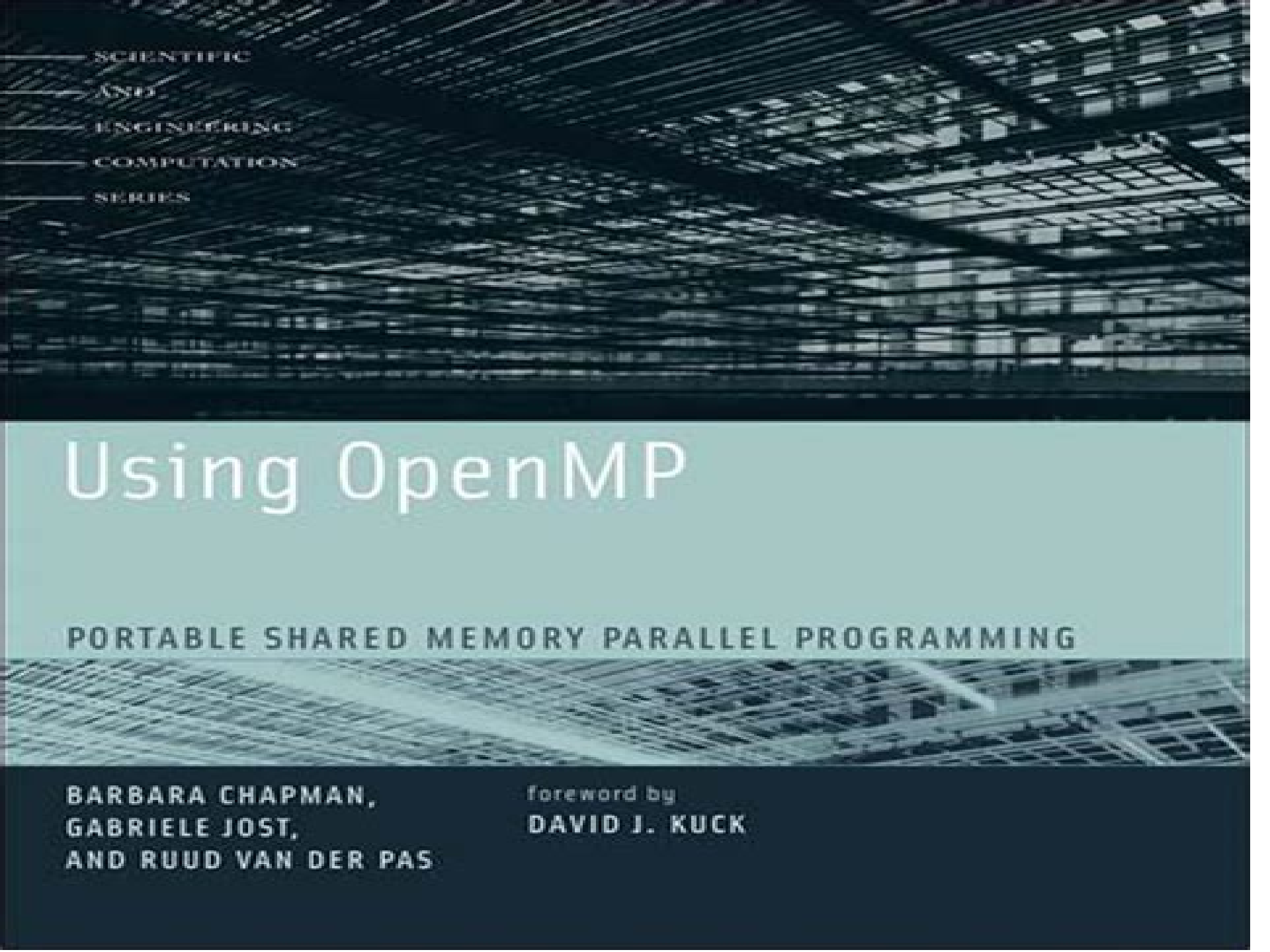




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Using OpenMP

PORTABLE SHARED MEMORY PARALLEL PROGRAMMING

BARBARA CHAPMAN,
GABRIELE JOST,
AND RUUD VAN DER PAS

foreword by
DAVID J. KUCK

Using Openmp Portable Shared Memory Parallel Programming

**Sanjay Rajopadhye, Michelle Mills
Strout**



Using Openmp Portable Shared Memory Parallel Programming:

