neural networks, including deep learning, as well as Gaussian processes, with examples in investment management and derivative modeling. The second part presents supervised learning for time series data, arguably the most common data type used in finance with examples in trading, stochastic volatility and fixed income modeling. Finally, the third part presents reinforcement learning and its applications in trading, investment and wealth management. Python code examples are provided to support the readers' understanding of the methodologies and applications. The book also includes more than 80 mathematical and programming exercises, with worked solutions available to instructors. As a bridge to research in this emergent field, the final chapter presents the frontiers of machine learning in finance from a researcher's perspective, highlighting how many well-known concepts in statistical physics are likely to emerge as important methodologies for machine learning in finance.

Covering both theoretical foundations and applications in mathematics and engineering, this graduate textbook introduces numerical, tensor-based methods for tackling high-dimensional problems. Concepts known as tensor trains, matrix product states or hierarchical tensor networks have a range of applications in solving differential equations, multidimensional integration, machine learning, condensed matter physics, and theoretical chemistry.

This updated and extended edition of the book combines the topics provided in the two parts of the previous editions as well as new topics. It is a comprehensive compilation covering most areas in mathematical and theoretical physics. The book provides a collection of problems together with their detailed solutions which will prove to be valuable to students as well as to researchers in the fields of mathematics, physics, engineering and other sciences. Each chapter provides a short introduction with the relevant definitions and notations. All relevant definitions are given. The topics range in difficulty from elementary to advanced. Almost all problems are solved in detail and most of the problems are self-contained. Stimulating supplementary problems are also provided in each chapter. Students can learn important principles and strategies required for problem solving. Teachers will also find this text useful as a supplement, since important concepts and techniques are developed in the problems. Introductory problems for both undergraduate and advanced undergraduate students are provided. More advanced problems together with their detailed solutions are collected, to meet the needs of graduate students and researchers. Problems included cover new fields in theoretical and mathematical physics such as tensor product, Lax representation, Bäcklund transformation, soliton equations, Hilbert space theory, uncertainty relation, entanglement, spin systems, Lie groups, Bose system, Fermi systems differential forms, Lie algebra valued differential forms, metric tensor fields, Hirota technique, Painlevé test, Bethe ansatz, Yang-Baxter relation, wavelets, gauge theory, differential geometry, string theory, chaos, fractals, complexity, ergodic theory, etc. A number of software implementations are also provided.

The European Conference on e-Learning was established 17 years ago. It has been held in France, Portugal, England, The Netherlands, Greece and Denmark to mention only a few of the countries who have hosted it. ECEL is generally attended by participants from more than 40 countries and attracts an interesting combination of academic scholars, practitioners and individuals who are engaged in various aspects of e-Learning. Among other journals, the Electronic Journal of e-Learning publishes a special edition of the best papers presented at this conference.

The First Part Of This Book Begins With An Introduction To Matrices Through Linear Transformations On Vector Spaces, Followed By A Discussion On The Algebra Of Matrices, Special Matrices, Linear Equations, The Eigenvalue Problem, Bilinear And Quadratic Forms, Kronecker Sum And Product Of Matrices. Other Matrices Which Occur In Physics, Such As The Rotation Matrix, Pauli Spin Matrices And Dirac Matrices, Are Then Presented. A Brief Account Of Infinite Matrices From The Point Of View Of Matrix Formulation Of Quantum Mechanics Is Also Included. The Emphasis In This Part Is On Linear Dependence And Independence Of Vectors And Matrices, Linear Combinations, Independent Parameters Of Various Special Matrices And Such Other Concepts As Help The Student In Obtaining A Clear Understanding Of The Subject. A Simplified Proof Of The Theorem That A Common Set Of Eigenvectors Can Be Found For Two Commuting Matrices Is Given. The Second Part Deals With Cartesian And General Tensors. Many Physical Situations Are Discussed Which Require The Use Of Second And Higher Rank Tensors, Such As Effective Mass Tensor, Moment Of Inertia Tensor, Stress, Strain And Elastic Constants, Piezoelectric Strain Coefficient Tensor, Etc. Einsteins Summation Convention Is Explained In Detail And Common Errors Arising In Its Use Are Pointed Out. Rules For Checking The Correctness Of Tensor Equations Are Given. This Is Followed By Four-Vectors In Special Relativity And Covarient Formulation Of Electrodynamics. This Part Comes To An End With The Concept Of Parallel Displacement Of Vectors In Riemannian Space And Covariant Derivative Of Tensors, Leading To The Curvature Tensors And Its Properties.Appendix I Has Expanded And Two New Appendices Have Been Added In This Edition.

