

Fractional Calculus View of Complexity

Tomorrow's Science

Bruce J. West



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Fractional Calculus View Of Complexity Tomorrows Science

YangQuan Chen



Fractional Calculus View Of Complexity Tomorrows Science:

Fractional Calculus View of Complexity Bruce J. West, 2016-01-05 This book is not a text devoted to a pedagogical presentation of a specialized topic nor is it a monograph focused on the author's area of research. It accomplishes both these things while providing a rationale for why the reader ought to be interested in learning about fractional calculus. This book is for researchers who have heard about many *Complex Systems in the Social and Behavioral Sciences* L. Douglas Kiel, Euel W. Elliott, 2021-06-22 *Complexity Systems in the Social and Behavioral Sciences* provides a sophisticated yet accessible account of complexity science or complex systems research. Phenomena in the behavioral, social, and hard sciences all exhibit certain important similarities consistent with complex systems. These include the concept of emergence, sensitivity to initial conditions, and interactions between agents in a system that yield unanticipated nonlinear outcomes. The topics discussed range from the implications for artificial intelligence and computing to questions about how to model complex systems through agent-based modeling to complex phenomena exhibited in international relations and in organizational behavior. This volume will be an invaluable addition for both the general reader and the specialist, offering new insights into this fascinating area of research. **Basic Theory** Anatoly Kochubei, Yuri Luchko, 2019-02-19 This multi-volume handbook is the most up-to-date and comprehensive reference work in the field of fractional calculus and its numerous applications. This first volume collects authoritative chapters covering the mathematical theory of fractional calculus, including fractional order operators, integral transforms, and equations, special functions, calculus of variations, and probabilistic and other aspects.

Contemporary Computational Mathematics - A Celebration of the 80th Birthday of Ian Sloan Josef Dick, Frances Y. Kuo, Henryk Woźniakowski, 2018-05-23 This book is a tribute to Professor Ian Hugh Sloan on the occasion of his 80th birthday. It consists of nearly 60 articles written by international leaders in a diverse range of areas in contemporary computational mathematics. These papers highlight the impact and many achievements of Professor Sloan in his distinguished academic career. The book also presents state-of-the-art knowledge in many computational fields such as quasi-Monte Carlo and Monte Carlo methods for multivariate integration, multi-level methods, finite element methods, uncertainty quantification, spherical designs, and integration on the sphere, approximation and interpolation of multivariate functions, oscillatory integrals, and in general, information-based complexity and tractability, as well as in a range of other topics. The book also tells the life story of the renowned mathematician, family man, colleague, and friend who has been an inspiration to many of us. The reader may especially enjoy the story from the perspective of his family: his wife, his daughter, and son, as well as grandchildren who share their views of Ian. The clear message of the book is that Ian H. Sloan has been a role model in science and life. **Crucial Event Rehabilitation Therapy** Bruce J. West, Paolo Grigolini, Mauro Bologna, 2023-11-30 This book describes a new strategy for rehabilitation from injury and/or disease using Crucial Event Therapy. Recent studies have shown that individuals can recuperate more rapidly from surgery and other invasive procedures intended to correct the negative effects of disease or

injury through the use of life support systems that operate at the body's natural biofrequencies. The same observation has been clinically shown to reverse the degenerative effects of neurodegenerative diseases such as Parkinson's and Alzheimer's Disease. Crucial Event Therapy describes medicine as the operational control of the functions of the human body treated as a network of networks with 1/f variable crucial events coding the dynamic states of health and disease through information flow within a network and information exchange between biomedical networks. A new way of thinking based on the statistics of Cortical Events is presented and the relevant literature is suitably referenced. This is an ideal book for biophysicists and data scientists seeking to understand the connection of complexity measures for the study of consciousness with the clinical aspects of designing a rehabilitation strategy. **On the Fractal Language of Medicine** Bruce J. West, W. Alan C.