Using OpenMP Barbara Chapman, Gabriele Jost, Ruud Van Der Pas, 2007-10-12 A comprehensive overview of OpenMP the standard application programming interface for shared memory parallel computing a reference for students and professionals I hope that readers will learn to use the full expressibility and power of OpenMP This book should provide an excellent introduction to beginners and the performance section should help those with some experience who want to push OpenMP to its limits from the foreword by David J Kuck Intel Fellow Software and Solutions Group and Director Parallel and Distributed Solutions Intel Corporation OpenMP a portable programming interface for shared memory parallel computers was adopted as an informal standard in 1997 by computer scientists who wanted a unified model on which to base programs for shared memory systems OpenMP is now used by many software developers it offers significant advantages over both hand threading and MPI Using OpenMP offers a comprehensive introduction to parallel programming concepts and a detailed overview of OpenMP Using OpenMP discusses hardware developments describes where OpenMP is applicable and compares OpenMP to other programming interfaces for shared and distributed memory parallel architectures It introduces the individual features of OpenMP provides many source code examples that demonstrate the use and functionality of the language constructs and offers tips on writing an efficient OpenMP program It describes how to use OpenMP in full scale applications to achieve high performance on large scale architectures discussing several case studies in detail and offers in depth troubleshooting advice It explains how OpenMP is translated into explicitly multithreaded code providing a valuable behind the scenes account of OpenMP program performance Finally Using OpenMP considers trends likely to influence OpenMP development offering a glimpse of the possibilities of a future OpenMP 3.0 from the vantage point of the current OpenMP 2.5 With multicore computer use increasing the need for a comprehensive introduction and overview of the standard interface is clear Using OpenMP provides an essential reference not only for students at both undergraduate and graduate levels but also for professionals who intend to parallelize existing codes or develop new parallel programs for shared memory computer architectures

Using OpenMP Barbara Chapman, Gabriele Jost, Ruud van der Pas, 2008 With multicore computer use increasing the need for a comprehensive introduction and overview of the standard interface is clear Using OpenMP provides an essential reference not only for students at both undergraduate and graduate levels but also for professionals who intend to parallelize existing codes or develop new parallel programs for shared memory computer architectures pub desc

OpenMP Shared Memory Parallel Programming Rudolf Eigenmann, 2001-07-18 This book constitutes the refereed proceedings of the International Workshop on OpenMP Applications and Tools WOMPAT 2001 held in West Lafayette IN USA in July 2001 The 15 full papers presented were carefully reviewed and revised for inclusion in the volume The book presents a state of the art overview on OpenMP shared memory parallel programming The papers are organized in topical sections on benchmarking compiler implementation and optimization tools and tool technology OpenMP

experience NUMA machines and clusters and OpenMP extensions

Using OpenMP#The Next Step Ruud Van Der Pas, Eric Stotzer, Christian Terboven, 2017-10-30 A guide to the most recent advanced features of the widely used OpenMP parallel programming model with coverage of major features in OpenMP 4.5 This book offers an up to date practical tutorial on advanced features in the widely used OpenMP parallel programming model Building on the previous volume Using OpenMP Portable Shared Memory Parallel Programming MIT Press this book goes beyond the fundamentals to focus on what has been changed and added to OpenMP since the 2.5 specifications It emphasizes four major and advanced areas thread affinity keeping threads close to their data accelerators special hardware to speed up certain operations tasking to parallelize algorithms with a less regular execution flow and SIMD hardware assisted operations on vectors As in the earlier volume the focus is on practical usage with major new features primarily introduced by example Examples are restricted to C and C++ but are straightforward enough to be understood by Fortran programmers After a brief recap of OpenMP 2.5 the book reviews enhancements introduced since 2.5 It then discusses in detail tasking a major functionality enhancement Non Uniform Memory Access NUMA architectures supported by OpenMP SIMD or Single Instruction Multiple Data heterogeneous systems a new parallel programming model to offload computation to accelerators and the expected further development of OpenMP

