

Information Theory A Tutorial Introduction

Originally developed by Claude Shannon in the 1940s, information theory laid the foundations for the digital revolution, and is now an essential tool in telecommunications, genetics, linguistics, brain sciences, and deep space communication. In this richly illustrated book, accessible examples are used to introduce information theory in terms of everyday games like '20 questions' before more advanced topics are explored. Online MatLab and Python computer programs provide hands-on experience of information theory in action, and PowerPoint slides give support for teaching. Written in an informal style, with a comprehensive glossary and tutorial appendices, this text is an ideal primer for novices who wish to learn the essential principles and applications of information theory.

This textbook takes a unified view of the fundamentals of wireless communication and explains cutting-edge concepts in a simple and intuitive way. An abundant supply of exercises make it ideal for graduate courses in electrical and computer engineering and it will also be of great interest to practising engineers.

In this richly illustrated book, deep neural network learning algorithms are explained informally first, followed by detailed mathematical analyses. Written in an informal style, with a comprehensive glossary, tutorial appendices, and further readings, this is an ideal introduction to the algorithmic engines of modern artificial intelligence.

Originally developed by Claude Shannon in the 1940s, information theory laid the foundations for the digital revolution, and is now an essential tool in telecommunications, genetics, linguistics, brain sciences, and deep space communication. In this richly illustrated book, accessible examples are used to introduce information theory in terms of everyday games like '20 questions' before more advanced topics are explored. These advanced topics include a summary of the relationship between information theory and thermodynamic entropy, and a review of applications in telecommunications and biology. Online MatLab and Python computer programs provide hands-on experience of information theory in action, and PowerPoint slides give support for teaching. Written in an informal style, with a comprehensive glossary and tutorial appendices, this text is an ideal primer for novices who wish to learn the essential principles and applications of information theory.--Publisher description.

" While multiple-access communication dates back to systems invented in the 1870s to transmit simultaneous data through a single wire, the foundation of the discipline now known as multiuser information theory was laid in 1961, when Claude E. Shannon published his paper on two-way channels. Since then, multiuser information theory has been an extremely active research area, and has seen a large number of fundamental contributions, covering, besides the two-way channel studied in, multiple access, interference, broadcast, and wiretap channels. However, several key canonical problems have defied many efforts. This book brings together leading experts working in the fields of information theory, coding theory, multiple user communications, discrete mathematics, etc., who survey recent and general results on multiple-access channels (rate regions, rate splitting, etc.), and give an overview of the problems of current CDMA solutions (fading channels, multi-user detection, multiple-antenna systems, iterative joint decoding, OFDMA, etc.). This publication consist of three parts. The first part includes chapters devoted to the information-theoretical aspects of multiple-access communication. In the second part, multiple-access techniques are discussed and the third part of this volume covers coding techniques. "

Graduate-level study for engineering students presents elements of modern probability theory, information theory, coding theory, more. Emphasis on sample space, random variables, capacity, etc. Many reference tables and extensive bibliography. 1961 edition.

First comprehensive introduction to information theory explores the work of Shannon, McMillan, Feinstein, and Khinchin. Topics include the entropy concept in probability theory, fundamental theorems, and other subjects. 1957 edition.

Information Theory and Statistics: A Tutorial is concerned with applications of information theory concepts in statistics, in the finite alphabet setting. The topics covered include large deviations, hypothesis testing, maximum likelihood estimation in exponential families, analysis of contingency tables, and iterative algorithms with an "information geometry" background. Also, an introduction is provided to the theory of universal coding, and to statistical inference via the minimum description length principle motivated by that theory. The tutorial does not assume the reader has an in-depth knowledge of Information Theory or statistics. As such, Information Theory and Statistics: A Tutorial, is an excellent introductory text to this highly-important topic in mathematics, computer science and electrical engineering. It provides both students and researchers with an invaluable resource to quickly get up to speed in the field.

Random Matrix Theory and Wireless Communications is the first tutorial on random matrices which provides an overview of the theory and brings together in one source the most significant results recently obtained.

Scientific knowledge grows at a phenomenal pace--but few books have had as lasting an impact or played as important a role in our modern world as The Mathematical Theory of Communication, published originally as a paper on communication theory more than fifty years ago. Republished in book form shortly thereafter, it has since gone through four hardcover and sixteen paperback printings. It is a revolutionary work, astounding in its foresight and contemporaneity. The University of Illinois Press is pleased and honored to issue this commemorative reprinting of a classic.

