

Yan Luo · Krishnendu Chakrabarty
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Hardware/Software Co-Design and Optimization for Cyberphysical Integration in Digital Microfluidic Biochips



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Hardwaresoftware Co Design And Optimization For Cyberphysical Integration In Digital Microfluidic Biochips

Krishnendu Chakrabarty, Tao Xu



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Hardware/Software Co-Design and Optimization for Cyberphysical Integration in Digital Microfluidic Biochips

Yan Luo, Krishnendu Chakrabarty, Tsung-Yi Ho, 2014-08-06 This book describes a comprehensive framework for hardware software co design optimization and use of robust low cost and cyberphysical digital microfluidic systems Readers with a background in electronic design automation will find this book to be a valuable reference for leveraging conventional VLSI CAD techniques for emerging technologies e g biochips or bioMEMS Readers from the circuit system design community will benefit from methods presented to extend design and testing techniques from microelectronics to mixed technology microsystems For readers from the microfluidics domain this book presents a new design and development strategy for cyberphysical microfluidics based biochips suitable for large scale bioassay applications Takes a transformative cyberphysical approach towards achieving closed loop and sensor feedback driven biochip operation under program control Presents a physically aware system reconfiguration technique that uses sensor data at intermediate checkpoints to dynamically reconfigure biochips Enables readers to simplify the structure of biochips while facilitating the general purpose use of digital microfluidic biochips for a wider range of applications

Enhancing Operational Efficiency and Predictive Maintenance Through Digital Innovation Minakshi, Kumar, Tarun, Bhatia, Madhulika, Wadhwa, Bhawna, Jain, Ranjana, 2025-09-18 In today's industrial landscape enhancing operational efficiency and implementing predictive maintenance strategies have become critical goals for organizations seeking sustainable growth and competitiveness Digital innovation has the potential to optimize workflows reduce downtime and predict equipment failures By utilizing real time data and intelligent systems companies can move from reactive to proactive maintenance models streamline operations and cut costs Further research into this shift may boost productivity while driving long term value creation across industries Enhancing Operational Efficiency and Predictive Maintenance Through Digital Innovation explores the synergistic impact of cutting edge technologies on our lives It delves into the interconnected world of devices the immense data they generate and the immense potential of advanced analytics and machine learning algorithms to derive valuable insights This book covers topics such as smart technology disease detection and environmental monitoring and is a useful resource for business owners engineers educators academicians researchers and scientists

Advanced Logic Synthesis André Inácio Reis, Rolf Drechsler, 2017-11-15 This book provides a single source reference to the state of the art in logic synthesis Readers will benefit from the authors expert perspectives on new technologies and logic synthesis new data structures big data and logic synthesis and convergent logic synthesis The authors describe techniques that will enable readers to take advantage of recent advances in big data techniques and frameworks in order to have better logic synthesis algorithms

Computer-Aided Design of Microfluidic Very Large Scale Integration (mVLSI) Biochips Kai Hu, Krishnendu Chakrabarty, Tsung-Yi Ho, 2017-04-05 This book provides a comprehensive overview of flow based microfluidic VLSI The

authors describe and solve in a comprehensive and holistic manner practical challenges such as control synthesis wash optimization design for testability and diagnosis of modern flow based microfluidic biochips They introduce practical solutions based on rigorous optimization and formal models The technical contributions presented in this book will not only shorten the product development cycle but also accelerate the adoption and further development of modern flow based microfluidic biochips by facilitating the full exploitation of design complexities that are possible with current fabrication techniques

Micro-Electrode-Dot-Array Digital Microfluidic Biochips Zipeng Li,Krishnendu Chakrabarty,Tsung-Yi Ho,Chen-Yi Lee,2018-12-14 This book provides an insightful guide to the design testing and optimization of micro electrode dot array MEDA digital microfluidic biochips The authors focus on the characteristics specific for MEDA biochips e g real time sensing and advanced microfluidic operations like lamination mixing and droplet shape morphing Readers will be enabled to enhance the automated design and use of MEDA and to develop a set of solutions to facilitate the full exploitation of design complexities that are possible with standard CMOS fabrication techniques The book provides the first set of design automation and test techniques for MEDA biochips The methods described in this book have been validated using fabricated MEDA biochips in the laboratory Readers will benefit from an in depth look at the MEDA platform and how to combine microfluidics with software e g applying biomolecular protocols to software controlled and cyberphysical microfluidic biochips

VLSI Design and Test Brajesh Kumar Kaushik,Sudeb Dasgupta,Virendra Singh,2017-12-21 This book constitutes the refereed proceedings of the 21st International Symposium on VLSI Design and Test VDAT 2017 held in Roorkee India in June July 2017 The 48 full papers presented together with 27 short papers were carefully reviewed and selected from 246 submissions The papers were organized in topical sections named digital design analog mixed signal VLSI testing devices and technology VLSI architectures emerging technologies and memory system design low power design and test RF circuits architecture and CAD and design verification

