ORIGINAL ARTICLE

Resonance algorithm: an intuitive algorithm to find all shortest paths between two nodes

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Abstract

The shortest path problem (SPP) is a classic problem and appears in a wide range of applications. Although a variety of algorithms already exist, new advances are still being made, mainly tuned for particular scenarios to have better performances. As a result, they become more and more technically complex and sophisticated. In this paper, we developed an intuitive and nature-inspired algorithm to compute all possible shortest paths between two nodes in a graph: *Resonance Algorithm* (RA). It can handle any undirected, directed, or mixed graphs, irrespective of loops, unweighted or positively weighted edges, and can be implemented in a fully decentralized manner. Although the original motivation for RA is not the speed per se, in certain scenarios (when sophisticated matrix operations can be employed, and when the map is very large and all possible shortest paths are demanded), it out-competes Dijkstra's algorithm, which suggests that in those scenarios, RA could also be practically useful.

Introduction

The shortest path problem (SPP), i.e., to find a path between two nodes in a graph such that the length (or weights) of the path is minimized, is a classic problem in graph theory and computer science [1], with a wide range of applications such as route planning [2–4], network routing [5–7] and task planning [8,9]. There is a variety of algorithms to solve SPP, including the classic Dijkstra's algorithm [10] (which

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is commonly used and lays the basis for many other methods [11–13]), Bellman–Ford algorithm [14], Chan's fast algorithm (in $O(n^3/\log n)$ time) [15], etc.

Although SPP has been studied extensively, new advances are still being made to have better performances in specific scenarios, including rapid explorations [16,17], solving multi-objective problems [18,19], handling dynamic networks [20–22] and stochastic situations [23,24]. More specifically, for example, Noto and Sato proposed a fast algorithm to compute paths as close as possible to the optimal solution (much faster than the algorithms that give optimal solutions) to handle real-time problems [17]. Galán-García et al. developed Probabilistic Extension of Dijkstra's Algorithm to calculate not only the shortest path but also the second-, third- or fourth-shortest path, by taking the traffic flows into account, which is extremely helpful in realistic car navigation [25]. Moreover, by taking off the "Fibonacci heap" in the original Dijkstra's algorithm, Xu et al. substantially improved the efficiency of Dijkstra's algorithm for sparse networks, to which the road traffic network belongs [26].

While finding one shortest path has a wide range of applications (as in the above examples), finding all possible shortest paths (without missing any one) is also a significant question to ask in various scenarios [27], e.g., when searching a path that should satisfy other conditions beyond having

[The Intuitive Algorithm](#)

Abraham Thomas

The Intuitive Algorithm:

The Intuitive Algorithm Abraham Thomas,2004   **The Intuitive Algorithm** Abraham Thomas,1991

Understanding and Teaching the Intuitive Mind Bruce Torff,Robert J. Sternberg,2001-01-01 The intuitive mind is a powerful force in the classroom and often an undetected one Intuitive conceptions knowledge or knowledge structures that individuals acquire and use largely without conscious reflection or explicit instruction sometimes work to facilitate learning in the classroom and other contexts But learning may also be impeded by intuitive conceptions and they can be difficult to dislodge as needed The literatures in psychology and education include a large and diverse body of theory and research on intuitive conceptions but this work is limited in some respects This volume contributes in four ways to overcome these limitations Understanding and Teaching the Intuitive Mind Student and Teacher Learning pulls together diverse theoretical and methodological approaches to the origin structure function and development of intuitive conceptions explores a diversity of academic disciplines paying equal attention not only to mathematics and science the fields in which intuitive concepts have been studied most extensively but also to the social sciences arts and humanities explicitly links theory and research to educational implications and classroom applications and focuses not only on students intuitive conceptions but also on teachers intuitive beliefs about learning and teaching Although the viewpoints of the contributors are diverse they share the belief that educational practices have much to gain by systematic studies of the intuitive learner and teacher This volume offers state of the art research based information and support for psychologists teacher educators educational administrators teachers prospective teachers and others who seek to develop educational practices that are cognizant of and responsive to the intuitive conceptions of students and teachers   **Developing the Intuitive Executive** Jay Liebowitz,2023-10-19 The leading traits of executives often include creativity and innovation Research shows that intuition can significantly enhance these traits Developing intuitive executives and honing intuition coupled with the ability to apply data and evidence to inform decision making is the focus of Developing the Intuitive Executive Using Analytics and Intuition for Success Some researchers call the complement of applying data analytics to intuition as quantitative intuition rational intuition or informed intuition Certainly in today s data driven environment analytics plays a key role in executive decision making However an executive s many years of experiential learning are not formally considered as part of the decision making process Learning from both failures and successes can help fine tune intuitive awareness what this book calls intuition based decision making Research also shows that many executives do not trust the internal data quality in their organizations and so they rely on their intuition rather than strictly on data This book presents the work of leading researchers worldwide on intuition in the management and executive domain Their chapters cover key issues trends concepts techniques and opportunities for applying intuition as part of the executive decision making process Highlights include Using intuition to manage new opportunities Intuition in medicine Rules based on intuition Balancing logic and intuition in decision making Smart heuristics

