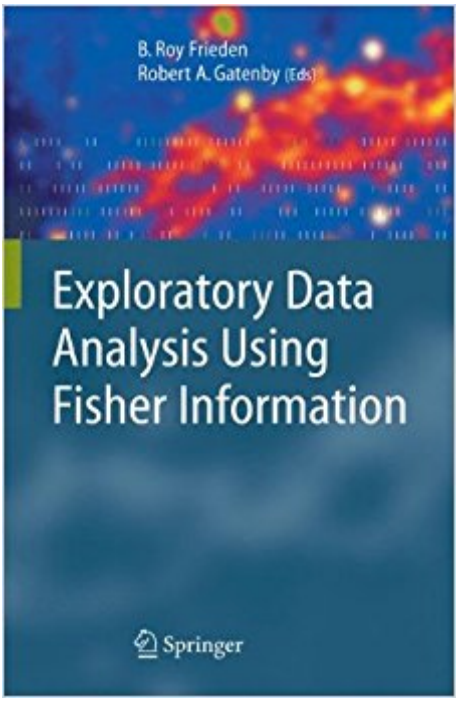
Exploratory Data Analysis Using Fisher Information



Synopsis

This book uses a mathematical approach to deriving the laws of science and technology, based upon the concept of Fisher information. The approach that follows from these ideas is called the principle of Extreme Physical Information (EPI). The authors show how to use EPI to determine the theoretical input/output laws of unknown systems. Will benefit readers whose math skill is at the level of an undergraduate science or engineering degree.

Book Information

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Customer Reviews

From the reviews: "Roy Frieden has been exploring the consequences of studying physical phenomena on the basis of Fisher information and extreme physical information Ã¢â ¬Â¦ . therefore wish to emphasize that the truly original feature of this book Ã¢â ¬Â¦ is precisely its broad coverage; its demonstration that such a simple principle, easily grasped, is capable of yielding valuable results in such a wide range of fields of enquiry. I found FriedenÃ¢â ¬â„¢s earlier books immensely original and intellectually thrilling and this one adds yet more weight to that opinion." (P. W. Hawkes, www..com, October, 2007) "I personally have used and exploited the Fisher information theme in numerous papers related to quantum mechanics and relativity, in particular via relations of FI to the quantum potential. I would even say that this theme seems to have Ã¢â ¬Ëœcosmic significanceÃ¢â ¬â„¢ and in the present arena of information technology, processing, retrieval, and distortion the book should be considered as must reading." (Robert Carroll, www..com, October, 2007) "The book begins with an introduction by Frieden, which covers Fisher information and its

uses when employing the EPI approach. Ã¢â ¬Â¦ This fascinating book is well organized, written in a careful and systematic way, and contains much new material. It will be useful to those interested in information technology (IT), processing, retrieval, and distortion. It is an excellent source of information for the study and research of exploratory data analysis." (P. R. Parthasarathy, ACM Computing Reviews, Vol. 49 (8), August, 2008)

The basic goal of a research scientist is to understand a given, unknown system. This innovative book develops a systematic approach for achieving this goal. All science is ultimately dependent upon observation which, in turn, requires a flow of information. Fisher information, in particular, is found to provide the key to understanding the system. It is developed as a new tool of exploratory data analysis, and is applied to a wide scope of systems problems. These range from molecules in a gas to biological organisms in their ecologies, to the socio-economic organization of people in their societies, to the physical constants in the universe and, ultimately, to proto-universes in the multiverse. Examples of system input-output laws discovered by the approach include the famous quarter-power laws of biology and the Tobin q-theory of optimized economic investment. System likelihood laws that can be determined include the probability density functions defining in situ cancer growth and a wide class of systems (thermodynamic, economic, cryptographic) obeying Schrodinger-like equations. Novel uncertainty principles in the fields of biology and economics are also found to hold. B. Roy Frieden and Robert A. Gatenby are professors at the University of Arizona. Frieden is in the College of Optics, and Gatenby is Chairman of the Radiology Dept. at the Arizona Health Sciences Center. Frieden has pioneered the use of information for developing image restoration approaches, and for understanding the physics of unknown systems, both nonliving and living. Gatenby has actively promoted the study of information as a determinant of healthy and malignant growth processes, and has developed integrated mathematical models and empirical techniques for this purpose.

You’ll really like this, if it’s the kind of thing you like.

B.R. Frieden and R.A. Gatenby (Eds), Exploratory Data Analysis using Fisher Information (Springer, London 2007) For some years now, Roy Frieden has been exploring the consequences of studying physical phenomena on the basis of Fisher information and extreme physical information (EPI). From the very beginning, the results were spectacular. From the slenderest beginnings, many of the fundamental equations of physics emerged from these EPI principles: the Klein-Gordon and Dirac