Applied Computing for Software and Smart Systems Rituparna Chaki,Nabendu Chaki,Agostino Cortesi,Khalid Saeed,2023-12-26 This book features a collection of high quality research papers presented at the 10th International Symposium on Applied Computing for Software and Smart systems ACSS 2023 to be held during September 15 16 2023 in Kolkata India The book presents innovative works by undergraduate graduate students as well as Ph D scholars The emphasis of the workshop is on software and smart systems and research outcomes on other relevant areas pertaining to advancement of computing

Optimization of Trustworthy Biomolecular Quantitative Analysis Using Cyber-Physical Microfluidic Platforms Mohamed Ibrahim,Krishnendu Chakrabarty,2020-05-31 A microfluidic biochip is an engineered fluidic device that controls the flow of analytes thereby enabling a variety of useful applications According to recent studies the fields that are best set to benefit from the microfluidics technology also known as lab on chip technology include forensic identification clinical chemistry point of care PoC diagnostics and drug discovery The growth in such fields has significantly amplified the impact of microfluidics

technology whose market value is forecast to grow from 4 billion in 2017 to 13.2 billion by 2023. The rapid evolution of lab on chip technologies opens up opportunities for new biological or chemical science areas that can be directly facilitated by sensor based microfluidics control. For example the digital microfluidics based ePlex system from GenMarkDx enables automated disease diagnosis and can bring syndromic testing near patients everywhere. However as the applications of molecular biology grow the adoption of microfluidics in many applications has not grown at the same pace despite the concerted effort of microfluidic systems engineers. Recent studies suggest that state of the art design techniques for microfluidics have two major drawbacks that need to be addressed appropriately: 1. current lab on chip systems were only optimized as auxiliary components and are only suitable for sample limited analyses therefore their capabilities may not cope with the requirements of contemporary molecular biology applications; 2. the integrity of these automated lab on chip systems and their biochemical operations are still an open question since no protection schemes were developed against adversarial contamination or result manipulation attacks. Optimization of Trustworthy Biomolecular Quantitative Analysis Using Cyber Physical Microfluidic Platforms provides solutions to these challenges by introducing a new design flow based on the realistic modeling of contemporary molecular biology protocols. It also presents a microfluidic security flow that provides a high level of confidence in the integrity of such protocols. In summary this book creates a new research field as it bridges the technical skills gap between microfluidic systems and molecular biology protocols but it is viewed from the perspective of an electronic systems engineer.

Fault-Tolerant Digital Microfluidic Biochips Paul Pop, Mirela Alistar, Elena Stuart, Jan Madsen, 2015-09-07. This book describes for researchers in the fields of compiler technology design and test and electronic design automation the new area of digital microfluidic biochips (DMBs) and thus offers a new application area for their methods. The authors present a routing based model of operation execution along with several associated compilation approaches which progressively relax the assumption that operations execute inside fixed rectangular modules. Since operations can experience transient faults during the execution of a bioassay the authors show how to use both offline design time and online runtime recovery strategies. The book also presents methods for the synthesis of fault tolerant application specific DMB architectures. Presents the current models used for the research on compilation and synthesis techniques of DMBs in a tutorial fashion. Includes a set of benchmarks which are presented in great detail and includes the source code of most of the techniques presented including solutions to the basic compilation and synthesis problems. Discusses several new research problems in detail using numerous examples.

Digital Microfluidic Biochips Krishnendu Chakrabarty, Tao Xu, 2010-05-03. Microfluidics based biochips combine electronics with biochemistry providing access to new application areas in a wide variety of fields. Continued technological innovations are essential to assuring the future role of these chips in functional diversification in biotech, pharmaceuticals and other industries. Revolutionary guidance on design opti

Digital Microfluidic Biochips Krishnendu Chakrabarty, Tao Xu, 2010-05-03. Microfluidics based biochips combine electronics with

biochemistry providing access to new application areas in a wide variety of fields Continued technological innovations are essential to assuring the future role of these chips in functional diversification in biotech pharmaceuticals and other industries Revolutionary guidance on design opti

Design and Testing of Digital Microfluidic Biochips Yang Zhao, Krishnendu Chakrabarty, 2012-07-25 This book provides a comprehensive methodology for automated design test and diagnosis and use of robust low cost and manufacturable digital microfluidic systems It focuses on the development of a comprehensive CAD optimization framework for digital microfluidic biochips that unifies different design problems With the increase in system complexity and integration levels biochip designers can utilize the design methods described in this book to evaluate different design alternatives and carry out design space exploration to obtain the best design point

