

A Theory of Heuristic Reasoning About Uncertainty

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Abstract

This article describes a theory of reasoning about uncertainty, based on a representation of states of certainty called *endorsements*. The theory of endorsements is an alternative to numerical methods for reasoning about uncertainty, such as subjective Bayesian methods (Shortliffe and Buchanan, 1975; Duda, Hart, and Nilsson, 1976) and the Shafer-Dezertner theory (Shafer, 1976). The fundamental concern with numerical representations of certainty is that they hide the reasoning that produces them and thus limit one's reasoning about uncertainty. While numbers are easy to propagate over inferences, what the numbers mean is unclear. The theory of endorsements provides a richer representation of the factors that affect certainty and supports multiple strategies for dealing with uncertainty.

NOTHING IS CERTAIN. People's certainty of the past is limited by the fidelity of the devices that record it, their knowledge of the present is always incomplete, and their knowledge of the future is but speculation. Even though nothing is certain, people behave as if almost nothing is uncertain. They are adept at discounting uncertainty — making it go away. This article discusses how AI programs might be made similarly adept.

Two types of uncertainty have been studied in AI. One arises from noisy data, illustrated in speech understanding and vision programs; the other is associated with the inference rules found in many expert systems. These types of uncertainty are managed by different methods.

Noisy data are usually handled by a control structure

that exploits converging evidence. The decision to attend to a hypothesis or ignore it is related to how certain the hypothesis is: Systems are said to establish and extend "islands of certainty" (e.g., Erman, Hayes-Roth, Lesser, and Reddy, 1980). But these systems do not reason explicitly about their beliefs in their hypotheses.

When inference rules are themselves uncertain, some systems augment domain inferences with parallel *certainty inferences*. Systems such as EMYCIN (van Melle, 1980) associate *certainty factors* with the conclusions of inference rules. A rule of the form "IF A and B and C, THEN D" asserts D when A, B, and C are certain; additionally, a number may be associated with D to indicate one's belief that D follows from A, B, and C. It may be that A, B, and C, though certain, suggest but do not confirm D, in which case the number associated with D might be less than the 1.0 that usually represents certainty in such systems. If A, B, or C are uncertain, then the number associated with D is modified to account for the uncertainty of its premises. These numbers are given different names by different authors; we refer to them as *degrees of belief* (Shafer, 1976). The functions that propagate degrees of belief over inferences are called *combining functions*. Domain rules are assigned a priori degrees of belief and the purpose of the combining functions is to faithfully represent the intent of each in the context in which it is eventually used. Some systems propagate not one degree of belief, but two, indicating a range of certainty. In

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Heuristic Reasoning about Uncertainty Paul R. Cohen, 1985 HEURISTIC REASONING ABOUT UNCERTAINTY: AN ARTIFICIAL INTELLIGENCE APPROACH Paul Raymond Cohen, 1988 *A Theory of Heuristic Reasoning about Uncertainty* Stanford University. Computer Science Dept. Heuristic Programming Project, P. R. Cohen, M. R. Grinberg, 1983 **A Computational Model of Heuristic Reasoning Under Uncertainty** Bong-Oh Kim, 1991 *Psychology and Mathematics Education* Gila Hanna, Laura Macchi, Karin Binder, Laura Martignon, Katharina Loibl, 2023-09-05 Modern Mathematics is constructed rigorously through proofs based on truths which are either axioms or previously proven theorems Thus it is par excellence a model of rational inquiry Links between Cognitive Psychology and Mathematics Education have been particularly strong during the last decades Indeed the Enlightenment view of the rational human mind that reasons makes decisions and solves problems based on logic and probabilities was shaken during the second half of the twentieth century Cognitive psychologists discovered that humans thoughts and actions often deviate from rules imposed by strict normative theories of inference Yet these deviations should not be called errors as Cognitive Psychologists have demonstrated these deviations may be either valid heuristics that succeed in the environments in which humans have evolved or biases that are caused by a lack of adaptation to abstract information formats Humans as the cognitive psychologist and economist Herbert Simon claimed do not usually optimize but rather satisfice even when solving problem This Research Topic aims at demonstrating that these insights have had a decisive impact on Mathematics Education We want to stress that we are concerned with the view of bounded rationality that is different from the one espoused by the heuristics and biases program In Simon s bounded rationality and its direct descendant ecological rationality rationality is understood in terms of cognitive success in the world correspondence rather than in terms of conformity to content free norms of coherence e g transitivity