The second edition of this textbook presents the basic mathematical knowledge and skills that are needed for courses on modern theoretical physics, such as those on quantum mechanics, classical and quantum field theory, and related areas. The authors stress that learning mathematical physics is not a passive process and include numerous detailed proofs, examples, and over 200 exercises, as well as hints linking mathematical concepts and results to the relevant physical concepts and theories. All of the material from the first edition has been updated, and five new chapters have been added on such topics as distributions, Hilbert space operators, and variational methods. The text is divided into three parts: - Part I: A brief introduction to (Schwartz) distribution theory. Elements from the theories of ultra distributions and (Fourier) hyperfunctions are given in addition to some deeper results for Schwartz distributions, thus providing a rather comprehensive introduction to the theory of generalized functions. Basic properties and methods for distributions are developed with applications to constant coefficient ODEs and PDEs. The relation between distributions and holomorphic functions is considered, as well as basic properties of Sobolev spaces. - Part II: Fundamental facts about Hilbert spaces. The basic theory of linear (bounded and unbounded) operators in Hilbert spaces and special classes of linear operators - compact, Hilbert-Schmidt, trace class, and Schrödinger operators, as needed in quantum physics and quantum information theory – are explored. This section also contains a detailed spectral analysis of all major classes of linear operators, including completeness of generalized eigenfunctions, as well as of (completely) positive mappings, in particular quantum operations. - Part III: Direct methods of the calculus of variations and their applications to boundary- and eigenvalue-problems for linear and nonlinear partial differential operators. The authors conclude with a discussion of the Hohenberg-Kohn variational principle. The appendices contain proofs of more general and deeper results, including completions, basic facts about metrizable Hausdorff locally convex topological vector spaces, Baire's fundamental results and their main consequences, and bilinear functionals. Mathematical Methods in Physics is aimed at a broad community of graduate students in mathematics, mathematical physics, quantum information theory, physics and engineering, as well as researchers in these disciplines. Expanded content and relevant updates will make this new edition a valuable resource for those working in these disciplines.

Written by an experienced physicist who is active in applying computer algebra to relativistic astrophysics and education, this is the resource for mathematical methods in physics using MapleTM and MathematicaTM. Through in-depth problems from core courses in the physics curriculum, the author guides students to apply analytical and numerical techniques in mathematical physics, and present the results in interactive graphics. Around 180 simulating exercises are included to facilitate learning by examples. This book is a must-have for students of physics, electrical and mechanical engineering, materials scientists, lecturers in physics, and university libraries. * Free online MapleTM material at http://www.wiley-vch.de/templates/pdf/maplephysics.zip * Free online MathematicaTM material at http://www.wiley-vch.de/templates/pdf/physicswithmathematica.zip * Solutions manual for lecturers available at www.wiley-vch.de/supplements/

A standalone text for courses on computational physics combining idiomatic Python, foundational numerical methods, and physics applications.

This book presents tensors and differential geometry in a comprehensive and approachable manner, providing a bridge from the place where physics and engineering mathematics end, and the place where tensor analysis begins. Among the topics examined are tensor analysis, elementary differential geometry of moving surfaces, and k-differential forms. The book includes numerous examples with solutions and concrete calculations, which guide readers through these complex topics step by step. Mindful of the practical needs of engineers and physicists, book favors simplicity over a more rigorous, formal approach. The book shows readers how to work with tensors and differential geometry and how to apply them to modeling the physical and engineering world. The authors provide chapter-length treatment of topics at the intersection of advanced mathematics, and physics and engineering: • General Basis and Bra-Ket Notation • Tensor Analysis • Elementary Differential Geometry • Differential Forms • Applications of Tensors and Differential Geometry • Tensors and Bra-Ket Notation in Quantum Mechanics The text reviews methods and applications in computational fluid dynamics; continuum mechanics; electrodynamics in special relativity; cosmology in the Minkowski four-dimensional space time; and relativistic and non-relativistic quantum mechanics. Tensor Analysis and Elementary Differential Geometry for Physicists and Engineers benefits research scientists and practicing engineers in a variety of fields, who use tensor analysis and differential geometry in the context of applied physics, and electrical and mechanical engineering. It will also interest graduate students in applied physics and engineering.

"First published by Cappella Archive in 2008."

This book presents a selection of high-quality peer-reviewed research papers on various aspects of computer science and networks. It not only discusses emerging applications of currently available solutions, but also outlines potential future techniques and lines of research in pattern recognition, image processing and communications. Given its scope, the book will be of considerable interest to researchers, students and practitioners alike. All papers gathered here were presented at the Image Processing and Communications Conference, held in Bydgoszcz, Poland on September 11–13, 2019.