Routing and Performance Optimization of Digital Microfluidic Biochip Sarit Chakraborty, 2024-01-22 Digital Microfluidic Biochips or DMFBs have emerged as a great alternative to various in vitro diagnostic tests in recent past These chips are expected to be closely coupled up with cyberphysical systems and with other healthcare related systems in the near future Hence design optimization of such micro or nano scale DMFB requires interdisciplinary study of computer science electronics along with biochemistry and medical technology Research in this new discipline of nano biotechnology needs the integration of diverse fields such as microelectronics biochemistry in vitro diagnostics computer aided design and optimization fabrication technology in association with healthcare engineering methodologies Potential applications of DMFBs include several real life applications such as point of care clinical diagnostics enzymatic analysis e g glucose and lactate assays high throughput DNA Deoxyribonucleic acid sequencing immunoassay proteomics study of protein structure and environmental toxicity monitoring water and air pollutant detection or food processing and so on and so forth These LoC systems provide a viable and low cost platform for rapid automated and accurate clinical diagnosis of various diseases including malaria neglected tropical diseases NTD prevalent in the developing countries Typically a microfluidic based chip implements one or more complex bioassays bio protocols by manipulating nanolitre or picoliter volume of fluids on a single chip of a few square centimeters in size

Digital Microfluidic Biochips Krishnendu Chakrabarty, Fei Su, 2018-10-03 Digital Microfluidic Biochips focuses on the automated design and production of microfluidic based biochips for large scale bioassays and safety critical applications Bridging areas of electronic design automation with microfluidic biochip research the authors present a system level design automation framework that addresses key issues in the design analysis and testing of digital microfluidic biochips The book describes a new generation of microfluidic biochips with more complex designs that offer dynamic reconfigurability system scalability system integration and defect tolerance Part I describes a unified design methodology that targets design optimization under resource constraints Part II investigates cost effective testing techniques for digital microfluidic biochips that include test resource optimization and fault detection while running normal bioassays Part III focuses on different reconfiguration based defect tolerance techniques designed to increase the yield and

dependability of digital microfluidic biochips Expanding upon results from ongoing research on CAD for biochips at Duke University this book presents new design methodologies that address some of the limitations in current full custom design techniques Digital Microfluidic Biochips is an essential resource for achieving the integration of microfluidic components in the next generation of system on chip and system in package designs *Secure and Trustworthy Cyberphysical Microfluidic Biochips* Jack Tang, Mohamed Ibrahim, Krishnendu Chakrabarty, Ramesh Karri, 2019-05-28 This book describes novel hardware security and microfluidic biochip design methodologies to protect against tampering attacks in cyberphysical microfluidic biochips CPMBs It also provides a general overview of this nascent area of research which will prove to be a vital resource for practitioners in the field This book shows how hardware based countermeasures and design innovations can be a simple and effective last line of defense demonstrating that it is no longer justifiable to ignore security and trust in the design phase of biochips **Placement Optimization in Cyber-Physical Digital Microfluidic Biochips**, 2016

Design Tools and Optimization Methods for Digital Microfluidic Biochips Tao Xu, 2007 **Optimization Tools for the Design of Reconfigurable Digital Microfluidic Biochips** Tao Xu, 2008 **Algorithms for Sample Preparation with Microfluidic Lab-on-Chip** Bhattacharjee, Sukanta, Bhattacharya, Bhargab B. , Chakrabarty, Krishnendu, 2019-02-05 Recent microfluidic technologies have brought a complete paradigm shift in automating biochemical processing on a tiny lab on chip a biochip that replaces expensive and bulky instruments traditionally used in implementing bench top laboratory protocols Biochips have already made a profound impact on various application domains such as clinical diagnostics DNA analysis genetic engineering and drug discovery among others They are capable of precisely manipulating micro pico liter quantities of fluids and provide integrated support for mixing storage transportation and sensing on chip In almost all bioprotocols sample preparation plays an important role which includes dilution and mixing of several fluids satisfying certain volumetric ratios However designing algorithms that minimize reactant cost and sample preparation time suited for microfluidic chips poses a great challenge from the perspective of protocol mapping scheduling and physical design Algorithms for Sample Preparation with Microfluidic Lab on Chip attempts to bridge the widening gap between biologists and engineers by introducing from the fundamentals several state of the art computer aided design CAD algorithms for sample preparation with digital and flow based microfluidic biochips Technical topics discussed in the book include Basics of digital and flow based microfluidic lab on chip Comprehensive review of state of the art sample preparation algorithms Sample preparation algorithms for digital microfluidic lab on chip Sample preparation algorithms for flow based microfluidic lab on chip *Microfluidic Very Large Scale Integration (VLSI)* Paul Pop, Wajid Hassan Minhass, Jan Madsen, 2016-02-08 This book presents the state of the art techniques for the modeling simulation testing compilation and physical synthesis of mVLSI biochips The authors describe a top down modeling and synthesis methodology for the mVLSI biochips inspired by microelectronics VLSI methodologies They introduce a modeling framework for the components and the biochip architecture

and a high level microfluidic protocol language Coverage includes a topology graph based model for the biochip architecture and a sequencing graph to model for biochemical application showing how the application model can be obtained from the protocol language The techniques described facilitate programmability and automation enabling developers in the emerging large biochip market

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Introduction

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