Mutch, 2024-07-17 *On the Fractal Language of Medicine* bridges a very clear gap among the knowledge gained over the last 20 years in the physical and life sciences on network theory, organ synchronicity and communication, the understanding of fractal signatures in health and disease and the importance of fractional calculus in integrating these concepts. The authors opine that the field of medicine has not appreciated this hard won knowledge and has suffered greatly as a result. This book addresses this perceived deficiency by introducing medical researchers, clinicians, residents, first year medical students and members of allied fields to the work of the so-called hard sciences. It seeks to facilitate effective communication between empiricists and theorists by making interdisciplinary efforts to explain complex mathematical concepts to physicians and equally important to elucidate complex medical concepts to physicists or mathematicians. This book will be of great interest to medical students, professionals and academics as well as students and researchers of applied mathematics, especially those interested in fractional calculus and fractals. [Network physiology, insights in systems interactions and organ networks:](#)

2021 Plamen Ch. Ivanov, 2023-06-06 **Smart Big Data in Digital Agriculture Applications** Haoyu Niu, YangQuan Chen, 2024-02-28 In the dynamic realm of digital agriculture, the integration of big data acquisition platforms has sparked both curiosity and enthusiasm among researchers and agricultural practitioners. This book embarks on a journey to explore the intersection of artificial intelligence and agriculture, focusing on small unmanned aerial vehicles (UAVs), unmanned ground vehicles (UGVs), edge AI sensors and the profound impact they have on digital agriculture, particularly in the context of heterogeneous crops such as walnuts, pomegranates, cotton, etc. For example, lightweight sensors mounted on UAVs, including multispectral and thermal infrared cameras, serve as invaluable tools for capturing high-resolution images. Their enhanced temporal and spatial resolutions, coupled with cost-effectiveness and near real-time data acquisition, position UAVs as an optimal platform for mapping and monitoring crop variability in vast expanses. This combination of data acquisition platforms and advanced analytics generates substantial datasets, necessitating a deep understanding of fractional order thinking, which is imperative due to the inherent complexity and consequent variability within the agricultural process. Much optimism is vested in the field of artificial intelligence, such as machine learning (ML) and computer vision (CV), where the efficient

utilization of big data to make it smart is of paramount importance in agricultural research Central to this learning process lies the intricate relationship between plant physiology and optimization methods The key to the learning process is the plant physiology and optimization method Crafting an efficient optimization method raises three pivotal questions 1 What represents the best approach to optimization 2 How can we achieve a more optimal optimization 3 Is it possible to demand more optimal machine learning exemplified by deep learning while minimizing the need for extensive labeled data for digital agriculture This book details the foundations of the plant physiology informed machine learning PPIML and the principle of tail matching POTM framework It is the 9th title of the Agriculture Automation and Control book series published by Springer

Towards Tree-level Evapotranspiration Estimation with Small UAVs in Precision Agriculture Haoyu Niu, Yangquan Chen, 2022-10-27 Estimating evapotranspiration ET has been one of the most critical research areas in agriculture because of water scarcity the growing population and climate change The accurate estimation and mapping of ET are necessary for crop water management Traditionally researchers use water balance soil moisture weighing lysimeters or an energy balance approach such as Bowen ratio or eddy covariance towers to estimate ET However these ET methods are point specific or area weighted measurements and cannot be extended to a large scale On the other hand while remote sensing is able to provide spatially distributed measurements the spatial resolution of multispectral satellite images is often not enough for crops with clumped canopy structures such as trees and vines Unmanned aerial vehicles UAVs can mitigate these spatial and temporal limitations Lightweight cameras and sensors can be mounted on the UAVs and take high resolution images Unlike satellite imagery the spatial resolution of the UAV images can be at the centimeter level UAVs can also fly on demand which provides high temporal imagery This book examines the different UAV based approaches of ET estimation Models and algorithms such as mapping evapotranspiration at high resolution with internalized calibration METRIC the two source energy balance TSEB model and machine learning ML are discussed It also covers the challenges and opportunities for UAVs in ET estimation with the final chapters devoted to new ET estimation methods and their potential applications for future research

Nature's Patterns and the Fractional Calculus Bruce J. West, 2017-09-11 Complexity increases with increasing system size in everything from organisms to organizations The nonlinear dependence of a system's functionality on its size by means of an allometry relation is argued to be a consequence of their joint dependency on complexity information In turn complexity is proven to be the source of allometry and to provide a new kind of force entailed by a system's information gradient Based on first principles the scaling behavior of the probability density function is determined by the exact solution to a set of fractional differential equations The resulting lowest order moments in system size and functionality gives rise to the empirical allometry relations Taking examples from various topics in nature the book is of interest to researchers in applied mathematics as well as investigators in the natural social physical and life sciences