Representing Uncertain Knowledge Paul Krause, Dominic Clark, 2012-12-06 The representation of uncertainty is a central issue in Artificial Intelligence AI and is being addressed in many different ways Each approach has its proponents and each has had its detractors However there is now an increasing move towards the belief that an eclectic approach is required to represent and reason under the many facets of uncertainty We believe that the time is ripe for a wide ranging yet accessible survey of the main formalisms In this book we offer a broad perspective on uncertainty and approaches to managing uncertainty Rather than provide a daunting mass of technical detail we have focused on the foundations and intuitions behind the various schools The aim has been to present in one volume an overview of the major issues and decisions to be made in representing uncertain knowledge We identify the central role of managing uncertainty to AI and Expert Systems and provide a comprehensive introduction to the different aspects of uncertainty We then describe the rationales advantages and limitations of the major approaches that have been taken using illustrative examples The book ends with a review of the lessons learned and current research directions in the field The intended readership will include

researchers and practitioners involved in the design and implementation of Decision Support Systems Expert Systems other Knowledge Based Systems and in Cognitive Science Intelligent Control: Principles, Techniques And Applications Zixing Cai, 1997-12-18 This book introduces the development process structural theories and research areas of intelligent control explains the knowledge representations searching and reasoning mechanisms as the fundamental techniques of intelligent control studies the theoretical principles and architectures of various intelligent control systems analyzes the paradigms of representative applications of intelligent control and discusses the research and development trends of the intelligent control From the general point of view this book possesses the following features updated research results both in theory and application that reflect the latest advances in intelligent control closed connection between theory and practice that enables readers to use the principles to their case studies and practical projects and comprehensive materials that helps readers in understanding and learning **Cybernetics and Systems '86** R. Trappl, 2012-12-06 This volume contains all papers presented at the Eighth European Meeting on Cybernetics and Systems Research 169 draft papers were submitted for evaluation In the process of careful refereeing 33 papers were rejected and the remaining authors were invited to submit final papers Out of these 119 were accepted for presentation at the conference and publication in this volume These papers were prepared by 173 scientists authors and co authors from 22 European and non European countries with different cultural social and economic structures Everybody tried hard to make this conference and its proceedings a true representation of state of the art research worldwide The members of the Programme Committee and the Chairmen of the Symposia were selected among the internationally leading scientists Great care was taken not to make this conference a European or even Austrian one We are happy and proud to hear that these European Meetings the name is a purely traditional one are recognized as the internationally leading conferences in cybernetics and systems research Important scientists from all over the world carefully prepare their papers containing their most recent research findings and then enjoy the discussions with their colleagues *Heuristic Rhetoric* Gábor Tahin, 2022-11-30 This book introduces a novel approach to the analysis and practice of persuasive speaking and writing heuristic rhetoric The new method has evolved to fulfil the need at universities government departments political organisations business enterprises and other public institutions for a modern practical alternative to classical rhetoric which is in the author's view no longer capable of giving a complete description of contemporary predominantly mediated forms of public persuasive discourse whilst other competing disciplines such as critical discourse analysis or strategic manoeuvring have not yet produced a set of tools which have the comprehensive nature and practical orientation of Classical Greek and Roman rhetorical system The book expounds heuristic rhetoric as an interdisciplinary method to develop advanced skills of critical and strategic reasoning Applying a novel set of principles for the strategic analysis of persuasive reasoning in complex rhetorical situations the method emphasizes preparing and continuously adjusting argumentation according to the demands of unpredictable circumstances Heuristic

Reasoning about Uncertainty in a Clinical Nursing Task Suzanne Marie Narayan,1990 **Proceedings of the Ninth International Joint Conference on Artificial Intelligence** International Joint Conferences on Artificial Intelligence,1985

11th Annual Conference Cognitive Science Society Pod Cognitive Science Society,2014-01-02 First published in 1989

This Program discusses The Eleventh Annual Conference of the Cognitive Science Society August 1989 in Ann Arbor Michigan The book begins with 66 paper presentations and concludes with 59 poster presentations across over 1000 pages This program also includes a comprehensive author listing with affiliations and titles *The Cambridge Handbook of Intelligence* Robert J. Sternberg,2020-01-16 Written by the foremost experts in human intelligence It not only includes traditional topics such as the nature measurement and development of intelligence but also contemporary research into intelligence and video games collective intelligence emotional intelligence and leadership intelligence In an area of study that has been fraught with ideological differences this Handbook provides scientifically balanced and objective chapters covering a wide range of topics It does not shy away from material that historically has been emotionally charged and sometimes covered in biased ways such as intellectual disability race and intelligence culture and intelligence and intelligence testing The overview provided by this two volume set leaves virtually no area of intelligence research uncovered making it an ideal resource for undergraduates graduate students and professionals looking for a refresher or a summary of the new developments *Expert Systems* Cornelius T. Leondes,2001-09-26 This six volume set presents cutting edge advances and applications of expert systems Because expert systems combine the expertise of engineers computer scientists and computer programmers each group will benefit from buying this important reference work An expert system is a knowledge based computer system that emulates the decision making ability of a human expert The primary role of the expert system is to perform appropriate functions under the close supervision of the human whose work is supported by that expert system In the reverse this same expert system can monitor and double check the human in the performance of a task Human computer interaction in our highly complex world requires the development of a wide array of expert systems Expert systems techniques and applications are presented for a diverse array of topics including Experimental design and decision support The integration of machine learning with knowledge acquisition for the design of expert systems Process planning in design and manufacturing systems and process control applications Knowledge discovery in large scale knowledge bases Robotic systems Geographical information systems Image analysis recognition and interpretation Cellular automata methods for pattern recognition Real time fault tolerant control systems CAD based vision systems in pattern matching processes Financial systems Agricultural applications Medical diagnosis AIME 89 Jim Hunter,John Cookson,Jeremy Wyatt,2012-12-06 The Second European Conference on Artificial Intelligence in Medicine followed the successful meeting in Marseilles in 1987 As for AIME 87 the goal of AIME 89 was to promote scientific interchange within and between all subfields of AI in medicine among researchers from all over the world and especially from Europe There were sessions on