Tensor network is a fundamental mathematical tool with a huge range of applications in physics, such as condensed matter physics, statistic physics, high energy physics, and quantum information sciences. This open access book aims to explain the tensor network contraction approaches in a systematic way, from the basic definitions to the important applications. This book is also useful to those who apply tensor networks in areas beyond physics, such as machine learning and the big-data analysis. Tensor network originates from the numerical renormalization group approach proposed by K. G. Wilson in 1975. Through a rapid development in the last two decades, tensor network has become a powerful numerical tool that can efficiently simulate a wide range of scientific problems, with particular success in quantum many-body physics. Varieties of tensor network algorithms have been proposed for different problems. However, the connections among different algorithms are not well discussed or reviewed. To fill this gap, this book explains the fundamental concepts and basic ideas that connect and/or unify different strategies of the tensor network contraction algorithms. In addition, some of the recent progresses in dealing with tensor decomposition techniques and quantum simulations are also represented in this book to help the readers to better understand tensor network. This open access book is intended for graduated students, but can also be used as a professional book for researchers in the related fields. To understand most of the contents in the book, only basic knowledge of quantum mechanics and linear algebra is required. In order to fully understand some advanced parts, the reader will need to be familiar with notion of condensed matter physics and quantum information, that however are not necessary to understand the main parts of the book. This book is a good source for non-specialists on quantum physics to understand tensor network algorithms and the related mathematics. This work was published by Saint Philip Street Press pursuant to a Creative Commons license

Tensors provide a generalized structure to store arbitrary indexable data, which is applicable in fields such as chemometrics, physics simulations, signal processing and lies at the heart of machine learning. Many naturally occurring tensors are considered sparse as they contain mostly zero values. As with sparse matrices, various techniques can be employed to more efficiently store and compute on these sparse tensors. This work explores several sparse tensor formats while ultimately evaluating two implementations; one based on explicitly storing coordinates and one that compresses these coordinates. The two formats, Coordinate and CSF2, were evaluated by comparing their execution time of tensor-matrix products and the MTTKRP operation on several datasets. We find that the Coordinate format is superior for uniformly distributed sparse tensors or when used in computation that emits a sparse tensor via a mode dependent operation. In all other considered cases for large sparse tensors, the storage savings of the compressed format provide the best results.
This book contains a systematic exposition of the theory of spinors in finite-dimensional Euclidean and Riemannian spaces. The applications of spinors in field theory and relativistic mechanics of continuous media are considered. The main mathematical part is connected with the study of invariant algebraic and geometric relations between spinors and tensors. The theory of spinors and the methods of the tensor representation of spinors and spinor equations are

thoroughly expounded in four-dimensional and three-dimensional spaces. Very useful and important relations are derived that express the derivatives of the spinor fields in terms of the derivatives of various tensor fields. The problems associated with an invariant description of spinors as objects that do not depend on the choice of a coordinate system are addressed in detail. As an application, the author considers an invariant tensor formulation of certain classes of differential spinor equations containing, in particular, the most important spinor equations of field theory and quantum mechanics. Exact solutions of the Einstein–Dirac equations, nonlinear Heisenberg's spinor equations, and equations for relativistic spin fluids are given. The book presents a large body of factual material and is suited for use as a handbook. It is intended for specialists in theoretical physics, as well as for students and post-graduate students of physical and mathematical specialties.

This undergraduate textbook provides a simple, concise introduction to tensor algebra and analysis, as well as special and general relativity. With a plethora of examples, explanations, and exercises, it forms a well-rounded didactic text that will be useful for any related course. The book is divided into three main parts, all based on lecture notes that have been refined for classroom teaching over the past two decades. Part I provides students with a comprehensive overview of tensors. Part II links the very introductory first part and the relatively advanced third part, demonstrating the important intermediate-level applications of tensor analysis. Part III contains an extended discussion of general relativity, and includes material useful for students interested primarily in quantum field theory and quantum gravity. Tailored to the undergraduate, this textbook offers explanations of technical material not easily found or detailed elsewhere, including an understandable description of Riemann normal coordinates and conformal transformations. Future theoretical and experimental physicists, as well as mathematicians, will thus find it a wonderful first read on the subject.

A concise and up-to-date introduction to mathematical methods for students in the physical sciences Mathematical Methods in Physics, Engineering and Chemistry offers an introduction to the most important methods of theoretical physics. Written by two physics professors with years of experience, the text puts the focus on the essential math topics that the majority of physical science students require in the course of their studies. This concise text also contains worked examples that clearly illustrate the mathematical concepts presented and shows how they apply to physical problems. This targeted text covers a range of topics including linear algebra, partial differential equations, power series, Sturm-Liouville theory, Fourier series, special functions, complex analysis, the Green's function method, integral equations, and tensor analysis. This important text: Provides a streamlined approach to the subject by putting the focus on the mathematical topics that physical science students really need Offers a text that is different from the often-found definition-theorem-proof scheme Includes more than 150 worked examples that help with an understanding of the problems presented Presents a guide with more than 200 exercises with different degrees of difficulty Written for advanced undergraduate and graduate students of physics, materials science, and engineering, Mathematical Methods in Physics, Engineering and Chemistry includes the essential methods of theoretical physics. The text is streamlined to provide only the most important mathematical concepts that apply to physical problems.

