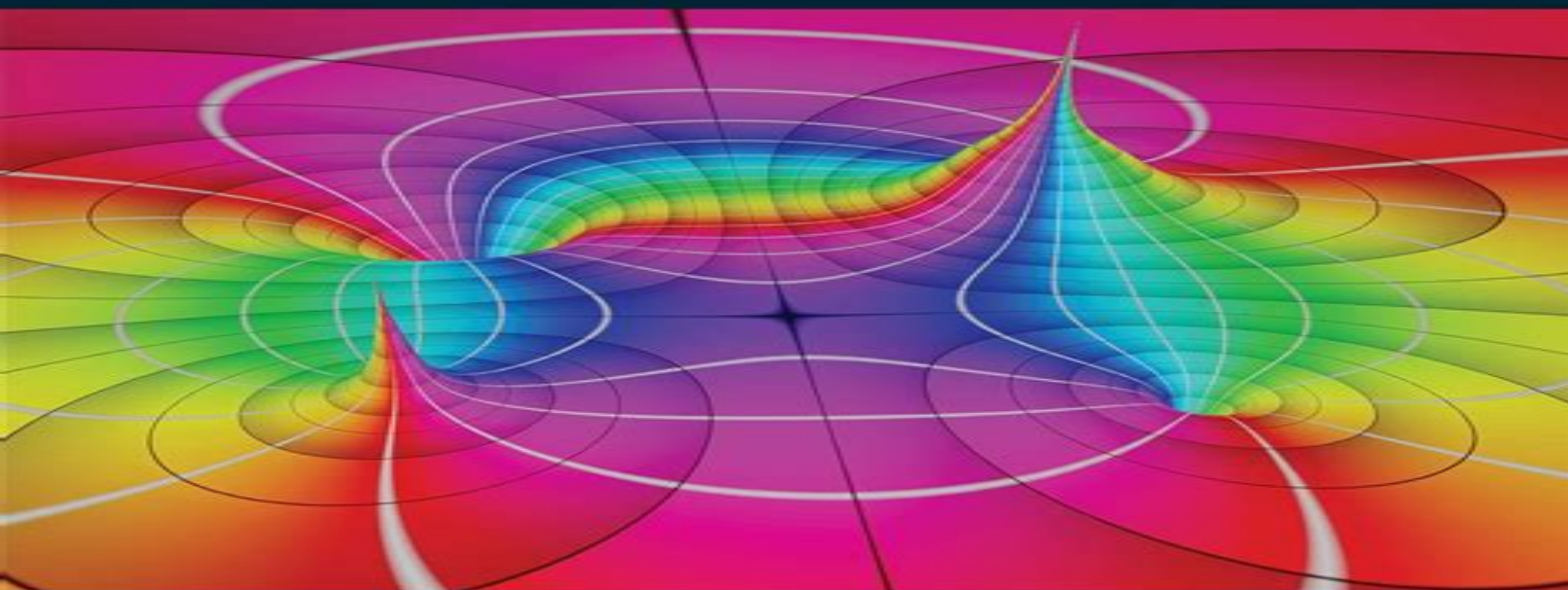


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Numerical Analysis and Scientific Computing

Designing Scientific Applications on GPUs



Edited by
Raphaël Couturier

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Designing Scientific Applications On Gpus Chapman Hallerc Numerical Analysis And Scientific Computing Series:

Designing Scientific Applications on GPUs Raphael Couturier, 2013-11-21 Many of today's complex scientific applications now require a vast amount of computational power. General purpose graphics processing units (GPGPUs) enable researchers in a variety of fields to benefit from the computational power of all the cores available inside graphics cards. Understand the Benefits of Using GPUs for Many Scientific Applications. *Designing Scientific Applications on GPUs* shows you how to use GPUs for applications in diverse scientific fields from physics and mathematics to computer science. The book explains the methods necessary for designing or porting your scientific application on GPUs. It will improve your knowledge about image processing, numerical applications, methodology to design efficient applications, optimization methods, and much more. Everything You Need to Design Port Your Scientific Application on GPUs. The first part of the book introduces the GPUs and Nvidia's CUDA programming model, currently the most widespread environment for designing GPU applications. The second part focuses on significant image processing applications on GPUs. The third part presents general methodologies for software development on GPUs, and the fourth part describes the use of GPUs for addressing several optimization problems. The fifth part covers many numerical applications including obstacle problems, fluid simulation, and atomic physics models. The last part illustrates agent-based simulations, pseudorandom number generation, and the solution of large sparse linear systems for integer factorization. Some of the codes presented in the book are available online. **Parallel Computing: On the Road to Exascale** Gerhard R. Joubert, Hugh Leather, Mark Parsons, Frans Peters, 2016-04-15 As predicted by Gordon E. Moore in 1965, the performance of computer processors increased at an exponential rate. Nevertheless, the increases in computing speeds of single processor machines were eventually curtailed by physical constraints. This led to the development of parallel computing, and whilst progress has been made in this field, the complexities of parallel algorithm design, the deficiencies of the available software development tools, and the complexity of scheduling tasks over thousands and even millions of processing nodes represent a major challenge to the construction and use of more powerful parallel systems. This book presents the proceedings of the biennial International Conference on Parallel Computing (ParCo2015) held in Edinburgh, Scotland, in September 2015. Topics covered include computer architecture and performance, programming models and methods, as well as applications. The book also includes two invited talks and a number of mini symposia. Exascale computing holds enormous promise in terms of increasing scientific knowledge acquisition and thus contributing to the future well-being and prosperity of mankind. A number of innovative approaches to the development and use of future high performance and high throughput systems are to be found in this book, which will be of interest to all those whose work involves the handling and processing of large amounts of data. CUDA for Engineers Duane Storti, Mete Yurtoglu, 2015-11-02 *CUDA for Engineers* gives you direct hands-on engagement with personal high performance parallel computing, enabling you to do computations on a gaming level PC that would have required a supercomputer just a few years ago. The authors introduce the

essentials of CUDA C programming clearly and concisely quickly guiding you from running sample programs to building your own code Throughout you ll learn from complete examples you can build run and modify complemented by additional projects that deepen your understanding All projects are fully developed with detailed building instructions for all major platforms Ideal for any scientist engineer or student with at least introductory programming experience this guide assumes no specialized background in GPU based or parallel computing In an appendix the authors also present a refresher on C programming for those who need it Coverage includes Preparing your computer to run CUDA programs Understanding CUDA s parallelism model and C extensions Transferring data between CPU and GPU Managing timing profiling error handling and debugging Creating 2D grids Interoperating with OpenGL to provide real time user interactivity Performing basic simulations with differential equations Using stencils to manage related computations across threads Exploiting CUDA s shared memory capability to enhance performance Interacting with 3D data slicing volume rendering and ray casting Using CUDA libraries Finding more CUDA resources and code Realistic example applications include Visualizing functions in 2D and 3D Solving differential equations while changing initial or boundary conditions Viewing processing images or image stacks Computing inner products and centroids Solving systems of linear algebraic equations Monte Carlo computations

Supercomputing Julian Martin Kunkel,Thomas Ludwig,Hans Meuer,2014-06-03 This book constitutes the refereed proceedings of the 29th International Supercomputing Conference ISC 2014 held in Leipzig Germany in June 2014 The 34 revised full papers presented together were carefully reviewed and selected from 79 submissions The papers cover the following topics scalable applications with 50K cores advances in algorithms scientific libraries programming models architectures performance models and analysis automatic performance optimization parallel I O and energy efficiency

Nonlinear Structural Dynamics and Damping Juan Carlos Jauregui,2019-03-14 This book compiles recent research in the field of nonlinear dynamics vibrations and damping applied to engineering structures It addresses the modeling of nonlinear vibrations in beams frames and complex mechanical systems as well as the modeling of damping systems and viscoelastic materials applied to structural dynamics The book includes several chapters related to solution techniques and signal analysis techniques Last but not least it deals with the identification of nonlinear responses applied to condition monitoring systems