to manage complexity Intuition and competitiveness Intuitive investment decision making across cultures Showing how intuition in executive decision making should play an important role this book enables managers to complement their knowledge gained from experience with analytics to improve decision making and business success *The Foundations of Computability Theory* Borut Robič,2020-11-13 This book offers an original and informative view of the development of fundamental concepts of computability theory The treatment is put into historical context emphasizing the motivation for ideas as well as their logical and formal development In Part I the author introduces computability theory with chapters on the foundational crisis of mathematics in the early twentieth century and formalism In Part II he explains classical computability theory with chapters on the quest for formalization the Turing Machine and early successes such as defining incomputable problems c e computably enumerable sets and developing methods for proving incomputability In Part III he explains relative computability with chapters on computation with external help degrees of unsolvability the Turing hierarchy of unsolvability the class of degrees of unsolvability c e degrees and the priority method and the arithmetical hierarchy Finally in the new Part IV the author revisits the computability Church Turing thesis in greater detail He offers a systematic and detailed account of its origins evolution and meaning he describes more powerful modern versions of the thesis and he discusses recent speculative proposals for new computing paradigms such as hypercomputing This is a gentle introduction from the origins of computability theory up to current research and it will be of value as a textbook and guide for advanced undergraduate and graduate students and researchers in the domains of computability theory and theoretical computer science This new edition is completely revised with almost one hundred pages of new material In particular the author applied more up to date more consistent terminology and he addressed some notational redundancies and minor errors He developed a glossary relating to computability theory expanded the bibliographic references with new entries and added the new part described above and other new sections *Algorithms and Data Structures - Applications to Graphics and Geometry* Textbook Equity,2014-09-15 This is a college level introductory textbook of algorithms and data structures with application to graphics and geometry This textbook released under a Creative Commons Share Alike CC BY SA license is presented in its original format with the academic content unchanged It was authored by Jurg Nievergelt ETH Zurich and Klaus Hinrichs Institut fur Informatik and provided by the University of Georgia s Global Textbook Project Textbookequity org algorithms and data structures Photo Credit Renato Keshet GFDL commons wikimedia org Contents Part I Programming environments for motion graphics and geometry Part II Programming concepts beyond notation Part IV Complexity of problems and algorithms Part V Data structures Textbook Equity Edition http textbookequity org algorithms and data structures **Introduction To The Analysis Of Algorithms, An (3rd Edition)** Michael Soltys-kulinicz,2018-01-31 A successor to the first and second editions this updated and revised book is a leading companion guide for students and engineers alike specifically software engineers who design algorithms While succinct this edition is mathematically rigorous