equations of quantum mechanics as well as the SchrÃƒÂ¶dinger equation; Newton's second law; Maxwell's equations; many of the equations of general relativity; and this does not exhaust the list. These ideas, gradually developed in a series of publications in very respectable and severely refereed scientific journals, were brought together in Physics from Fisher Information (1998) and its successor, Science from Fisher Information (2004). It was clear from that work that the approach should not be limited to physics but the extent to which it has shown itself fruitful, charted in Frieden's latest book, is a revelation. This is not a monograph but a collection of essays, edited by Frieden and R.A. Gatenby, a life scientist, on a very wide range of topics, all of which are shown to benefit from the use of EPI. The book begins with an introduction by Frieden, in which the reader is told what Fisher information is and how to use it, employing the EPI approach. Eight chapters follow, contributed by the editors and 11 other authors, on financial economics (Frieden, R.J. Hawkins and and J.L. d'Anna); tissue growth and cancer (by the editors); statistical mechanics and `thermal physics' - not very different from what I was taught to call thermodynamics (A. and A.R. Plastino); astrobiology (by Frieden and B.H. Soffer), which is described as a unification of biology and astrophysics; encryption (R.C. Venkatesan); the management of sustainable environmental systems (A.L. Mayer, C.W. Pawlowski, B.D. Fath and H. Cabezas); ecology (by the editors); and to conclude, `Sociohistory: an information theory of social change' (M.I. Yolles and Frieden). This makes for a very adventurous book, all of which makes fascinating reading though some chapters are more readable than others and occasionally, the authors seem unnecessarily on the defensive, as though they expect readers to have a red pencil at the ready. The list of chapters already gives a good idea of the diversity of the contents and even within individual chapters, the coverage is often surprising; thus Chapter 7 (Environmental systems) ends with a section on `Sociopolitical data', in which "state failure", the risk of a "catatastrophic collapse of a nation's governing body" is examined and illustrated with a histogram showing the stability of five countries, Sweden, France, Argentina, Sierra Leone and Haiti. The Fisher index based on eight criteria is very high (indicating great stability) for Sweden, low for Argentina, Sierra Leone and Haiti and only marginally better for France (in the years between 1961 and 1995)! The concluding chapter (Sociohistory) is the most difficult for readers from the exact sciences, unaccustomed to Kant's notion of the noumenon, the Hegelian doctrine of the dialectic and the autonomous holon, though the authors have tried hard to render the vocabulary of the sociologist palatable.The very different nature of the topics examined makes it less easy to appreciate the remarkable role of EPI than in the earlier books, addressed to physicists in language with which they were familiar, however revolutionary the theory presented. I imagine that readers of this latest offering will peruse only the chapter that deals with their own particular

interest. I therefore wish to emphasize that the truly original feature of this book - apart from EPI itself - is precisely its broad coverage; its demonstration that such a simple principle, easily grasped, is capable of yielding valuable results in such a wide range of fields of enquiry. I found Frieden's earlier books immensely original and intellectually thrilling and this one adds yet more weight to that opinion.P.W. Hawkes(M.A., Ph.D., Sc.D., Cambridge; emeritus Director of Research, CNRS)

In a simple-minded way Fisher information can be expressed in one dimensionas an integral of (P') squared over P where P is a suitable probability density.For example P could be the square modulus of a quantum wave function.Many action principles for physical systems in quantum mechanics orrelativity involve extremizing a Lagrangian which contains such Fisher information(FI) terms. The book applies such ideas to a huge variety of physical, biological,economic, ecological, social, game theoretical, and informational systems.One uses FI in a unified approach to statistically based science calledEPI (extreme physical information). This leads to a program (EPA) ofexploratory data analysis whose inputs are real or Gedanken data and whoseoutputs are the natural laws governing a system. The results often appear in the form ofdifferential equations. Here one thinks of theuniverse as information-dominated and "participatory", of Harrison type,allowing maximuminformation gain at each observation and "favoring" the intelligentobservation of information.One speaks of three levels of solution for EPI,depending on the three levels of prior knowledge categorized by the19th century philosopher C. Pierce. These are(A) The highest levelor "abduction", giving exact (quantum) solutions; (B) The next highest levelor "deduction", giving accurate but inexact (non-quantum) solutions ofclassical physics; and(C) The lowest level or "induction" using merely empirical data giving approximatebut smooth solutions.The exact type (A) solutions of EPI require a measurement space connectedvia unitary transformations with some other space having a physical reality.In this event one arrives via EPI at the correct dynamical equations for themeasurement space. There are two earlier books in these directions:(1) Physics from Fisher information, Cambridge Univ. Press, 1998 and(2) Science from Fisher information, Cambridge Univ. Press, 2004, bothby B.R. Frieden.The present book is is a collaboration by H. Cabezas, J.L. D'Anna, B.D. Fath,B.R. Frieden, R.A. Gatenby, R.J. Hawkins, A.L. Mayer, C. Pawlowski, A. Plastino,A.R. Plastino, B.H. Soffer, R.C. Venkatesan, and M. Yolles. The topics include (1)A tutorial on FI and background mathematics plus chapters on(2) Financial economics from FI, (3) Growth characteristics of organisms,(4) Information theory and thermal physics, (5) Parallel information phenomenain biology and astrophysics, (6) Encryption of covert information through aFisher game, (7) Applications of FI to the management of sustainableenvironmental

systems, (8) FI in ecological systems, and (9) Sociohistory:An information theory of social change.There is much to reflect on here and strong evidence that this is indeed theway to go. I personally have used and exploited the Fisher information themein numerous papers related to quantum mechanics and relativity, in particularvia relations of FI to the quantum potential. I would even say that this themeseems to have "cosmic significance" and in the present arena of informationtechnology, processing, retrieval, and distortion the book should be considered asmust reading.Robert Carroll, Emeritus Professor, University of Illinois

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