In this richly illustrated book, it is shown how Shannon's mathematical theory of information defines absolute limits on neural efficiency; limits which ultimately determine the neuroanatomical microstructure of the eye and brain. Written in an informal style this is an ideal introduction to cutting-edge research in neural information theory.

The first unified treatment of the interface between information theory and emerging topics in data science, written in a clear, tutorial style. Covering topics such as data acquisition, representation, analysis, and communication, it is ideal for graduate students and researchers in information theory, signal processing, and machine learning.

This comprehensive treatment of network information theory and its applications provides the first unified coverage of both classical and recent results. With an approach that balances the introduction of new models and new coding techniques, readers are guided through Shannon's point-to-point information theory, single-hop networks, multihop networks, and extensions to distributed computing, secrecy, wireless communication, and networking. Elementary mathematical tools and techniques are used throughout, requiring only basic knowledge of probability, whilst unified

proofs of coding theorems are based on a few simple lemmas, making the text accessible to newcomers. Key topics covered include successive cancellation and superposition coding, MIMO wireless communication, network coding, and cooperative relaying. Also covered are feedback and interactive communication, capacity approximations and scaling laws, and asynchronous and random access channels. This book is ideal for use in the classroom, for self-study, and as a reference for researchers and engineers in industry and academia.

This book helps readers create good VHDL descriptions and simulate VHDL designs. It teaches VHDL using selected sample problems, which are solved step by step and with precise explanations, so that readers get a clear idea of what a good VHDL code should look like. The book is divided into eight chapters, covering aspects ranging from the very basics of VHDL syntax and the module concept, to VHDL logic circuit implementations. In the first chapter, the entity and architecture parts of a VHDL program are explained in detail. The second chapter explains the implementations of combinational logic circuits in VHDL language, while the following chapters offer information on the simulation of VHDL programs and demonstrate how to define data types other than the standard ones available in VHDL libraries. In turn, the fifth chapter explains the implementation of clocked sequential logic circuits, and the sixth shows the implementation of registers and counter packages. The book's last two chapters detail how components, functions and procedures, as well as floating-point numbers, are implemented in VHDL. The book offers extensive exercises at the end of each chapter, inviting readers to learn VHDL by doing it and writing good code.

An introduction to a broad range of topics in deep learning, covering mathematical and conceptual background, deep learning techniques used in industry, and research perspectives. "Written by three experts in the field, Deep Learning is the only comprehensive book on the subject." —Elon Musk, cochair of OpenAI; cofounder and CEO of Tesla and SpaceX
Deep learning is a form of machine learning that enables computers to learn from experience and understand the world in terms of a hierarchy of concepts. Because the computer gathers knowledge from experience, there is no need for a human computer operator to formally specify all the knowledge that the computer needs. The hierarchy of concepts allows the computer to learn complicated concepts by building them out of simpler ones; a graph of these hierarchies would be many layers deep. This book introduces a broad range of topics in deep learning. The text offers mathematical and conceptual background, covering relevant concepts in linear algebra, probability theory and information theory, numerical computation, and machine learning. It describes deep learning techniques used by practitioners in industry, including deep feedforward networks, regularization, optimization algorithms, convolutional networks, sequence modeling, and practical methodology; and it surveys such applications as natural language processing, speech recognition, computer vision, online recommendation systems, bioinformatics, and videogames. Finally, the book offers research perspectives, covering such theoretical topics as linear factor models, autoencoders, representation learning, structured probabilistic models, Monte Carlo methods, the partition function, approximate inference, and deep generative models. Deep Learning can be used by undergraduate or graduate students planning careers in either industry or research, and by software engineers who want to begin using deep learning in their products or platforms. A website offers supplementary material for both readers and instructors.

A fundamental problem in neural network research, as well as in many other disciplines, is finding a suitable representation of multivariate data, i.e. random vectors. For reasons of computational and conceptual simplicity, the representation is often sought as a linear transformation of the original data. In other words, each component of the representation is a linear combination of the original variables. Well-known linear transformation methods include principal component analysis, factor analysis, and projection pursuit. Independent component analysis (ICA) is a recently developed method in which the goal is to find a linear representation of nongaussian data so that the components are statistically independent, or as independent as possible. Such a representation seems to capture the essential structure of the data in many applications, including feature extraction and signal separation.