Trends in Electromagnetism Victor Barsan,Radu Lungu,2012-03-23 Among the branches of classical physics electromagnetism is the domain which experiences the most spectacular development both in its fundamental and practical aspects The quantum corrections which generate non linear terms of the standard Maxwell equations their specific form in curved spaces whose predictions can be confronted with the cosmic polarization rotation or the topological model of electromagnetism constructed with electromagnetic knots are significant examples of recent theoretical developments The similarities of the Sturm Liouville problems in electromagnetism and quantum mechanics make possible deep analogies between the wave propagation in waveguides ballistic electron movement in mesoscopic conductors

and light propagation on optical fibers facilitating a better understanding of these topics and fostering the transfer of techniques and results from one domain to another Industrial applications like magnetic refrigeration at room temperature or use of metamaterials for antenna couplers and covers are of utmost practical interest So this book offers an interesting and useful reading for a broad category of specialists

Scientific Computing with Multicore and Accelerators Jakub Kurzak, David A. Bader, Jack Dongarra, 2010-12-07 The hybrid heterogeneous nature of future microprocessors and large high performance computing systems will result in a reliance on two major types of components multicore manycore central processing units and special purpose hardware massively parallel accelerators While these technologies have numerous benefits they also pose substantial performance challenges for developers including scalability software tuning and programming issues Researchers at the Forefront Reveal Results from Their Own State of the Art Work Edited by some of the top researchers in the field and with contributions from a variety of international experts Scientific Computing with Multicore and Accelerators focuses on the architectural design and implementation of multicore and manycore processors and accelerators including graphics processing units GPUs and the Sony Toshiba IBM STI Cell Broadband Engine BE currently used in the Sony PlayStation 3 The book explains how numerical libraries such as LAPACK help solve computational science problems explores the emerging area of hardware oriented numerics and presents the design of a fast Fourier transform FFT and a parallel list ranking algorithm for the Cell BE It covers stencil computations auto tuning optimizations of a computational kernel sequence alignment and homology and pairwise computations The book also evaluates the portability of drug design applications to the Cell BE and illustrates how to successfully exploit the computational capabilities of GPUs for scientific applications It concludes with chapters on dataflow frameworks the Charm programming model scan algorithms and a portable intracore communication framework Explores the New Computational Landscape of Hybrid Processors By offering insight into the process of constructing and effectively using the technology this volume provides a thorough and practical introduction to the area of hybrid computing It discusses introductory concepts and simple examples of parallel computing logical and performance debugging for parallel computing and advanced topics and issues related to the use and building of many applications

Exascale Scientific Applications Tjerk P. Straatsma, Katerina B. Antypas, Timothy J. Williams, 2017-11-13 From the Foreword The authors of the chapters in this book are the pioneers who will explore the exascale frontier The path forward will not be easy These authors along with their colleagues who will produce these powerful computer systems will with dedication and determination overcome the scalability problem discover the new algorithms needed to achieve exascale performance for the broad range of applications that they represent and create the new tools needed to support the development of scalable and portable science and engineering applications Although the focus is on exascale computers the benefits will permeate all of science and engineering because the technologies developed for the exascale computers of tomorrow will also power the petascale

servers and terascale workstations of tomorrow These affordable computing capabilities will empower scientists and engineers everywhere Thom H Dunning Jr Pacific Northwest National Laboratory and University of Washington Seattle Washington USA This comprehensive summary of applications targeting Exascale at the three DoE labs is a must read Rio Yokota Tokyo Institute of Technology Tokyo Japan Numerical simulation is now a need in many fields of science technology and industry The complexity of the simulated systems coupled with the massive use of data makes HPC essential to move towards predictive simulations Advances in computer architecture have so far permitted scientific advances but at the cost of continually adapting algorithms and applications The next technological breakthroughs force us to rethink the applications by taking energy consumption into account These profound modifications require not only anticipation and sharing but also a paradigm shift in application design to ensure the sustainability of developments by guaranteeing a certain independence of the applications to the profound modifications of the architectures it is the passage from optimal performance to the portability of performance It is the challenge of this book to demonstrate by example the approach that one can adopt for the development of applications offering performance portability in spite of the profound changes of the computing architectures Christophe Calvin CEA Fundamental Research Division Saclay France Three editors one from each of the High Performance Computer Centers at Lawrence Berkeley Argonne and Oak Ridge National Laboratories have compiled a very useful set of chapters aimed at describing software developments for the next generation exa scale computers Such a book is needed for scientists and engineers to see where the field is going and how they will be able to exploit such architectures for their own work The book will also benefit students as it provides insights into how to develop software for such computer architectures Overall this book fills an important need in showing how to design and implement algorithms for exa scale architectures which are heterogeneous and have unique memory systems The book discusses issues with developing user codes for these architectures and how to address these issues including actual coding examples Dr David A Dixon Robert Ramsay Chair The University of Alabama Tuscaloosa Alabama USA