Shared Memory Application Programming Victor Alessandrini, 2015-11-06 Shared Memory Application Programming presents the key concepts and applications of parallel programming in an accessible and engaging style applicable to developers across many domains Multithreaded programming is today a core technology at the basis of all software development projects in any branch of applied computer science This book guides readers to develop insights about threaded programming and introduces two popular platforms for multicore development OpenMP and Intel Threading Building Blocks TBB Author Victor Alessandrini leverages his rich experience to explain each platform's design strategies analyzing the focus and strengths underlying their often complementary capabilities as well as their interoperability The book is divided into two parts the first develops the essential concepts of thread management and synchronization discussing the way they are implemented in native multithreading libraries Windows threads Pthreads as well as in the modern C++11 threads standard The second provides an in depth discussion of TBB and OpenMP including the latest features in OpenMP 4.0 extensions to ensure readers skills are fully up to date Focus progressively shifts from traditional thread parallelism to modern task parallelism deployed by modern programming environments Several chapters include examples drawn from a variety of disciplines including molecular dynamics and image processing with full source code and a software library incorporating a number of utilities that readers can adapt into their own projects Designed to introduce threading and multicore programming to teach modern coding strategies for developers in applied computing Leverages author Victor Alessandrini's rich experience to explain each platform's design strategies analyzing the focus and strengths underlying their often complementary capabilities as well as their interoperability Includes complete up to date discussions of OpenMP 4.0 and TBB

Based on the author's training sessions including information on source code and software libraries which can be repurposed

Languages and Compilers for Parallel Computing Călin Cașcaval, Pablo Montesinos, 2014-09-30 This book constitutes the thoroughly refereed post conference proceedings of the 26th International Workshop on Languages and Compilers for Parallel Computing LCPC 2013 held in Tokyo Japan in September 2012 The 20 revised full papers and two keynote papers presented were carefully reviewed and selected from 44 submissions The focus of the papers is on following topics parallel programming models compiler analysis techniques parallel data structures and parallel execution models to GPGPU and other heterogeneous execution models code generation for power efficiency on mobile platforms and debugging and fault tolerance for parallel systems **OpenMP: Portable Multi-Level Parallelism on Modern Systems** Kent Milfeld, Bronis R. de Supinski, Lars Koesterke, Jannis Klinkenberg, 2020-09-01 This book constitutes the proceedings of the 16th International Workshop on OpenMP IWOMP 2020 held in Austin TX USA in September 2020 The conference was held virtually due to the COVID 19 pandemic The 21 full papers presented in this volume were carefully reviewed and selected for inclusion in this book The papers are organized in topical sections named performance methodologies applications OpenMP extensions performance studies tools NUMA compilation techniques heterogeneous computing and memory The chapters A Case Study on Addressing Complex Load Imbalance in OpenMP and A Study of Memory Anomalies in OpenMP Applications are available open access under a Creative Commons Attribution 4.0 License via link.springer.com

Languages and Compilers for Parallel Computing Sanjay Rajopadhye, Michelle Mills Strout, 2013-01-18 This book constitutes the thoroughly refereed post conference proceedings of the 24th International Workshop on Languages and Compilers for Parallel Computing LCPC 2011 held in Fort Collins CO USA in September 2011 The 19 revised full papers presented and 19 poster papers were carefully reviewed and selected from 52 submissions The scope of the workshop spans the theoretical and practical aspects of parallel and high performance computing and targets parallel platforms including concurrent multithreaded multicore accelerator multiprocessor and cluster systems *Parallel Processing and Applied Mathematics, Part I* Roman Wyrzykowski, Jack Dongarra, Konrad Karczewski, Jerzy Wasniewski, 2010-07-07 Annotation This book constitutes the proceedings of the 8th International Conference on Parallel Processing and Applied Mathematics PPAM 2009 held in Wroclaw Poland in September 2009

