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Quaternions and Rotation Sequences
Harmonic Analysis for Engineers and Applied Scientists
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Angular Momentum Theory for Diatomic Molecules
Problem Solving with Mathematica
Theory, Modeling, and Simulations

KIDD WU

Princeton University Press
There has been an increasing interest in multi-disciplinary research on multisensor attitude estimation technology driven by its versatility and diverse areas of application, such as sensor networks, robotics, navigation, video, biomedicine, etc. Attitude estimation consists of the determination of rigid bodies' orientation in 3D space. This research area is a multilevel, multifaceted process handling the automatic association, correlation, estimation, and combination of data and information from several sources. Data fusion for attitude estimation is motivated by several issues and problems, such as data imperfection, data multi-modality, data dimensionality, processing framework, etc. While many of these problems have been identified and heavily investigated, no single data fusion algorithm is capable of addressing all the aforementioned challenges. The variety of methods in the literature focus on a subset of these issues to solve, which would be determined based on the application in hand. Historically, the problem of attitude estimation has been introduced by Grace Wahba in 1965 within the estimate of satellite attitude and aerospace applications. This book intends to provide the reader with both a generic and comprehensive view of contemporary data fusion methodologies for attitude estimation, as well as the most recent researches and novel advances on multisensor attitude estimation task. It explores the design of algorithms and architectures, benefits, and challenging aspects, as well as a broad array of disciplines, including: navigation, robotics, biomedicine, motion analysis, etc. A number of issues that make data fusion for attitude estimation a challenging task, and which will be discussed through the different chapters of the book, are related to: 1) The nature of sensors and information sources (accelerometer, gyroscope, magnetometer, GPS, inclinometer, etc.); 2) The computational ability at the sensors; 3) The theoretical developments and convergence proofs; 4) The system architecture, computational resources, fusion level.

From Natural Numbers to Quaternions Dr. Marco A. V. Bitetto
This open access textbook presents a comprehensive treatment of the arithmetic theory of quaternion algebras and orders, a subject with applications in diverse areas of mathematics. Written to be accessible and approachable to the graduate student reader, this text collects and synthesizes results from across the literature. Numerous pathways offer explorations in many different directions, while the unified treatment makes this book an essential reference for students and researchers alike. Divided into five parts, the book begins with a basic introduction to the noncommutative algebra underlying the theory of quaternion algebras over fields, including the relationship to quadratic forms. An in-depth exploration of the arithmetic of quaternion algebras and orders follows. The third part considers analytic aspects, starting with zeta functions and then passing to an idelic approach, offering a pathway from local to global that includes strong approximation. Applications of unit groups of quaternion orders to hyperbolic geometry and low-dimensional topology follow, relating geometric and topological properties to arithmetic invariants. Arithmetic geometry completes the volume, including quaternionic aspects of modular forms, supersingular elliptic curves, and the moduli of QM abelian surfaces. Quaternion Algebras encompasses a vast wealth of knowledge at the intersection of many fields. Graduate students interested in algebra, geometry, and number theory will appreciate the many avenues and connections to be explored. Instructors will find numerous options for constructing introductory and advanced courses, while researchers will value the all-embracing treatment. Readers are assumed to have some familiarity with algebraic number theory and commutative algebra, as well as the fundamentals of linear algebra, topology, and complex analysis. More advanced topics call upon additional background, as noted, though essential concepts and motivation are recapped throughout.
Finite Rotation Shells Cambridge University Press
The standard model of subatomic particles and the periodic table of the atoms have the common goal to bring order in the bewildering chaos of the constituents of matter. Their success relies on the presence of fundamental symmetries in their core. The purpose of the book is to share the admiration for the power and the beauty of these symmetries. The reader is taken on a journey from the basic geometric symmetry group of a circle to the sublime dynamic symmetries that govern the motions of the particles. The trail follows the lines of parentage linking groups upstream to the unitary symmetry of the eightfold way of quarks, and to the four-dimensional symmetry of the hydrogen atom. Along the way the theory of symmetry groups is gradually introduced with special emphasis on graphical representations. The final challenge is to open up the structure of Mendeleev's table which goes beyond the symmetry of the hydrogen atom. Breaking this symmetry to accommodate the multi-electron atoms requires to leave the common ground of linear algebras and explore the potential of non-linearity.
Abstractionism Springer Science & Business Media
This book presents a new approach for the analysis of chaotic behavior in non-linear dynamical systems, in which output can be represented in quaternion parametrization. It offers a new family of methods for the analysis of chaos in the quaternion domain along with extensive numerical experiments performed on human motion data and artificial data. All methods and algorithms are designed to allow detection of deterministic chaos behavior in quaternion data representing the rotation of a body in 3D space. This book is an excellent reference for engineers, researchers, and postgraduate students conducting research on human gait analysis, healthcare informatics, dynamical systems with deterministic chaos or time series analysis.
Shattered Symmetry John Wiley & Sons
This detailed monograph treats finite point groups as subgroups of the full rotation group, providing geometrical and topological methods which allow a unique definition of the quaternion parameters for all operations. An important feature is an elementary but comprehensive discussion of projective representations and their application to the spinor representations, which yield great advantages in precision and accuracy over the more classical double group method. A self-contained treatment, with many solved problems to clarify key points, this monograph provides a powerful tool for handling rotations and double groups.