GPU Solutions to Multi-scale Problems in Science and Engineering David A. Yuen, Long Wang, Xuebin Chi, Lennart Johnsson, Wei Ge, Yaolin Shi, 2013-01-09 This book covers the new topic of GPU computing with many applications involved taken from diverse fields such as networking seismology fluid mechanics nano materials data mining earthquakes mantle convection visualization It will show the public why GPU computing is important and easy to use It will offer a reason why GPU computing is useful and how to implement codes in an everyday situation

GPU Computing and Applications Yiyu Cai, Simon See, 2014-11-20 This book presents a collection of state of the art research on GPU Computing and Application The major part of this book is selected from the work presented at the 2013 Symposium on GPU Computing and Applications held in Nanyang Technological University Singapore Oct 9 2013 Three major domains of GPU application are covered in the book including 1 Engineering design and simulation 2 Biomedical Sciences and 3 Interactive Digital Media The book also addresses the fundamental issues in GPU computing with a focus on

big data processing Researchers and developers in GPU Computing and Applications will benefit from this book Training professionals and educators can also benefit from this book to learn the possible application of GPU technology in various areas

Numerical Computations with GPUs Volodymyr Kindratenko,2014-07-03 This book brings together research on numerical methods adapted for Graphics Processing Units GPUs It explains recent efforts to adapt classic numerical methods including solution of linear equations and FFT for massively parallel GPU architectures This volume consolidates recent research and adaptations covering widely used methods that are at the core of many scientific and engineering computations Each chapter is written by authors working on a specific group of methods these leading experts provide mathematical background parallel algorithms and implementation details leading to reusable adaptable and scalable code fragments This book also serves as a GPU implementation manual for many numerical algorithms sharing tips on GPUs that can increase application efficiency The valuable insights into parallelization strategies for GPUs are supplemented by ready to use code fragments Numerical Computations with GPUs targets professionals and researchers working in high performance computing and GPU programming Advanced level students focused on computer science and mathematics will also find this book useful as secondary text book or reference

ARCHITECTURE OF ADVANCED NUMERICAL ANALYSIS SYSTEMS LIANG. ZHAO WANG (JIANXIN.),2023

CUDA Application Design and Development Rob Farber,2011-10-31 The book then details the thought behind CUDA and teaches how to create analyze and debug CUDA applications Throughout the focus is on software engineering issues how to use CUDA in the context of existing application code with existing compilers languages software tools and industry standard API libraries Pub desc

GPU Programming in MATLAB Nikolaos Ploskas,Nikolaos Samaras,2016-08-25 GPU programming in MATLAB is intended for scientists engineers or students who develop or maintain applications in MATLAB and would like to accelerate their codes using GPU programming without losing the many benefits of MATLAB The book starts with coverage of the Parallel Computing Toolbox and other MATLAB toolboxes for GPU computing which allow applications to be ported straightforwardly onto GPUs without extensive knowledge of GPU programming The next part covers built in GPU enabled features of MATLAB including options to leverage GPUs across multicore or different computer systems Finally advanced material includes CUDA code in MATLAB and optimizing existing GPU applications Throughout the book examples and source codes illustrate every concept so that readers can immediately apply them to their own development Provides in depth comprehensive coverage of GPUs with MATLAB including the parallel computing toolbox and built in features for other MATLAB toolboxes Explains how to accelerate computationally heavy applications in MATLAB without the need to re write them in another language Presents case studies illustrating key concepts across multiple fields Includes source code sample datasets and lecture slides