New Technologies Constantin Volosencu, 2012-03-30 The book *New Technologies Trends Innovations and Research* presents contributions made by researchers from the entire world and from some modern fields of technology serving as a valuable tool for scientists researchers graduate students and professionals Some practical applications in particular areas are presented offering the capability to solve problems resulted from economic needs and to perform specific functions The book will make possible for scientists and engineers to get familiar with the ideas from researchers from some modern fields of activity It will provide interesting examples of practical applications of knowledge assist in the designing process as well as bring changes to their research areas A collection of techniques that combine scientific resources is provided to make

necessary products with the desired quality criteria Strong mathematical and scientific concepts were used in the applications They meet the requirements of utility usability and safety Technological applications presented in the book have appropriate functions and they may be exploited with competitive advantages The book has 17 chapters covering the following subjects manufacturing technologies nanotechnologies robotics telecommunications physics dental medical technologies smart homes speech technologies agriculture technologies and management

The Art of Structuring
Katrin Bergener, Michael Räckers, Armin Stein, 2019-01-25 Structuring or as it is referred to in the title of this book the art of structuring is one of the core elements in the discipline of Information Systems While the world is becoming increasingly complex and a growing number of disciplines are evolving to help make it a better place structure is what is needed in order to understand and combine the various perspectives and approaches involved Structure is the essential component that allows us to bridge the gaps between these different worlds and offers a medium for communication and exchange The contributions in this book build these bridges which are vital in order to communicate between different worlds of thought and methodology be it between Information Systems IS research and practice or between IS research and other research disciplines They describe how structuring can be and should be done so as to foster communication and collaboration The topics covered reflect various layers of structure that can serve as bridges models processes data organizations and technologies In turn these aspects are complemented by visionary outlooks on how structure influences the field

Advances in Computer Science and Ubiquitous Computing James J. Park, Vincenzo Loia, Gangman Yi, Yunsick Sung, 2017-12-19 This book presents the combined proceedings of the 12th KIPS International Conference on Ubiquitous Information Technologies and Applications CUTE 2017 and the 9th International Conference on Computer Science and its Applications CSA2017 both held in Taichung Taiwan December 18 20 2017 The aim of these two meetings was to promote discussion and interaction among academics researchers and professionals in the field of ubiquitous computing technologies These proceedings reflect the state of the art in the development of computational methods involving theory algorithms numerical simulation error and uncertainty analysis and novel applications of new processing techniques in engineering science and other disciplines related to ubiquitous computing James J Jong Hyuk Park received Ph D degrees in Graduate School of Information Security from Korea University Korea and Graduate School of Human Sciences from Waseda University Japan From December 2002 to July 2007 Dr Park had been a research scientist of R D Institute Hanwha S C Co Ltd Korea From September 2007 to August 2009 He had been a professor at the Department of Computer Science and Engineering Kyungnam University Korea He is now a professor at the Department of Computer Science and Engineering and Department of Interdisciplinary Bio IT Materials Seoul National University of Science and Technology SeoulTech Korea Dr Park has published about 200 research papers in international journals and conferences He has been serving as chair program committee or organizing committee chair for many international conferences and workshops He is a steering chair