Essays in Philosophy of Mathematics CRC Press
Ever since the Irish mathematician William Rowan Hamilton introduced quaternions in the nineteenth century--a feat he celebrated by carving the founding equations into a stone bridge--mathematicians and engineers have been fascinated by these mathematical objects. Today, they are used in applications as various as describing the geometry of spacetime, guiding the Space Shuttle, and developing computer applications in virtual reality. In this book, J. B. Kuipers introduces quaternions for scientists and engineers who have not encountered them before and shows how they can be used in a variety of practical situations. The book is primarily an exposition of the quaternion, a 4-tuple, and its primary application in a rotation operator. But Kuipers also presents the more conventional and familiar 3 x 3 (9-element) matrix rotation operator. These parallel presentations allow the reader to judge which approaches are preferable for specific applications. The volume is divided into three main parts. The opening chapters present introductory material and establish the book's terminology and notation. The next part presents the mathematical properties of quaternions, including quaternion algebra and geometry. It includes more advanced special topics in spherical trigonometry, along with an introduction to quaternion calculus and perturbation theory, required in many situations involving dynamics and kinematics. In the final section, Kuipers discusses state-of-the-art applications. He presents a six degree-of-freedom electromagnetic position and orientation transducer and concludes by discussing the computer graphics necessary for the development of applications in virtual reality.
Orientations and Rotations Springer Science & Business Media
Essentially, Orientations and Rotations treats the mathematical and computational foundations of texture analysis. It contains an extensive and thorough introduction to parameterizations and geometry of the rotation space. Since the notions of orientations and rotations are of primary importance for science and engineering, the book can be useful for a very broad audience using rotations in other fields.
Rotations, Quaternions, and Double Groups World Scientific Publishing Company
This self-contained text presents a consistent description of the geometric and quaternionic treatment of rotation operators, employing methods that lead to a rigorous formulation and offering complete solutions to many illustrative problems. Geared toward upper-level undergraduates and graduate students, the book begins with chapters covering the fundamentals of symmetries, matrices, and groups, and it presents a primer on rotations and rotation matrices. Subsequent chapters explore rotations and angular momentum, tensor bases, the bilinear transformation, projective representations, and the geometry, topology, and algebra of rotations. Some familiarity with the basics of group theory is assumed, but the text assists students in developing the requisite mathematical tools as necessary.
Hyperspatial Dynamics Rotations, Quaternions, and Double Groups
Here is a detailed, self-contained work on the rotation and Lorentz groups and their representations. Treatment of the structure of the groups is elaborate and includes many new results only recently published in journals. The chapter on linear vector spaces is exhaustive yet clear, and the book highlights the fact that all results of the orthosynchronous proper Lorentz group may be obtained from those of the rotation group via complex quaternions. The approach is unified, and special properties and exceptional cases are addressed.
Volume 2 Relativistic Effects in Atoms and Molecules Springer
This dissertation has as its central focus the study of hyperspatial dynamics and as such makes use of mathematics in such an understanding and also the MAXYMA artificial intelligence computer simulation and programming language. As such, it will both discuss the use of MAXYMA in the understanding of hyperspatial dynamics and also include MAXYMA programs as well. This dissertation will conclude with a discussion of hyperspace and how one can travel through hyperspace and why one would want to travel through hyperspace.
Group Theory with Applications in Chemical Physics CRC Press
Introduced 160 years ago as an attempt to generalize complex numbers to higher dimensions, quaternions are now recognized as one of the most important concepts in modern computer graphics. They offer a powerful way to represent rotations and compared to rotation matrices they use less memory, compose faster, and are naturally suited for efficient interpolation of rotations. Despite this, many practitioners have avoided quaternions because of the mathematics used to understand them, hoping that some day a more intuitive description will be available. The wait is over. Andrew Hanson's new book is a fresh perspective on quaternions. The first part of the book focuses on visualizing quaternions to provide the intuition necessary to use them, and includes many illustrative examples to motivate why they are important—a beautiful introduction to those wanting to explore quaternions unencumbered by their mathematical aspects. The second part covers the all-important advanced applications, including quaternion curves, surfaces, and volumes. Finally, for those wanting the full story of the mathematics behind quaternions, there is a gentle introduction to their four-dimensional nature and to Clifford Algebras, the all-encompassing framework for vectors and quaternions. Richly illustrated introduction for the developer, scientist, engineer, or student in computer graphics, visualization, or entertainment computing. Covers both non-mathematical and mathematical approaches to quaternions.
Selections from The Mathematical Intelligencer Springer
The book deals with kinematics of mechanisms. It focuses on a solid theoretical foundation and on mathematical methods applicable to the solution of problems of very diverse nature. Applications are demonstrated in a large number of fully worked-out problems. In kinematics a wide variety of mathematical tools is applicable. In this book, wherever possible vector equations are formulated instead of lengthy scalar coordinate equations. The principle of transference is applied to problems of very diverse nature. 15 chapters of the book are devoted to spatial kinematics and three chapters to planar kinematics. In Chapt. 19 nonlinear dynamics equations of motion are formulated for general spatial mechanisms. Nearly one half of the book is dealing with position theory and the other half with motion. The book is intended for use as reference book for researchers and as textbook in advanced courses on kinematics of mechanisms.
On Quaternions and Octonions Springer
This book investigates the geometry of quaternion and octonion algebras. Following a comprehensive historical introduction, the book illuminates the special properties of 3- and 4-dimensional Euclidean spaces using quaternions, leading to enumerations of the corresponding finite groups of symmetries. The second half of the book discusses the less f
Fundamental Concepts and Applications Springer Science & Business Media