covering the foundations for both computer scientists and mathematicians with interest in the algorithmic foundations of Computer Science Besides expositions on traditional algorithms such as Greedy Dynamic Programming and Divide Conquer the book explores two classes of algorithms that are often overlooked in introductory textbooks Randomised and Online algorithms with emphasis placed on the algorithm itself The book also covers algorithms in Linear Algebra and the foundations of Computation The coverage of Randomized and Online algorithms is timely the former have become ubiquitous due to the emergence of cryptography while the latter are essential in numerous fields as diverse as operating systems and stock market predictions While being relatively short to ensure the essentiality of content a strong focus has been placed on self containment introducing the idea of pre post conditions and loop invariants to readers of all backgrounds as well as all the necessary mathematical foundations The programming exercises in Python will be available on the web see www msoltys com book for the companion web site **Algorithm Of Mind & Brain** Akash Gopal Bagade,2024-02-27 Ever wondered about the secrets of your brain s inner workings We re diving deep into the dance of neurons the evolution of thoughts and the mind blowing concept of neuroplasticity Get ready to uncover the blueprint of your consciousness ALGORITHM OF MIND we re uncovering the philosophy of consciousness free will and the ethics of enhancing our minds 7 A Tapestry of Insight Algorithm of Mind and Brain isn t your typical book it s a rich tapestry woven with 150 illuminating points From the neuroscience of art to the impact of culture on mental health this book paints a holistic picture of the mind s vast terrain 8 Your Mind s Potential The Grand Finale As you flip through these pages imagine unlocking the limitless potential of your mind Picture a future where brain machine interfaces are everyday tools and ethical AI is a guiding principle Algorithm of Mind and Brain is not just a book it s your guide to envisioning the incredible possibilities that lie within you Get ready for a ride that s part scientific exploration part philosophical thinking and all about discovering the marvels of your own mind Are you ready to dive in Let the adventure begin Algorithms - ESA '95 Paul Spirakis,1995-09-13 This book consitutes the proceedings of the Third Annual European Symposium on Algorithms ESA 95 held in Corfu Greece in September 1995 The volume presents 42 full revised papers selected during a careful refereeing process from a total of 119 submissions in addition there is a prominent keynote address This year the scope has been further expanded to new areas of computational endeavour in science the book covers many aspects of algorithms research and application ranging from combinatorial mathematics to hardware design Algorithms in Combinatorial Geometry Herbert Edelsbrunner,2012-12-06 Computational geometry as an area of research in its own right emerged in the early seventies of this century Right from the beginning it was obvious that strong connections of various kinds exist to questions studied in the considerably older field of combinatorial geometry For example the combinatorial structure of a geometric problem usually decides which algorithmic method solves the problem most efficiently Furthermore the analysis of an algorithm often requires a great deal of combinatorial knowledge As it turns out however the connection between the two research areas commonly referred to as

computa tional geometry and combinatorial geometry is not as lop sided as it appears Indeed the interest in computational issues in geometry gives a new and con structive direction to the combinatorial study of geometry It is the intention of this book to demonstrate that computational and com binatorial investigations in geometry are doomed to profit from each other To reach this goal I designed this book to consist of three parts acorn binatorial part a computational part and one that presents applications of the results of the first two parts The choice of the topics covered in this book was guided by my attempt to describe the most fundamental algorithms in computational geometry that have an interesting combinatorial structure In this early stage geometric transforms played an important role as they reveal connections between seemingly unrelated problems and thus help to structure the field   Algorithmics for Hard Problems Juraj Hromkovič,2013-03-14 Algorithmic design especially for hard problems is more essential for success in solving them than any standard improvement of current computer technologies Because of this the design of algorithms for solving hard problems is the core of current algorithmic research from the theoretical point of view as weIl as from the practical point of view There are many general textbooks on algorithmics and several specialized books devoted to particular approaches such as local search randomization approximation algorithms or heuristics But there is no textbook that focuses on the design of algorithms for hard computing tasks and that systematically explains combines and compares the main possibilities for attacking hard algorithmic problems As this topic is fundamental for computer science this book tries to elose this gap Another motivation and probably the main reason for writing this book is connected to education The considered area has developed very dynamically in recent years and the research on this topic discovered several profound re sults new concepts and new methods Some of the achieved contributions are so fundamental that one can speak about paradigms which should be ineluded in the education of every computer science student Unfortunately this is very far from reality This is because these paradigms are not sufficiently known in the computer science community and so they are insufficiently communicated to students and practitioners   **P, NP, and NP-Completeness** Oded Goldreich,2010-08-16 The focus of this book is the P versus NP Question and the theory of NP completeness It also provides adequate preliminaries regarding computational problems and computational models The P versus NP Question asks whether or not finding solutions is harder than checking the correctness of solutions An alternative formulation asks whether or not discovering proofs is harder than verifying their correctness It is widely believed that the answer to these equivalent formulations is positive and this is captured by saying that P is different from NP Although the P versus NP Question remains unresolved the theory of NP completeness offers evidence for the intractability of specific problems in NP by showing that they are universal for the entire class Amazingly enough NP complete problems exist and furthermore hundreds of natural computational problems arising in many different areas of mathematics and science are NP complete   *Leadership by Algorithm* David De Cremer,2020-05-26 With artificial intelligence on the rise the way we run our organisations will change and drastically But what exactly will that future look like And who will take the leading role