Issues in Chemical Engineering and other Chemistry Specialties: 2013 Edition is a ScholarlyEditions™ book that delivers timely, authoritative, and comprehensive information about Chemical Modeling. The editors have built Issues in Chemical Engineering and other Chemistry Specialties: 2013 Edition on the vast information databases of ScholarlyNews.™ You can expect the information about Chemical Modeling in this book to be deeper than what you can access anywhere else, as well as consistently reliable, authoritative, informed, and relevant. The content of Issues in Chemical Engineering and other Chemistry Specialties: 2013 Edition has been produced by the world's leading scientists, engineers, analysts, research institutions, and companies. All of the content is from peer-reviewed sources, and all of it is written, assembled, and edited by the editors at ScholarlyEditions™ and available exclusively from us. You now have a source you can cite with authority, confidence, and credibility. More information is available at http://www.ScholarlyEditions.com/.

This book is intended for those students, engineers, scientists, and applied mathematicians who find it necessary to formulate models of diverse phenomena. To facilitate the formulation of such models, some aspects of the tensor calculus will be introduced. However, no knowledge of tensors is assumed. The chief aim of this calculus is the investigation of relations that remain valid in going from one coordinate system to another. The invariance of tensor quantities with respect to coordinate transformations can be used to advantage in formulating mathematical models. As a consequence of the geometrical simplification inherent in the tensor method, the formulation of problems in curvilinear coordinate systems can be reduced to series of routine operations involving only summation and differentiation. When conventional methods are used, the form which the equations of mathematical physics assume depends on the coordinate system used to describe the problem being studied. This dependence, which is due to the practice of expressing vectors in terms of their physical components, can be removed by the simple expedient of expressing all vectors in terms of their tensor components. For the benefit of those who have access to digital computers equipped with formula manipulation compilers, the convenience of computerized formulations will be demonstrated. No programming experience is necessary, and the few programming steps required will be explained as they occur. The first chapter is concerned with those aspects of the tensor calculus that are considered necessary for an understanding of later chapters. It is assumed that the reader has a knowledge of elementary vector analysis and matrix operations. The reader may encounter unfamiliar entities such as covariant and contravariant vectors and tensors, and unfamiliar operations such as covariant differentiation. It will be seen, however, that the only operations involved in applying these concepts to practical problems are summation, in accordance with the summation convention, and differentiation. In using tensor methods to formulate mathematical models, considerable insight is obtained and the striking similarity of all formulations of physical systems becomes apparent. This is due to the fact that all such formulations evolve from a fundamental metric which is simply an expression for the square of the distance between two adjacent points on a surface. Hence, in addition to its utility, the method advocated has a definite educational value. The major part of the book is devoted to applications using the theory given in the first chapter. The applications are chosen to demonstrate the feasibility of combining tensor methods and computer capability to formulate problems of interest to students, engineers, and theoretical physicists. Chapter 2 is devoted to aeronautical applications that culminate in the formulation of a mathematical model of an aeronautical system. In Chapter 3, the equations of motion of a particle are formulated in tensor form. The methods described in Chapter 4 can be used to formulate mathematical models involving fluid dynamics. The tensor theory contained in Chapter 1 is required to formulate the cosmological models described in Chapter 5. The final chapter describes how the symbol manipulation language MACSYMA may be used to assist in the formulation of mathematical models. The techniques described in this book represent an attempt to simplify the formulation of mathematical models by reducing the modeling process to a series of routine operations, which can be performed either manually or by computer. This attempt is part of a continuing effort in support of simulation experimentation in the Simulation Sciences Division

This volume presents, for the very first time, an exhaustive collection of those modern numerical methods specifically tailored for the analysis of Strongly Correlated Systems. Many novel materials, with functional properties emerging from macroscopic quantum behaviors at the frontier of modern research in physics, chemistry and material science, belong to this class of systems. Any technique is presented in great detail by its own inventor or by one of the world-wide recognized main contributors. The exposition has a clear pedagogical cut and fully reports on the most relevant case study where the specific technique showed to be very successful in describing and enlightening the puzzling physics of a particular strongly correlated system. The book is intended for advanced graduate students and post-docs in the field as textbook and/or main reference, but also for other researchers in the field who appreciate consulting a single, but comprehensive, source or wishes to get acquainted, in a as painless as possible way, with the working details of a specific technique.

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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.