As the ultimate information processing device, the brain naturally lends itself to being studied with information theory. The application of information theory to neuroscience has spurred the development of principled theories of brain function, and has led to advances in the study of consciousness, as well as to the development of analytical techniques to crack the neural code—that is, to unveil the language used by neurons to encode and process information. In particular, advances in experimental techniques enabling the precise recording and manipulation of neural activity on a large scale now enable for the first time the precise formulation and the quantitative testing of hypotheses about how the brain encodes and transmits the information used for specific functions across areas. This Special Issue presents twelve original contributions on novel approaches in neuroscience using information theory, and on the development of new information theoretic results inspired by problems in neuroscience.

An effective blend of carefully explained theory and practical applications, this text imparts the fundamentals of both information theory and data compression. Although the two topics are related, this unique text allows either topic to be presented independently, and it was specifically designed so that the data compression section requires no prior knowledge of information theory. The treatment of information theory, while theoretical and abstract, is quite elementary, making this text less daunting than many others. After presenting the fundamental definitions and results of the theory, the authors then apply the theory to memoryless, discrete channels with zeroth-order, one-state sources. The chapters on data compression acquaint students with a myriad of lossless compression methods and then introduce two lossy compression methods. Students emerge from this study competent in a wide range of techniques. The authors' presentation is highly practical but includes some important proofs, either in the text or in the exercises, so instructors can, if they choose, place more emphasis on the mathematics. Introduction to Information Theory and Data Compression, Second Edition is ideally suited for an upper-level or graduate course for students in mathematics, engineering, and computer science. Features: Expanded discussion of the historical and theoretical basis of information

theory that builds a firm, intuitive grasp of the subject Reorganization of theoretical results along with new exercises, ranging from the routine to the more difficult, that reinforce students' ability to apply the definitions and results in specific situations. Simplified treatment of the algorithm(s) of Gallager and Knuth Discussion of the information rate of a code and the trade-off between error correction and information rate Treatment of probabilistic finite state source automata, including basic results, examples, references, and exercises Octave and MATLAB image compression codes included in an appendix for use with the exercises and projects involving transform methods Supplementary materials, including software, available for download from the authors' Web site at www.dms.auburn.edu/compression

This open access Brief introduces the basic principles of control theory in a concise self-study guide. It complements the classic texts by emphasizing the simple conceptual unity of the subject. A novice can quickly see how and why the different parts fit together. The concepts build slowly and naturally one after another, until the reader soon has a view of the whole. Each concept is illustrated by detailed examples and graphics. The full software code for each example is available, providing the basis for experimenting with various assumptions, learning how to write programs for control analysis, and setting the stage for future research projects. The topics focus on robustness, design trade-offs, and optimality. Most of the book develops classical linear theory. The last part of the book considers robustness with respect to nonlinearity and explicitly nonlinear extensions, as well as advanced topics such as adaptive control and model predictive control. New students, as well as scientists from other backgrounds who want a concise and easy-to-grasp coverage of control theory, will benefit from the emphasis on concepts and broad understanding of the various approaches.

A thorough exposition of quantum computing and the underlying concepts of quantum physics, with explanations of the relevant mathematics and numerous examples. The combination of two of the twentieth century's most influential and revolutionary scientific theories, information theory and quantum mechanics, gave rise to a radically new view of computing and information. Quantum information processing explores the implications of using quantum mechanics instead of classical mechanics to model information and its processing. Quantum computing is not about changing the physical substrate on which computation is done from classical to quantum but about changing the notion of computation itself, at the most basic level. The fundamental unit of computation is no longer the bit but the quantum bit or qubit. This comprehensive introduction to the field offers a thorough exposition of quantum computing and the underlying concepts of quantum physics, explaining all the relevant mathematics and offering numerous examples. With its careful development of concepts and thorough explanations, the book makes quantum computing accessible to students and professionals in mathematics, computer science, and engineering. A reader with no prior knowledge of quantum physics (but with sufficient knowledge of linear algebra) will be able to gain a fluent understanding by working through the book. Gives an introduction to the principles of information combining. This book describes the concept, the bounds for repetition codes and proofs for single parity-check codes, and also provides some applications. It is useful for students, researchers and professionals working in communications and information theory.

In this richly illustrated book, a range of accessible examples are used to show how Bayes' rule is actually a natural consequence of commonsense reasoning. The tutorial style of writing, combined with a comprehensive glossary, makes this an ideal primer for the novice who wishes to become familiar with the basic principles of Bayesian analysis.

