

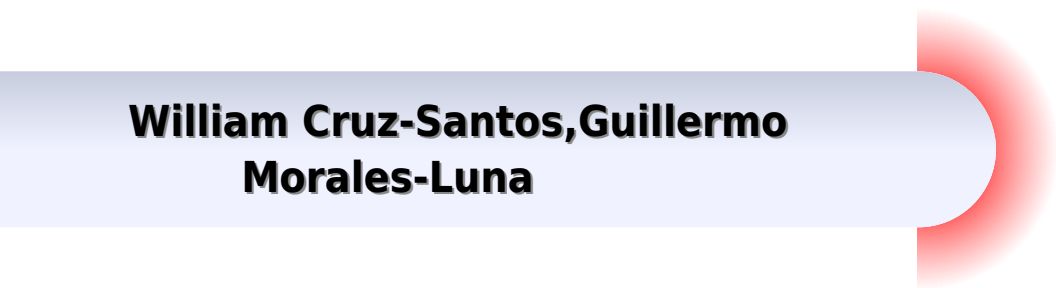
Catherine C. McGeoch

Adiabatic Quantum Computation and Quantum Annealing

Theory and Practice

Adiabatic Quantum Computation And Quantum Annealing Theory And Practice Catherine C Mcgeoch

**William Cruz-Santos,Guillermo
Morales-Luna**



Adiabatic Quantum Computation And Quantum Annealing Theory And Practice Catherine C McGeoch:

Adiabatic Quantum Computation and Quantum Annealing Catherine C. McGeoch, 2014-07-01 Adiabatic quantum computation AQC is an alternative to the better known gate model of quantum computation The two models are polynomially equivalent but otherwise quite dissimilar one property that distinguishes AQC from the gate model is its analog nature Quantum annealing QA describes a type of heuristic search algorithm that can be implemented to run in the native instruction set of an AQC platform D Wave Systems Inc manufactures quantum annealing processor chips that exploit quantum properties to realize QA computations in hardware The chips form the centerpiece of a novel computing platform designed to solve NP hard optimization problems Starting with a 16 qubit prototype announced in 2007 the company has launched and sold increasingly larger models the 128 qubit D Wave One system was announced in 2010 and the 512 qubit D Wave Two system arrived on the scene in 2013 A 1 000 qubit model is expected to be available in 2014 This monograph presents an introductory overview of this unusual and rapidly developing approach to computation We start with a survey of basic principles of quantum computation and what is known about the AQC model and the QA algorithm paradigm Next we review the D Wave technology stack and discuss some challenges to building and using quantum computing systems at a commercial scale The last chapter reviews some experimental efforts to understand the properties and capabilities of these unusual platforms The discussion throughout is aimed at an audience of computer scientists with little background in quantum computation or in physics

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Adiabatic Quantum Computation Quantum Annealing The D Wave Platform Computational Experience Bibliography Author s Biography Approximability of Optimization Problems through Adiabatic Quantum Computation William Cruz-Santos,Guillermo Morales-Luna,2022-05-31 The adiabatic quantum computation AQC is based on the adiabatic theorem to approximate solutions of the Schr dinger equation The design of an AQC algorithm involves the construction of a Hamiltonian that describes the behavior of the quantum system This Hamiltonian is expressed as a linear interpolation of an initial Hamiltonian whose ground state is easy to compute and a final Hamiltonian whose ground state corresponds to the solution of a given combinatorial optimization problem The adiabatic theorem asserts that if the time evolution of a quantum system described by a Hamiltonian is large enough then the system remains close to its ground state An AQC algorithm uses the adiabatic theorem to approximate the ground state of the final Hamiltonian that corresponds to the solution of the given optimization problem In this book we investigate the computational simulation of AQC algorithms applied to the MAX SAT problem A symbolic analysis of the AQC solution is given in order to understand the involved computational complexity of AQC algorithms This approach can be extended to other combinatorial optimization problems and can be used for the classical simulation of an AQC algorithm where a Hamiltonian problem is constructed This construction requires the computation of a sparse matrix of dimension $2^n \times 2^n$ by means of tensor products where n is the dimension of the quantum system Also a general scheme to design AQC algorithms is proposed based on a natural correspondence between optimization Boolean variables and quantum bits Combinatorial graph problems are in correspondence with pseudo Boolean maps that are reduced in polynomial time to quadratic maps Finally the relation among NP hard problems is investigated as well as its logical representability and is applied to the design of AQC algorithms It is shown that every monadic second order logic MSOL expression has associated pseudo Boolean maps that can be obtained by expanding the given expression and also can be reduced to quadratic forms Table of Contents Preface Acknowledgments Introduction Approximability of NP hard Problems Adiabatic Quantum Computing Efficient Hamiltonian Construction AQC for Pseudo Boolean Optimization A General Strategy to Solve NP Hard Problems Conclusions Bibliography Authors Biographies *Quantum Robotics* Prateek Tandon,Stanley Lam,Ben Shih,Tanay Mehta,Alex Mitev,Zhiyang Ong,2022-05-31 Quantum robotics is an emerging engineering and scientific research discipline that explores the application of quantum mechanics quantum computing quantum algorithms and related fields to robotics This work broadly surveys advances in our scientific understanding and engineering of quantum mechanisms and how these developments are expected to impact the technical capability for robots to sense plan learn and act in a dynamic environment It also discusses the new technological potential that quantum approaches may unlock for sensing and control especially for exploring and manipulating quantum scale environments Finally the work surveys the state of the art in current implementations along with their benefits and limitations and provides a roadmap for the future **Quantum Technology and Optimization Problems** Sebastian Feld,Claudia

