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An Introduction To Kolmogorov Complexity

In algorithmic information theory, the Kolmogorov complexity of an

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object, such as a piece of text, is the length of a shortest computer program that produces the object as output. It is a measure of the computational resources needed to specify the object, and is also known as algorithmic complexity, Solomonoff-Kolmogorov-Chaitin complexity, program-size complexity, descriptive complexity, or algorithmic entropy. It is named after Andrey Kolmogorov, who first published on the subject in ...

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Kolmogorov complexity - Wikipedia

Kolmogorov complexity is a central concept and a powerful tool in the understanding of the quantitative nature of information and its processing and transmission. Li and Vitanyi's book beautifully captures the elegance of these ideas, their relevance to more of computer science and their theoretical as well as practical applications.

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Introduction. This must-read textbook presents an essential introduction to Kolmogorov complexity (KC), a central theory and powerful tool in information science that deals with the quantity of

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information in individual objects. The text covers both the fundamental concepts and the most important practical applications, supported by a wealth of didactic features.

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Kolmogorov complexity can be seen as an algorithmic version of entropy. Like for entropy, we can define a conditional version:  $K(x|y)$  = the shortest computer program (in binary) that transforms  $y$  into  $x$  (the formalization is done as before). A fundamental result is the symmetry of information (Levin and Kolmogorov 1970).

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Kolmogorov complexity is a modern notion of randomness dealing with the quantity of information in individual objects; that is, pointwise randomness rather than average randomness as produced by a...

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An Introduction to Kolmogorov Complexity and Its Applications

New topics in this edition include Omega numbers, Kolmogorov? Loveland randomness, universal learning, communication complexity, Kolmogorov?s random graphs, time-limited universal distribution, Shannon information and others. An Introduction to Kolmogorov Complexity and Its Applications (Texts in Computer Science) Ebook. Author: Ming Li

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An Introduction to Kolmogorov Complexity and Its ...

Introduction This ongoing bestseller, now in its third edition, is considered the standard reference on Kolmogorov complexity, a modern

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the most important practical applications, supported by a wealth of didactic features. This thoroughly revised and enhanced fourth edition includes new and updated material on, amongst other topics, the Miller-Yu theorem, the Gács-Ku?era theorem, the Day-Gács theorem, increasing randomness, short lists computable from an input string containing the incomputable Kolmogorov complexity of the input, the Lovász local lemma, sorting, the algorithmic full Slepian-Wolf theorem for individual strings, multiset normalized information distance and normalized web distance, and conditional universal distribution. Topics and features: describes the mathematical theory of KC, including the theories of algorithmic complexity and algorithmic probability; presents a general theory of inductive reasoning and its applications, and reviews the utility of the incompressibility method; covers the practical application of KC in great detail, including the normalized information distance (the similarity metric) and information diameter of multisets in phylogeny, language trees, music, heterogeneous files, and clustering; discusses the many applications of resource-bounded KC, and examines different physical theories from a KC point of view; includes numerous examples that elaborate the theory, and a range of exercises of varying difficulty (with solutions); offers explanatory asides on technical issues, and extensive historical sections; suggests structures for several one-



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semester courses in the preface. As the definitive textbook on Kolmogorov complexity, this comprehensive and self-contained work is an invaluable resource for advanced undergraduate students, graduate students, and researchers in all fields of science.

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Briefly, we review the basic elements of computability theory and probability theory that are required. Finally, in order to place the subject in the appropriate historical and conceptual context we trace the main roots of Kolmogorov complexity. This way the stage is set for Chapters 2 and 3, where we introduce the notion of optimal effective descriptions of objects. The length of such a description (or the number of bits of information in it) is its Kolmogorov complexity. We treat all aspects of the elementary mathematical theory of Kolmogorov

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complexity. This body of knowledge may be called algorithmic complexity theory. The theory of Martin-Lof tests for randomness of finite objects and infinite sequences is inextricably intertwined with the theory of Kolmogorov complexity and is completely treated. We also investigate the statistical properties of finite strings with high Kolmogorov complexity. Both of these topics are eminently useful in the applications part of the book. We also investigate the recursion theoretic properties of Kolmogorov complexity (relations with Godel's incompleteness result), and the Kolmogorov complexity version of information theory, which we may call "algorithmic information theory" or "absolute information theory." The treatment of algorithmic probability theory in Chapter 4 presupposes Sections 1.6, 1.11.2, and Chapter 3 (at least Sections 3.1 through 3.4).