Contents Complexity Empirical allometry Statistics scaling and simulation Allometry theories Strange kinetics Fractional

probability calculus **Fractional Calculus and the Future of Science** Bruce J. West, 2022 Newton foresaw the limitations of geometry's description of planetary behavior and developed fluxions differentials as the new language for celestial mechanics and as the way to implement his laws of mechanics Two hundred years later Mandelbrot introduced the notion of fractals into the scientific lexicon of geometry dynamics and statistics and in so doing suggested ways to see beyond the limitations of Newton's laws Mandelbrot's mathematical essays suggest how fractals may lead to the understanding of turbulence viscoelasticity and ultimately to end of dominance of the Newton's macroscopic world view Fractional Calculus and the Future of Science examines the nexus of these two game changing contributions to our scientific understanding of the world It addresses how non integer differential equations replace Newton's laws to describe the many guises of complexity most of which lay beyond Newton's experience and many had even eluded Mandelbrot's powerful intuition The book's authors look behind the mathematics and examine what must be true about a phenomenon's behavior to justify the replacement of an integer order with a noninteger order fractional derivative This window into the future of specific science disciplines using the fractional calculus lens suggests how what is seen entails a difference in scientific thinking and understanding

Fractional Calculus and the Future of Science Bruce J West, 2022-04-22 Newton foresaw the limitations of geometry's description of planetary behavior and developed fluxions differentials as the new language for celestial mechanics and as the way to implement his laws of mechanics Two hundred years later Mandelbrot introduced the notion of fractals into the scientific lexicon of geometry dynamics and statistics and in so doing suggested ways to see beyond the limitations of Newton's laws Mandelbrot's mathematical essays suggest how fractals may lead to the understanding of turbulence viscoelasticity and ultimately to end of dominance of the Newton's macroscopic world view Fractional Calculus and the Future of Science examines the nexus of these two game changing contributions to our scientific understanding of the world It addresses how non integer differential equations replace Newton's laws to describe the many guises of complexity most of which lay beyond Newton's experience and many had even eluded Mandelbrot's powerful intuition The book's authors look behind the mathematics and examine what must be true about a phenomenon's behavior to justify the replacement of an integer order with a noninteger order fractional derivative This window into the future of specific science disciplines using the fractional calculus lens suggests how what is seen entails a difference in scientific thinking and understanding

Fractional Calculus for Skeptics I Bruce J. West, YangQuan Chen, 2024-05-16 This book is the first of its kind on fractional calculus FC dedicated to advocating for FC in STEM education and research Fractional calculus is increasingly used today but there remains a core population of skeptics regarding the utility of this new calculus This book is intended for those who are skeptical about the need for fractional calculus to describe dynamic complex networks and must be convinced of its use on a case by case basis It is a one stop resource to rapidly read and replace the appropriate skepticism with new knowledge It offers compelling reasons from the perspectives of the physical social and life sciences as

to why fractional calculus is needed when addressing the complexity of an underlying STEM phenomenon The six chapters are accompanied by useful and essential appendices and chapter end references Each includes new fractional order ways of thinking about statistics complexity dynamics and what constitutes a solution to a complexity science problem The book will appeal to students and researchers in all STEM related fields such as engineering physics biology and biomedicine climate change big data and machine learning It is also suitable for general readers interested in these fields [Current Index to Journals in Education](#) ,1983-07

Fractional Calculus: An Introduction For Physicists (2nd Edition) Richard Herrmann,2014-01-03 The book presents a concise introduction to the basic methods and strategies in fractional calculus and enables the reader to catch up with the state of the art in this field as well as to participate and contribute in the development of this exciting research area The contents are devoted to the application of fractional calculus to physical problems The fractional concept is applied to subjects in classical mechanics group theory quantum mechanics nuclear physics hadron spectroscopy and quantum field theory and it will surprise the reader with new intriguing insights This new extended edition now also covers additional chapters about image processing folded potentials in cluster physics infrared spectroscopy and local aspects of fractional calculus A new feature is exercises with elaborated solutions which significantly supports a deeper understanding of general aspects of the theory As a result this book should also be useful as a supporting medium for teachers and courses devoted to this subject [Nature's Patterns and the Fractional Calculus](#) Bruce J.