Sir William Rowan Hamilton was a genius, and will be remembered for his significant contributions to physics and mathematics. The Hamiltonian, which is used in quantum physics to describe the total energy of a system, would have been a major achievement for anyone, but Hamilton also invented quaternions, which paved the way for modern vector analysis. Quaternions are one of the most documented inventions in the history of mathematics, and this book is about their invention, and how they are used to rotate vectors about an arbitrary axis. Apart from introducing the reader to the features of quaternions and their associated algebra, the book provides valuable historical facts that bring the subject alive. Quaternions for Computer Graphics introduces the reader to quaternion algebra by describing concepts of sets, groups, fields and rings. It also includes chapters on imaginary quantities, complex numbers and the complex plane, which are essential to understanding quaternions. The book contains many illustrations and worked examples, which make it essential reading for students, academics, researchers and professional practitioners.

Group Theory From the Eightfold Way to the Periodic Table Springer

Thisvolume isdevotedtomethodsfor thestudyoftheeffectsofrelativity on theelectronicstructure ofatomsand molecules. The accurate descrip tionofrelativisticeffectsinheavyatomshaslongbeenrecognizedason eof the central problems ofatomic physics. Contemporary relativistic atomic structure calculations can be performed almost routinely. Recent years have seen agrowinginterestin thestudyoftheeffects ofrelativityon the structureofmolecules. Even for molecularsystemscontainingatoms from thesecondrowoftheperiodictable theenergyassociatedwith relativistic effects is often larger than that arising from electron correlation. For moleculescontainingheavieratoms relativistic effects become increasingly important, andforsystemscontainingveryheavyatomsrelativityisknown todominatemanychemicalproperties. In this volum, one of the pioneers of relativistic atomic structure calculations, Ian P. Grant, providesadetailedsurveyofthecomputational techniquesemployedincontemporarystudiesoftheeffectsofrelativity on atomicstructure.