Linnhoff-Popien,2019-03-13 This book constitutes the refereed proceedings of the First International Workshop on Quantum Technology and Optimization Problems QTOP 2019 held in Munich Germany in March 2019 The 18 full papers presented together with 1 keynote paper in this volume were carefully reviewed and selected from 21 submissions The papers are grouped in the following topical sections analysis of optimization problems quantum gate algorithms applications of quantum annealing and foundations and quantum technologies **Principles of Superconducting Quantum Computers** Daniel D. Stancil,Gregory T. Byrd,2022-04-19 Explore the intersection of computer science physics and electrical and computer engineering with this discussion of the engineering of quantum computers In Principles of Superconducting Quantum Computers a pair of distinguished researchers delivers a comprehensive and insightful discussion of the building of quantum computing hardware and systems Bridging the gaps between computer science physics and electrical and computer engineering the book focuses on the engineering topics of devices circuits control and error correction Using data from actual quantum computers the authors illustrate critical concepts from quantum computing Questions and problems at the end of each chapter assist students with learning and retention while the text offers descriptions of fundamentals concepts ranging from the physics of gates to quantum error correction techniques The authors provide efficient implementations of classical computations and the book comes complete with a solutions manual and demonstrations of many of the concepts discussed within It also includes A thorough introduction to qubits gates and circuits including unitary transformations single qubit gates and controlled two qubit gates Comprehensive explorations of the physics of single qubit gates including the requirements for a quantum computer rotations two state systems and Rabi oscillations Practical discussions of the physics of two qubit gates including tunable qubits SWAP gates controlled NOT gates and fixed frequency qubits In depth examinations of superconducting quantum computer systems including the need for cryogenic temperatures transmission lines S parameters and more Ideal for senior level undergraduate and graduate students in electrical and computer engineering programs Principles of Superconducting Quantum Computers also deserves a place in the libraries of practicing engineers seeking a better understanding of quantum computer systems KUANTUM HESAPLAYICILAR VE KUANTUM HESAPLAMAYA GİRİŞ Mustafa Nuri URAL,2021-06-10 Klasik bilgisayarlar 20 yy a y n vermi tir Sanayi devriminin toplumun yap s n de i tirmesi gibi bili im teknolojileri de yeni bir paradigma olu mas na neden olmu tur Bug n bilgisayarlar n insandan daha zeki olup olamayaca tart lmaktad r lk elektrik hesaplay c olarak kabul edilen ENIAC n mucitleri bilgisayar d nyas n n bug n geldi i noktay hayal bile edemezlerdi Hen z ancak laboratuvar ortam nda kullan labilen kuantum bilgisayarlar klasik bilgisayarlardan farkl yap lar ile hesaplaman n do as n yeniden yap land racak gibi g z kmektedir Bu bilgisayarlar n ne gibi geli melerin kap s n aralayaca n imdiden kestirmek zordur Ama bizim i in bug nden ok farkl bir gelece in b y k h zla yakla t ve bu gelecekte kuantum bilgisayarlar n b y k paya sahip olaca imdiden a k Bu kitapta temel matematik ve fizik altyap s na dair zet bilgiler verildikten sonra klasik bilgisayarlar n ne oldu u nas l al t na ve kuantum bilgisayarlar n klasik bilgisayarlar ile kar