With this book, the authors are trying to present in a unified treatment an introduction to the central ideas and their applications of the Kolmogorov Complexity, the theory dealing with the quantity of information in individual objects. This book is appropriate for either a one- or two-semester introductory course in departments of computer science, mathematics, physics, probability theory and statistics, artificial intelligence, and philosophy. Although the mathematical theory of Kolmogorov complexity contains sophisticated mathematics,

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the amount of math one needs to know to apply the notions in widely divergent areas, is very little. The authors' purpose is to develop the theory in detail and outline a wide range of illustrative applications. This book is an attempt to grasp the mass of fragmented knowledge of this fascinating theory. Chapter 1 is a compilation of material on the diverse notations and disciplines we draw upon in order to make the book self-contained. The mathematical theory of Kolmogorov complexity is treated in chapters 2-4; the applications are treated in chapters 4-8.

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The mathematical theory of computation has given rise to two important approaches to the informal notion of "complexity": Kolmogorov complexity, usually a complexity measure for a single object such as a string, a sequence etc., measures the amount of information necessary to describe the object. Computational complexity, usually a complexity measure for a set of objects, measures the computational resources necessary to recognize or produce elements of the set. The relation between these two complexity measures has been considered for more than two decades, and many interesting and deep observations have been obtained. In March 1990, the Symposium on Theory and Application of Minimal Length Encoding was held at Stanford University as a part of the AAAI 1990 Spring Symposium Series. Some sessions of the

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symposium were dedicated to Kolmogorov complexity and its relations to the computational complexity theory, and excellent expository talks were given there. Feeling that, due to the importance of the material, some way should be found to share these talks with researchers in the computer science community, I asked the speakers of those sessions to write survey papers based on their talks in the symposium. In response, five speakers from the sessions contributed the papers which appear in this book.

Computability and complexity theory are two central areas of research in theoretical computer science. This book provides a systematic, technical development of "algorithmic randomness" and complexity for scientists from diverse fields.

No statistical model is "true" or "false," "right" or "wrong"; the models just have varying performance, which can be assessed. The main theme in this book is to teach modeling based on the principle that the objective is to extract the information from data that can be learned with suggested classes of probability models. The intuitive and fundamental concepts of complexity, learnable information, and noise are formalized, which provides a firm information theoretic foundation for statistical modeling. Although the prerequisites

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include only basic probability calculus and statistics, a moderate level of mathematical proficiency would be beneficial.

Personal motivation. The dream of creating artificial devices that reach or outperform human intelligence is an old one. It is also one of the dreams of my youth, which have never left me. What makes this challenge so interesting? A solution would have enormous implications on our society, and there are reasons to believe that the AI problem can be solved in my expected lifetime. So, it's worth sticking to it for a lifetime, even if it takes 30 years or so to reap the benefits.

The AI problem. The science of artificial intelligence (AI) may be defined as the construction of intelligent systems and their analysis. A natural definition of a system is anything that has an input and an output stream. Intelligence is more complicated. It can have many faces like creativity, solving problems, pattern recognition, classification, learning, induction, deduction, building analogies, optimization, surviving in an environment, language processing, and knowledge. A formal definition incorporating every aspect of intelligence, however, seems difficult. Most, if not all known facets of intelligence can be formulated as goal driven or, more precisely, as maximizing some utility function. It is, therefore, sufficient to study goal-driven AI; e. g. the (biological) goal of animals and

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humans is to survive and spread. The goal of AI systems should be to be useful to humans.

This book constitutes the proceedings of the 6th International Computer Science Symposium in Russia, CSR 2011, held in St. Petersburg, Russia, in June 2011. The 29 papers presented were carefully reviewed and selected from 76 submissions. The scope of topics of the symposium was quite broad and covered basically all areas of the foundations of theoretical computer science.

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