of international conferences MUE FutureTech CSA CUTE UCAWSN World IT Congress Jeju He is editor in chief of Human centric Computing and Information Sciences HCIS by Springer The Journal of Information Processing Systems JIPS by KIPS and Journal of Convergence JoC by KIPS CSWRG He is Associate Editor Editor of 14 international journals including JoS JNCA SCN CJ and so on In addition he has been serving as a Guest Editor for international journals by some publishers Springer Elsevier John Wiley Oxford Univ press Emerald Inderscience MDPI He got the best paper awards from ISA 08 and ITCS 11 conferences and the outstanding leadership awards from IEEE HPCC 09 ICA3PP 10 IEE ISPA 11 PDCAT 11 IEEE AINA 15 Furthermore he got the outstanding research awards from the SeoulTech 2014 His research interests include IoT Human centric Ubiquitous Computing Information Security Digital Forensics Vehicular Cloud Computing Multimedia Computing etc He is a member of the IEEE IEEE Computer Society KIPS and KMMS Vincenzo Loia BS 85 MS 87 PhD 89 is Full Professor of Computer Science His research interests include Intelligent Agents Ambient intelligence Computational Intelligence Currently he is Founder Editor in chief of Ambient Intelligence and Humanized Computing and Co Editor in Chief of Softcomputing Springer Verlag He is Chair of the Task Forces Intelligent Agents and Ambient Intelligence IEEE CIS ETTC He has been Chair the Emergent Technical Committee Emergent Technology IEEE CIS Society and Vice Chair of Intelligent Systems Applications Technical Committee He has been author of more than 200 scientific works Editor co editor of 4 Books 64 journal papers 25 book chapters and 100 conference papers He is Senior member of the IEEE Associate Editor of IEEE Transactions on Industrial Informatics and Associate Editor of IEEE Transactions on Systems Man and Cybernetics Systems Many times reviewers for national and international projects Dr Loia is active in the research domain of agents ambient intelligence computational intelligence smartgrids distributed platform for enrich added value Gangman Yi in Computer Sciences at Texas A M University USA in 2007 and doctorate in Computer Sciences at Texas A M University USA in 2011 In May 2011 he joined System S W group in Samsung Electronics Suwon Korea He joined the Department of Computer Science Engineering Gangneung Wonju National University Korea since March 2012 Dr Yi has been researched in an interdisciplinary field of researches His research focuses especially on the development of computational methods to improve understanding of biological systems and its big data Dr Yi actively serves as a managing editor and reviewer for international journals and chair of international conferences and workshops Yunsick Sung received his B S degree in division of electrical and computer engineering from Pusan National University Busan Korea in 2004 his M S degree in computer engineering from Dongguk University Seoul Korea in 2006 and his Ph D degree in game engineering from Dongguk University Seoul Korea in 2012 He was employed as a member of the researcher at Samsung Electronics between 2006 and 2009 He was the plural professor at Shinheung College in 2009 and at Dongguk University in 2010 His main research interests are many topics in brain computer Interface programming by demonstration ubiquitous computing and reinforcement learning His Journal Service Experiences is Associate Editor at Human centric Computing and Information

Sciences Springer 2015 Current Computer Science And Technology - Proceedings Of The International Conference (Cst2016) Ning Cai, 2016-11-28 This proceedings consists of selected papers presented at the International Conference on Computer Science and Technology CST2016 which was successfully held in Shenzhen China during January 8 10 2016 CST2016 covered a wide range of fundamental studies technical innovations and industrial applications in 7 areas namely Computer Systems Computer Network Security Databases and Information Systems Artificial Intelligence and Multimedia Theory and Software Engineering and Computer Applications CST 2016 aims to provide a forum for researchers engineers and students in the area of computer science and technology It features unique mixed various topics in computer science and technology including big data system architecture hardware and applications CST 2016 attracted more than 300 submissions Among them only 142 papers were accepted in to the conference after a stringent peer review process *Modern Fortran* Norman S. Clerman, Walter Spector, 2011-12-05 Fortran is one of the oldest high level languages and remains the premier language for writing code for science and engineering applications This book is for anyone who uses Fortran from the novice learner to the advanced expert It describes best practices for programmers scientists engineers computer scientists and researchers who want to apply good style and incorporate rigorous usage in their own Fortran code or to establish guidelines for a team project The presentation concentrates primarily on the characteristics of Fortran 2003 while also describing methods in Fortran 90 95 and valuable new features in Fortran 2008 The authors draw on more than a half century of experience writing production Fortran code to present clear succinct guidelines on formatting naming documenting programming and packaging conventions and various programming paradigms such as parallel processing including OpenMP MPI and coarrays OOP generic programming and C language interoperability **Novel Developments in Futuristic AI-based Technologies** Manoj Sahni, José M. Merigó, Walayat Hussain, 2023-07-19 The book offers many ideas based on the artificial intelligence techniques fueled by digital technologies that can be implemented in human lives to make them smarter and more intelligent to survive in this rapidly changing world This book contains diverse applications based on intelligence systems such as in the development of innovative digital technologies based on cloud based infrastructure agriculture supply chain management technology that enables the visually impaired to live more comfortably and confidently in their daily lives It contains new techniques of encryption and decryption development of various decision making systems artificial intelligence techniques in medical areas etc This book addresses newly developed technologies and key ideas for new theory which can be used in the development of more advanced and intelligent world for better future **Heterogeneous Computing with OpenCL** Benedict Gaster, Lee Howes, David R. Kaeli, Perhaad Mistry, Dana Schaa, 2012-12-31 Heterogeneous Computing with OpenCL Second Edition teaches OpenCL and parallel programming for complex systems that may include a variety of device architectures multi core CPUs GPUs and fully integrated Accelerated Processing Units APUs such as AMD Fusion technology It is the first textbook that presents OpenCL programming appropriate for the classroom and