knowledge elicitation and acquisition architectures for medical knowledge based systems clinical applications methodology reasoning based on physiological models and uncertainty It is clear from the quality of papers presented that the rate of development which took place between the Pavia meeting of 1985 and AIME 87 has been well maintained With the launch of the European Community's exploratory programme in Advanced Informatics in Medicine in Europe 1989 is clearly a very important year for this discipline AIME 89 provided an important forum which demonstrated progress in some of the more difficult methodological problems and advances in the application of these techniques to real world medicine This volume should be consulted by anyone who wishes to appreciate the state of the art in Medical AI in Europe **Proceedings of the ... International Joint Conference on Artificial Intelligence** ,1987 **Exploring Artificial Intelligence** Howard E. Shrobe,2014-05-12 Exploring Artificial Intelligence Survey Talks from the National Conference on Artificial Intelligence provides information pertinent to the distinct subareas of artificial intelligence research This book discusses developments in machine learning techniques Organized into six parts encompassing 16 chapters this book begins with an overview of intelligent tutoring systems which describes how to guide a student to learn new concepts This text then links closely with one of the concerns of intelligent tutoring systems namely how to interact through the utilization of natural language Other chapters consider the various aspects of natural language understanding and survey the huge body of work that tries to characterize heuristic search programs This book discusses as well how computer programs can create plans to satisfy goals The final chapter deals with computational facilities that support This book is a valuable resource for cognitive scientists psychologists domain experts computer scientists instructional designers expert teachers and research workers **The Mathematics Enthusiast** Bharath Sriraman,2015-10-01 The Mathematics Enthusiast TME is an eclectic internationally circulated peer reviewed journal which focuses on mathematics content mathematics education research innovation interdisciplinary issues and pedagogy The journal exists as an independent entity It is published on a print on demand basis by Information Age Publishing and the electronic version is hosted by the Department of Mathematical Sciences University of Montana The journal is not affiliated to nor subsidized by any professional organizations but supports PMENA Psychology of Mathematics Education North America through special issues on various research topics **Fuzzy Modelling** Witold Pedrycz,1996-03-31 Provides recent information on fuzzy models identification algorithms and applications Section I on relational models includes theory and case studies in areas such as speech recognition prediction and ecological systems Section II on fuzzy neural networks covers fundamentals such as neurocomputing explains the relationship between fuzzy systems and neural networks and details architectures Section III addresses design principles governing the development of rule based models Of interest to researchers and practitioners developing models of complex systems Annotation copyright by Book News Inc Portland OR **7th Int. Conf. Industrial & En** Frank D. Anger,Rita V. Rodriguez,Moonis Ali,1994-05-23 Over the years the promise of artificial intelligence has inspired many researchers and many schemes only to have incipient

hopes thwarted by its complexity With each generation of computational engines a new wave of enthusiasm sweeps the community as solutions to a few problems come within reach However intractability and undecidability continue to frustrate the unwary practitioner while unsubstantiated methodologies offer ingenious solutions that hold more promise than potential Despite its undulate past and variegated present AI has made solid contributions to a growing information technology Expert systems and allied tools have become a mainstay of industrial and business organizations intelligent interfaces have increased accessibility of computational resources and robotic innovations have redefined the manufacturing industries Meanwhile research in evolutionary algorithms neural networks fuzzy reasoning and other exciting approaches promise continued progress in surprising new directions These proceedings record the latest results of industrial commercial military and academic artificial intelligence exploration Seventy seven papers divided into twenty different areas document a significant slice of this broad and exciting field Although dozens of themes are treated in the papers the topical divisions of this volume comprise The Software Engineering AI Interface Knowledge Based Systems Temporal Reasoning Machine Learning Robotics Intelligent Databases Planning Expert Systems Applications Search Techniques Genetic and Evolutionary Methods Design Qualitative Reasoning Neural Networks Knowledge Representation Application Paradigms Fuzzy and Pattern Recognition Reasoning about Physical Systems Parallel and Distributed AI and Diagnostic Systems

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