la t rmas na yer verilmi tir Daha sonra kuantum bilgisayarlar da kullan lan kap lar ve temel baz algoritma ve devreler rnekle nmi tir Kuantum bilgisayarlar n fiziksel yap s zetlendikten sonra son olarak kuantum kriptoloji konusuna de inilmi tir Kuantum hesaplay c lar d nyas na ilgi duyan ancak nereden ba layaca n bilemeyen okuyucular i in bu kitab n iyi bir ba lang noktas olmas n umuyoruz nemli Ba l klar Hilbert Uzay Matrisler ve Dirac Notasyonu Zamandan Ba ms z Schr dinger Denklemi Kuantum Mekani inin Temelleri Kuantum Korelasyonlar Dola kl k S per Pozisyon l me Post latlar Klasik Bilgisayarlar Kuantum Bilgisayarlar Bloch K resi No Signalling Teorem Tekli ve oklu K bitler Kuantum Kap lar ve Operat rler Pauli Kap lar Hadamard Kap s Toffoli Kap s Fredkin Kap s CNOT Kap s Kuantum Algoritmalar Deutsch Algoritmas Shor Algoritmas Grover Algoritmas Kuantum Devreler Kuantum Bilgisayarlar n Fiziksel Yap s Kuantum Kriptografi NN84 Algoritmas EPR_Ekert Protokol

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Experience with Quantum Annealing Computation Catherine McGeoch, Susan Mniszewski, Nicholas Chancellor, David Esteban Bernal Neira, 2024-09-18 The past decade has seen four generations of quantum annealing processors with qubit counts increasing from 512 on the D Wave Two released in 2013 to over 5000 on Advantage processors available in 2023 During this time expanding access for researchers has sparked enormous growth in publications and in the body of knowledge surrounding capabilities applications and best practices in use of these novel computing systems This Research Topic will invite submissions on all aspects of empirical experience with annealing based quantum computers The intention is to present a broad survey of the current state of knowledge about quantum annealing hardware performance software infrastructures and applications

Approximability of Optimization Problems through

Adiabatic Quantum Computation William Cruz-Santos,Guillermo Morales-Luna,2014-09-01 The adiabatic quantum computation AQC is based on the adiabatic theorem to approximate solutions of the Schrödinger equation The design of an AQC algorithm involves the construction of a Hamiltonian that describes the behavior of the quantum system This Hamiltonian is expressed as a linear interpolation of an initial Hamiltonian whose ground state is easy to compute and a final Hamiltonian whose ground state corresponds to the solution of a given combinatorial optimization problem The adiabatic theorem asserts that if the time evolution of a quantum system described by a Hamiltonian is large enough then the system remains close to its ground state An AQC algorithm uses the adiabatic theorem to approximate the ground state of the final Hamiltonian that corresponds to the solution of the given optimization problem In this book we investigate the computational simulation of AQC algorithms applied to the MAX SAT problem A symbolic analysis of the AQC solution is given in order to understand the involved computational complexity of AQC algorithms This approach can be extended to other combinatorial optimization problems and can be used for the classical simulation of an AQC algorithm where a Hamiltonian problem is constructed This construction requires the computation of a sparse matrix of dimension $2^n \times 2^n$ by means of tensor products where n is the dimension of the quantum system Also a general scheme to design AQC algorithms is proposed based on a natural correspondence between optimization Boolean variables and quantum bits Combinatorial graph problems are in correspondence with pseudo Boolean maps that are reduced in polynomial time to quadratic maps Finally the relation among NP hard problems is investigated as well as its logical representability and is applied to the design of AQC algorithms It is shown that every monadic second order logic MSOL expression has associated pseudo Boolean maps that can be obtained by expanding the given expression and also can be reduced to quadratic forms Table of Contents Preface Acknowledgments Introduction Approximability of NP hard Problems Adiabatic Quantum Computing Efficient Hamiltonian Construction AQC for Pseudo Boolean Optimization A General Strategy to Solve NP Hard Problems Conclusions Bibliography Authors Biographies

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