The latest edition of this classic is updated with new problem sets and material The Second Edition of this fundamental textbook maintains the book's tradition of clear, thought-provoking instruction. Readers are provided once again with an instructive mix of mathematics, physics, statistics, and information theory. All the essential topics in information theory are covered in detail, including entropy, data compression, channel capacity, rate distortion, network information theory, and hypothesis testing. The authors provide readers with a solid understanding of the underlying theory and applications. Problem sets and a telegraphic summary at the end of each chapter further assist readers. The historical notes that follow each chapter recap the main points. The Second Edition features: * Chapters reorganized to improve teaching * 200 new problems * New material on source coding, portfolio theory, and feedback capacity * Updated references Now current and enhanced, the Second Edition of Elements of Information Theory remains the ideal textbook for upper-level undergraduate and graduate courses in electrical engineering, statistics, and telecommunications.

The Fourier transform is a fundamental tool in the physical sciences, with applications in communications theory, electronics, engineering, biophysics and quantum mechanics. In this brief book, the essential mathematics required to understand and apply Fourier analysis is explained. The tutorial style of writing, combined with over 60 diagrams, offers a visually intuitive and rigorous account of Fourier methods. Hands-on experience is provided in the form of simple examples, written in Python and Matlab computer code. Supported by a comprehensive Glossary and an annotated list of Further Readings, this represents an ideal introduction to the Fourier transform.

This text is an elementary introduction to information and coding theory. The first part focuses on information theory, covering uniquely decodable and instantaneous codes, Huffman coding, entropy, information channels, and Shannon's Fundamental Theorem. In the second part, linear algebra is used to construct examples of such codes, such as the Hamming, Hadamard, Golay and Reed-Muller codes. Contains proofs, worked examples, and exercises.

Introduces probability and its applications to beginning students in mathematics, statistics or computer science.

Information Theory A Tutorial Introduction Sebtel Press

The fundamental mathematical tools needed to understand machine learning include linear algebra, analytic geometry, matrix decompositions, vector calculus, optimization, probability and statistics. These topics are traditionally taught in disparate courses, making it hard for data science or computer science students, or professionals, to efficiently learn the mathematics. This self-contained textbook bridges the gap between mathematical and machine learning texts, introducing the mathematical concepts with a minimum of prerequisites. It uses these concepts to derive four central machine learning methods: linear regression, principal component analysis, Gaussian mixture models and support vector machines. For students and others with a mathematical background, these derivations provide a starting point to machine learning texts. For those learning the mathematics for the first time, the methods help build intuition and practical experience with

applying mathematical concepts. Every chapter includes worked examples and exercises to test understanding. Programming tutorials are offered on the book's web site.

Highly useful text studies logarithmic measures of information and their application to testing statistical hypotheses. Includes numerous worked examples and problems. References. Glossary. Appendix. 1968 2nd, revised edition.

Understanding quantum mechanics matters because it is the engine that powers the universe. Supported by a comprehensive Glossary, this is an ideal introduction to the mathematics that underpins the engine of quantum mechanics.

This book is an introduction to information and coding theory at the graduate or advanced undergraduate level. It assumes a basic knowledge of probability and modern algebra, but is otherwise self-contained. The intent is to describe as clearly as possible the fundamental issues involved in these subjects, rather than covering all aspects in an encyclopedic fashion. The first quarter of the book is devoted to information theory, including a proof of Shannon's famous Noisy Coding Theorem. The remainder of the book is devoted to coding theory and is independent of the information theory portion of the book. After a brief discussion of general families of codes, the author discusses linear codes (including the Hamming, Golay, the Reed-Muller codes), finite fields, and cyclic codes (including the BCH, Reed-Solomon, Justesen, Goppa, and Quadratic Residue codes). An appendix reviews relevant topics from modern algebra.

A concise, easy-to-read guide, introducing beginners to the engineering background of modern communication systems, from mobile phones to data storage. Assuming only basic knowledge of high-school mathematics and including many practical examples and exercises to aid understanding, this is ideal for anyone who needs a quick introduction to the subject.

First-ever comprehensive introduction to the major new subject of quantum computing and quantum information.