GPU Computing Gems Emerald Edition ,2011-01-13 GPU Computing Gems Emerald Edition offers practical techniques in parallel computing using graphics processing units GPUs to enhance scientific research The first volume in Morgan

Kaufmann's Applications of GPU Computing Series this book offers the latest insights and research in computer vision electronic design automation and emerging data intensive applications It also covers life sciences medical imaging ray tracing and rendering scientific simulation signal and audio processing statistical modeling video and image processing This book is intended to help those who are facing the challenge of programming systems to effectively use GPUs to achieve efficiency and performance goals It offers developers a window into diverse application areas and the opportunity to gain insights from others algorithm work that they may apply to their own projects Readers will learn from the leading researchers in parallel programming who have gathered their solutions and experience in one volume under the guidance of expert area editors Each chapter is written to be accessible to researchers from other domains allowing knowledge to cross pollinate across the GPU spectrum Many examples leverage NVIDIA's CUDA parallel computing architecture the most widely adopted massively parallel programming solution The insights and ideas as well as practical hands on skills in the book can be immediately put to use Computer programmers software engineers hardware engineers and computer science students will find this volume a helpful resource For useful source codes discussed throughout the book the editors invite readers to the following website Covers the breadth of industry from scientific simulation and electronic design automation to audio video processing medical imaging computer vision and more Many examples leverage NVIDIA's CUDA parallel computing architecture the most widely adopted massively parallel programming solution Offers insights and ideas as well as practical hands on skills you can immediately put to use *Desktop Grid Computing* Christophe Cerin,Gilles Fedak,2012-06-25

Desktop Grid Computing presents common techniques used in numerous models algorithms and tools developed during the last decade to implement desktop grid computing These techniques enable the solution of many important sub problems for middleware design including scheduling data management security load balancing result certification and fault tolerance The book's first part covers the initial ideas and basic concepts of desktop grid computing The second part explores challenging current and future problems Each chapter presents the sub problems discusses theoretical and practical issues offers details about implementation and experiments and includes references to further reading and notes One of the first books to give a thorough and up to date presentation of this topic this resource describes various approaches and models as well as recent trends that underline the evolution of desktop grids It balances the theory of designing desktop grid middleware and architecture with applications and real world deployment on large scale platforms **GPU Computing Gems Jade Edition**

Wen-mei Hwu,2011-09-28 Since the introduction of CUDA in 2007 more than 100 million computers with CUDA capable GPUs have been shipped to end users GPU computing application developers can now expect their application to have a mass market With the introduction of OpenCL in 2010 researchers can now expect to develop GPU applications that can run on hardware from multiple vendors **Scalable Scientific Computing Applications for GPU-accelerated Heterogeneous Systems** Christoph Riesinger,2017 **Contemporary High Performance Computing** Jeffrey S. Vetter,2017-11-23 HPC is

used to solve a number of complex questions in computational and data intensive sciences These questions include the simulation and modeling of physical phenomena such as climate change energy production drug design global security and materials design the analysis of large data sets such as those in genome sequencing astronomical observation and cybersecurity and the intricate design of engineered products such as airplanes and automobiles This second volume of Contemporary High Performance Computing From Petascale toward Exascale continues to document international HPC ecosystems including the sponsors and sites that host them Each chapter is punctuated with a site s flagship system and Presents highlights of applications workloads and benchmarks Describes hardware architectures system software and programming systems Explores storage visualization and analytics Examines the data center facility as well as system statistics Featuring pictures of buildings and systems in production floorplans and many block diagrams and charts to illustrate system design and performance Contemporary High Performance Computing From Petascale toward Exascale Volume Two delivers a detailed snapshot of the rich history of practice in modern HPC This book provides a valuable reference for researchers in HPC and computational science *Scalable Scientific Computing Applications for GPU-accelerated Heterogeneous Systems* Christoph Karl Riesinger,2017

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