machines or people In this compelling new book leading management guru David De Cremer identifies the key areas where algorithms will collide with human skills and assesses the likely outcomes Will your next boss be a robot Can an AI boss display the human qualities that define a good leader compassion empathy imagination ethics and strategic awareness Drawing on his own research findings and those from thought leaders around the world the author presents fascinating insights into the challenges that an automated work environment poses for organisations of the future Leadership by Algorithm offers some startling conclusions that make clear the true nature of the power struggle between man and machine It also identifies the leadership qualities needed to deal with this struggle most effectively **Neural Information Processing** Derong Liu,Shengli Xie,Yuanqing Li,Dongbin Zhao,El-Sayed M. El-Alfy,2017-11-07 The six volume set LNCS 10634 LNCS 10635 LNCS 10636 LNCS 10637 LNCS 10638 and LNCS 10639 constitues the proceedings of the 24rd International Conference on Neural Information Processing ICONIP 2017 held in Guangzhou China in November 2017 The 563 full papers presented were carefully reviewed and selected from 856 submissions The 6 volumes are organized in topical sections on Machine Learning Reinforcement Learning Big Data Analysis Deep Learning Brain Computer Interface Computational Finance Computer Vision Neurodynamics Sensory Perception and Decision Making Computational Intelligence Neural Data Analysis Biomedical Engineering Emotion and Bayesian Networks Data Mining Time Series Analysis Social Networks Bioinformatics Information Security and Social Cognition Robotics and Control Pattern Recognition Neuromorphic Hardware and Speech Processing *Graphs, Networks and Algorithms* Dieter Jungnickel,2012-11-08 From the reviews of the previous editions The book is a first class textbook and seems to be indispensable for everybody who has to teach combinatorial optimization It is very helpful for students teachers and researchers in this area The author finds a striking synthesis of nice and interesting mathematical results and practical applications the author pays much attention to the inclusion of well chosen exercises The reader does not remain helpless solutions or at least hints are given in the appendix Except for some small basic mathematical and algorithmic knowledge the book is self contained K Engel Mathematical Reviews 2002 The substantial development effort of this text involving multiple editions and trailing in the context of various workshops university courses and seminar series clearly shows through in this new edition with its clear writing good organisation comprehensive coverage of essential theory and well chosen applications The proofs of important results and the representation of key algorithms in a Pascal like notation allow this book to be used in a high level undergraduate or low level graduate course on graph theory combinatorial optimization or computer science algorithms The well worked solutions to exercises are a real bonus for self study by students The book is highly recommended P B Gibbons Zentralblatt f r Mathematik 2005 Once again the new edition has been thoroughly revised In particular some further material has been added more on NP completeness especially on dominating sets a section on the Gallai Edmonds structure theory for matchings and about a dozen additional exercises as always with solutions Moreover the section on the 1 factor theorem has

been completely rewritten it now presents a short direct proof for the more general Berge Tutte formula Several recent research developments are discussed and quite a few references have beenadded   *The Accidental Homo Sapiens* Ian Tattersall,Robert DeSalle,2019-04-02 What happens now that human population has outpaced biological natural selection Two leading scientists reveal how we became who we are and what we might become When we think of evolution the image that likely comes to mind is the iconic straight forward image of a primate morphing into a human being Yet random events have played huge roles in determining the evolutionary histories of everything from lobsters to humans However random genetic novelties are most likely to stick in small populations It is mathematically unlikely to happen in large ones With our enormous and seemingly inexorably expanding population humanity has fallen under the influence of the famous or infamous bell curve This revelatory new book explores what the future of our species could hold while simultaneously revealing what we didn t become and what we won t become A cognitively unique species our actions fall on a bell curve as well Individuals may be saintly or evil narrow minded or visionary But it is possible not just for the species but for a person to be all of these things even in a single day We all fall somewhere within the giant hyperspace of the human condition that these curves describe The Accidental Homo Sapiens shows readers that though humanity now exists on this bell curve we are far from a stagnant species Tattersall and DeSalle reveal how biological evolution in modern humans has given way to a cultural dynamic that is unlike anything else the Earth has ever witnessed and that will keep life interesting perhaps sometimes too interesting for as long as we exist on this planet   **Advances in Cryptology – ASIACRYPT 2022** Shweta Agrawal,Dongdai Lin,2023-01-24 The four volume proceedings LNCS 13791 13792 13793 and 13794 constitute the proceedings of the 28th International Conference on the Theory and Application of Cryptology and Information Security ASIACRYPT 2022 held in Taipei Taiwan during December 5 9 2022 The total of 98 full papers presented in these proceedings was carefully reviewed and selected from 364 submissions The papers were organized in topical sections as follows Part I Award papers functional and witness encryption symmetric key cryptanalysis multiparty computation real world protocols and blockchains and cryptocurrencies Part II Isogeny based cryptography homomorphic encryption NIZK and SNARKs non interactive zero knowledge and symmetric cryptography Part III Practical cryptography advanced encryption zero knowledge quantum algorithms lattice cryptoanalysis Part IV Signatures commitments theory cryptoanalysis and quantum cryptography   *An Introduction to Gödel's Theorems* Peter Smith,2007-07-26 In 1931 the young Kurt G del published his First Incompleteness Theorem which tells us that for any sufficiently rich theory of arithmetic there are some arithmetical truths the theory cannot prove This remarkable result is among the most intriguing and most misunderstood in logic G del also outlined an equally significant Second Incompleteness Theorem How are these Theorems established and why do they matter Peter Smith answers these questions by presenting an unusual variety of proofs for the First Theorem showing how to prove the Second Theorem and exploring a family of related results including some not easily available elsewhere The formal explanations are