Thisisanareaofresearchinwhichcalculationscanoften lead to a particularly impressive degreeofagreement between theoryand experiment. Furthermore, theseatomicstudies haveprovided manyofthe foundations of a fully relativistic quantum chemistry. However, the spherical symmetry ofatoms allows significantsimplificationsto bemade in their quantum mechanical treatment, simplifications which are not possibleinstudiesofmolecules. Inparticular, as is wellknown from non relativistictheoriesofmolecularelectronicstructure, itisalmostobligatory to invoke the algebraic approximation in molecular work and use finite basis set expansions. The problem of describing relativistic effects in molecules is addressed in Chapter2 by Stephen Wilson. This chapter is devotedtoab initiorelativisticmolecularstructurecalculationsinwhichall electrons are explicitly considered. The problem of induding relativistic effects in molecular studies is also addressed in Chapters3 and 4. In Chapter 3, Odd Gropen describes the use of relativistic effective core ix x Preface potentials in calculations on molecular systems involving heavy atoms. This approach can lead to more tractable algorithms than the methods described in Chapter2 and thus significantly extends the range of applications. The use of semiempirical methods has yielded a wealth of informationabouttheinfluenceofrelativityonthechemistryoftheheav ier elements. Thisimportantarea is reviewed inChapter4 by Pekka Pyykk6. Finally, inChapter5, Harry M."

Applications of Geometric Algebra in Computer Science and Engineering John Wiley & Sons

While group theory and its application to solid state physics is well established, this textbook raises two completely new aspects. First, it provides a better understanding by focusing on problem solving and making extensive use of Mathematica tools to visualize the concepts. Second, it offers a new tool for the photonics community by transferring the concepts of group theory and its application to photonic crystals. Clearly divided into three parts, the first provides the basics of group theory. Even at this stage, the authors go beyond the widely used standard examples to show the broad field of applications. Part II is devoted to applications in condensed matter physics, i.e. the electronic structure of materials. Combining the application of the computer algebra system Mathematica with pen and paper derivations leads to a better and faster understanding. The exhaustive discussion shows that the basics of group theory can also be applied to a totally different field, as seen in Part III. Here, photonic applications are discussed in parallel to the electronic case, with the focus on photonic crystals in two and three dimensions, as well as being partially expanded to other problems in the field of photonics. The authors have developed Mathematica package GTPack which is available for download from the book's homepage. Analytic considerations, numerical calculations and visualization are carried out using the same software. While the use of the Mathematica tools are demonstrated on elementary examples, they can equally be applied to more complicated tasks resulting from the reader's own research.

Mathematical Conversations Courier Corporation

Rotations, Quaternions, and Double GroupsCourier Corporation

Methods in Computational Chemistry Oxford University Press

This book introduces systematically the eigenfunction method, a new approach to the group representation theory which was developed by the authors in the 1970's and 1980's in accordance with the concept and method used in quantum mechanics. It covers the applications of the group theory in various branches of physics and quantum chemistry, especially nuclear and molecular physics. Extensive tables and computational methods are presented. Group Representation Theory for Physicists may serve as a handbook for researchers doing group theory calculations. It is also a good reference book and textbook for undergraduate and graduate students who intend to use group theory in their future research careers.

Radiolocation in Ubiquitous Wireless Communication John Wiley & Sons

Matrix groups touch an enormous spectrum of the mathematical arena. This textbook brings them into the undergraduate curriculum. It makes an excellent one-semester course for students familiar with linear and abstract algebra and prepares them for a graduate course on Lie groups. Matrix Groups for Undergraduates is concrete and example-driven, with geometric motivation and rigorous proofs. The story begins and ends with the rotations of a globe. In between, the author combines rigor and intuition to describe the basic objects of Lie theory: Lie algebras, matrix exponentiation, Lie brackets, maximal tori, homogeneous spaces, and roots. This second edition includes two new chapters that allow for an easier transition to the general

theory of Lie groups.
Visualizing Quaternions Springer Science & Business Media Approximately fifty articles that were published in The Mathematical Intelligencer during its first eighteen years. The selection demonstrates the wide variety of attractive articles that have appeared over the years, ranging from general interest articles of a historical nature to lucid expositions of important current discoveries. Each article is introduced by the editors. "...The Mathematical Intelligencer publishes stylish, well-illustrated articles, rich in ideas and usually short on proofs. ...Many, but not all articles fall within the reach of the advanced undergraduate mathematics major. ... This book makes a nice addition to any undergraduate mathematics collection that does not already sport back issues of The Mathematical Intelligencer." D.V. Feldman, University of New Hamphire, CHOICE Reviews, June 2001.