West,2017 Complexity increases with increasing system size in everything from organisms to organizations The nonlinear dependence of a system s functionality on its size by means of an allometry relation is argued to be a consequence of their joint dependency on complexity information In turn complexity is proven to be the source of allometry and to provide a new kind of force entailed by a system s information gradient Based on first principles the scaling behavior of the probability density function is determined by the exact solution to a set of fractional differential equations The resulting lowest order moments in system size and functionality gives rise to the empirical allometry relations Taking examples from various topics in nature the book is of interest to researchers in applied mathematics as well as investigators in the natural social physical and life sciences ContentsComplexityEmpirical allometryStatistics scaling and simulationAllometry theoriesStrange

kineticsFractional probability calculus **Fractional Calculus in Medical and Health Science** Devendra Kumar,Jagdev Singh,2020-07-09 This book covers applications of fractional calculus used for medical and health science It offers a collection of research articles built into chapters on classical and modern dynamical systems formulated by fractional differential equations describing human diseases and how to control them The mathematical results included in the book will be helpful to mathematicians and doctors by enabling them to explain real life problems accurately The book will also offer case studies of real life situations with an emphasis on describing the mathematical results and showing how to apply the results to medical and health science and at the same time highlighting modeling strategies The book will be useful to

graduate level students educators and researchers interested in mathematics and medical science

Fractional Calculus for Skeptics Bruce J. West, YangQuan Chen, 2024 This book is the first of its kind on fractional calculus FC dedicated to advocating for FC in STEM education and research Fractional calculus is increasingly used today but there remains a core population of skeptics regarding the utility of this new calculus This book is intended for those who are skeptical about the need for fractional calculus to describe dynamic complex networks and must be convinced of its use on a case by case basis It is a one stop resource to rapidly read and replace the appropriate skepticism with new knowledge It offers compelling reasons from the perspectives of the physical social and life sciences as to why fractional calculus is needed when addressing the complexity of an underlying STEM phenomenon The six chapters are accompanied by useful and essential appendices and chapter end references Each includes new fractional order ways of thinking about statistics complexity dynamics and what constitutes a solution to a complexity science problem The book will appeal to students and researchers in all STEM related fields engineering physics biology and biomedicine climate change big data machine learning etc It is also suitable for general readers interested in these fields

Fractional Calculus for Complex Systems YangQuan Chen, 2019-06-28 This volume in the Encyclopedia of Complexity and Systems Science Second Edition offers a detailed account of fractional calculus tools signatures of complex systems hidden connections to fractional calculus and applications and case studies involving fractional calculus in complex signal analysis and complex system modelling analysis and control MAD The authors document both the foundational concepts of fractional calculus in complexity science as well as their applications to and role in the optimization of complex engineered systems Fractional calculus is about differentiation and integration of non integer orders Convenience has driven the use of integer order models and controllers for complex natural or man made systems but these traditional models and tools for the control of dynamic systems may result in suboptimum performance and even anomalous behavior In contrast a growing literature documents more optimal performance when fractional order calculus tools are applied From an engineering point of view new and beneficial uses of this versatile mathematical tool are both possible and important and may become an enabler of new scientific discoveries

Fractional Calculus: Models And Numerical Methods (Second Edition) Juan J Trujillo, Enrico Scalas, Kai Diethelm, Dumitru Baleanu, 2016-09-15 This book will give readers the possibility of finding very important mathematical tools for working with fractional models and solving fractional differential equations such as a generalization of Stirling numbers in the framework of fractional calculus and a set of efficient numerical methods Moreover we will introduce some applied topics in particular fractional variational methods which are used in physics engineering or economics We will also discuss the relationship between semi Markov continuous time random walks and the space time fractional diffusion equation which generalizes the usual theory relating random walks to the diffusion equation These methods can be applied in finance to model tick by tick log price fluctuations in insurance theory to study ruin as well as in macroeconomics as prototypical growth models All these topics are

complementary to what is dealt with in existing books on fractional calculus and its applications This book will keep in mind the trade off between full mathematical rigor and the needs of readers coming from different applied areas of science and engineering In particular the numerical methods listed in the book are presented in a readily accessible way that immediately allows the readers to implement them on a computer in a programming language of their choice The second edition of the book has been expanded and now includes a discussion of additional newly developed numerical methods for fractional calculus and a chapter on the application of fractional calculus for modeling processes in the life sciences

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