interwoven with discussions of the wider significance of the two Theorems This book will be accessible to philosophy students with a limited formal background It is equally suitable for mathematics students taking a first course in mathematical logic   **The Performance Studies Reader** Henry Bial,Sara Brady,2025-01-31 Since its first publication in 2004 The Performance Studies Reader has become the leading anthology of key writings on performance studies Now in its fourth edition it continues to offer an unparalleled selection of work by the foremost scholars in this continually evolving field offering a stimulating introduction to the crucial debates of Performance Studies These critical and theoretical contributions are joined in this edition by 26 new chapters bringing the collection up to date with current discourse and ideas and significantly expanding the range of subjects and authors represented Each essay includes contextual headnotes from the editors to introduce students to the writer and their impact on the field Newly added to this edition are contributions from Swati Arora Sara Ahmed Sarah Bay Cheng Claire Bishop Felipe Cervera Theron Schmidt and Hannah Schwadron Anita E Cherian and Gargi Bharadwaj Thomas F DeFrantz SLIPPAGE Soyica Diggs Colbert Tracy C Davis Saidiya V Hartman Travis Jackson Branislav Jakovljevi Ailton Krenak Andr Lepecki Fred Moten Jos Esteban Mu oz Tavia Nyong o Tamara Searle Stephanie Nohelani Teves and McKenzie Wark This new edition of The Performance Studies Reader provides an overview of the full range of performance theory for undergraduates at all levels and beginning graduate students in Performance Studies theatre performing arts and cultural studies   **Interactive Multi-modal Question-Answering** Antal van den Bosch,Gosse Bouma,2011-05-10 This book is the result of a group of researchers from different disciplines asking themselves one question what does it take to develop a computer interface that listens talks and can answer questions in a domain First obviously it takes specialized modules for speech recognition and synthesis human interaction management dialogue input fusion and multimodal output fusion basic question understanding and answer finding While all modules are researched as independent subfields this book describes the development of state of the art modules and their integration into a single working application capable of answering medical encyclopedic questions such as How long is a person with measles contagious or How can I prevent RSI The contributions in this book which grew out of the IMIX project funded by the Netherlands Organisation for Scientific Research document the development of this system but also address more general issues in natural language processing such as the development of multidimensional dialogue systems the acquisition of taxonomic knowledge from text answer fusion sequence processing for domain specific entity recognition and syntactic parsing for question answering Together they offer an overview of the most important findings and lessons learned in the scope of the IMIX project making the book of interest to both academic and commercial developers of human machine interaction systems in Dutch or any other language Highlights include integrating multi modal input fusion in dialogue management Van Schooten and Op den Akker state of the art approaches to the extraction of term variants Van der Plas Tiedemann and Fahmi Tjong Kim Sang Hofmann and De Rijke and multi modal answer fusion two chapters by Van Hooijdonk

Bosma Krahmer Maes Theune and Marsi Watch the IMIX movie at www nwo nl imix film Like IBM s Watson the IMIX system described in the book gives naturally phrased responses to naturally posed questions Where Watson can only generate synthetic speech the IMIX system also recognizes speech On the other hand Watson is able to win a television quiz while the IMIX system is domain specific answering only to medical questions The Netherlands has always been one of the leaders in the general field of Human Language Technology and IMIX is no exception It was a very ambitious program with a remarkably successful performance leading to interesting results The teams covered a remarkable amount of territory in the general sphere of multimodal question answering and information delivery question answering information extraction and component technologies Eduard Hovy USC USA Jon Oberlander University of Edinburgh Scotland and Norbert Reithinger DFKI Germany

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