This unique text and video set presents a thorough introduction to Autodesk Inventor for anyone with little or no prior experience with CAD software. It can be used in virtually any setting from four year engineering schools to on-the-job use or self-study. Unlike other books of its kind, it begins at a very basic level and ends at a very advanced level. It's perfect for anyone interested in learning Autodesk Inventor quickly and effectively using a "learning by doing" approach. Additionally, the extensive videos that are included with this book make it easier than ever to learn Inventor by clearly demonstrating how to use its tools. The philosophy behind this book is that learning computer aided design programs is best accomplished by emphasizing the application of the tools. Students also seem to learn more quickly and retain information and skills better if they are actually creating something with the software program. The driving force behind this book is "learning by doing." The instructional format of this book centers on making sure that students learn by doing and that students can learn from this book on their own. In fact, this is one thing that differentiates this book from others: the emphasis on being able to use the book for self-study. The presentation of Autodesk Inventor is structured so that no previous knowledge of any CAD program is required. This book uses the philosophy that Inventor is mastered best by concentrating on applying the program to create different types of solid models, starting simply and then using the power of the program to progressively create more complex solid models. The Drawing Activities at the end of each chapter are more complex iterations of the part developed by each chapter's objectives. CAD programs are highly visual, there are graphical illustrations showing how to use the program. This reinforces the "learn by doing" philosophy since a student can see exactly what the program shows, and then step through progressive commands to implement the required operations. Rather than using a verbal description of the command, a screen capture of each command is replicated.

When I was a student, in the early fifties, the properties of gratings were generally explained according to the scalar theory of optics. The grating formula (which predicts the diffraction angles for a given angle of incidence) was established, experimentally verified, and intensively used as a source for textbook problems. Indeed those grating properties, we can call optical properties, were taught in a satisfactory manner and the students were able to clearly understand the diffraction and dispersion of light by gratings. On the other hand, little was said about the "energy properties", i. e. , about the prediction of efficiencies. Of course, the existence of the blaze effect was pointed out, but very frequently nothing else was taught about the efficiency curves. At most a good student had to know that, for an echelette grating, the efficiency in a given order can approach unity insofar as the diffracted wave vector can be deduced from the incident one by a specular reflexion on the large facet. Actually this rule of thumb was generally sufficient to make good use of the optical gratings available about thirty years ago. Thanks to the spectacular improvements in grating manufacture after the end of the second world war, it became possible to obtain very good gratings with more and more lines per mm. Nowadays, in gratings used in the visible region, a spacing smaller than half a micron is common. This book provides readers with a concise introduction to current studies on operator-algebras and their generalizations, operator spaces and operator systems, with a special focus on their application in quantum information science. This basic framework for the mathematical formulation of quantum information can be traced back to the mathematical work of John von Neumann, one of the pioneers of operator algebras, which forms the underpinning of most current mathematical treatments of the quantum theory, besides being one of the most dynamic areas of twentieth century functional analysis. Today, von Neumann's foresight finds expression in the rapidly growing field of quantum information theory. These notes gather the content of lectures given by a very distinguished group of mathematicians and quantum information theorists, held at the IMS in Chennai some years ago, and great care has been taken to present the material as a primer on the subject matter. Starting from the basic definitions of operator spaces and operator systems, this text proceeds to discuss several important theorems including Stinespring's dilation theorem for completely positive maps and Kirchberg's theorem on tensor products of C^* -algebras. It also takes a closer look at the abstract characterization of operator systems and, motivated by the requirements of different tensor products in quantum information theory, the theory of tensor products in operator systems is discussed in detail. On the quantum information side, the book offers a rigorous treatment of quantifying entanglement in bipartite quantum systems, and moves on to review four different areas in which ideas from the theory of operator systems and operator algebras play a natural role: the issue of zero-error communication over quantum channels, the strong subadditivity property of quantum entropy, the different norms on quantum states and the corresponding induced norms on quantum channels, and, lastly, the applications of matrix-valued random variables in the quantum information setting.

This book is about the definition of the Shannon measure of Information, and some derived quantities such as conditional information and mutual information. Unlike many books, which refer to the Shannon's Measure of information (SMI) as "Entropy," this book makes a clear distinction between the SMI and Entropy. In the last chapter, Entropy is derived as a special case of SMI. Ample examples are provided which help the reader in understanding the different concepts discussed in this book. As with previous books by the author, this book aims at a clear and mystery-free presentation of the central concept in Information theory — the Shannon's Measure of Information. This book presents the fundamental concepts of Information theory in a friendly-simple language and is devoid of all kinds of fancy and pompous statements made by authors of popular science books who write on this

subject. It is unique in its presentation of Shannon's measure of information, and the clear distinction between this concept and the thermodynamic entropy. Although some mathematical knowledge is required by the reader, the emphasis is on the concepts and their meaning rather on the mathematical details of the theory.

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