is intended to support a parallel programming course Students will come away from this text with hands on experience and significant knowledge of the syntax and use of OpenCL to address a range of fundamental parallel algorithms Designed to work on multiple platforms and with wide industry support OpenCL will help you more effectively program for a heterogeneous future Written by leaders in the parallel computing and OpenCL communities Heterogeneous Computing with OpenCL explores memory spaces optimization techniques graphics interoperability extensions and debugging and profiling It includes detailed examples throughout plus additional online exercises and other supporting materials that can be downloaded at http://www.heterogeneouscompute.org/page_id/7 This book will appeal to software engineers programmers hardware engineers and students advanced students Explains principles and strategies to learn parallel programming with OpenCL from understanding the four abstraction models to thoroughly testing and debugging complete applications Covers image processing web plugins particle simulations video editing performance optimization and more Shows how OpenCL maps to an example target architecture and explains some of the tradeoffs associated with mapping to various architectures Addresses a range of fundamental programming techniques with multiple examples and case studies that demonstrate OpenCL extensions for a variety of hardware platforms

Advances in Computers Marvin Zelkowitz, 2010-03-13 This is volume 79 of Advances in Computers This series which began publication in 1960 is the oldest continuously published anthology that chronicles the ever changing information technology field In these volumes we publish from 5 to 7 chapters three times per year that cover the latest changes to the design development use and implications of computer technology on society today Covers the full breadth of innovations in hardware software theory design and applications Many of the in depth reviews have become standard references that continue to be of significant lasting value in this rapidly expanding field

Dependable Computer Systems and Networks Wojciech Zamojski, Jacek Mazurkiewicz, Jarosław Sugier, Tomasz Walkowiak, Janusz Kacprzyk, 2023-08-10 The book includes papers about various problems of dependable operation of computer systems and networks which were presented during the 18th DepCoS RELCOMEX conference Their collection can be an interesting source material for scientists researchers practitioners and students who are dealing with design analysis and engineering of computer systems and networks and must ensure their dependable operation The increasing role of artificial intelligence algorithms and tools in modern information technology and computer engineering especially rapid expansion of tools based on deep learning methods calls for extending our view on system dependability Selection of papers in these proceedings not only illustrates a wide ranging variety of multidisciplinary topics which should be considered in this context but also proves that virtually all areas of contemporary computer systems and networks must take into account an aspect of dependability

Artificial Life and Computational Intelligence Markus Wagner, Xiaodong Li, Tim Hendtlass, 2017-01-20 This book constitutes the refereed proceedings of the Third Australasian Conference on Artificial Life and Computational Intelligence ACALCI 2017 held in Geelong VIC Australia in January February 2017 The 32 papers

presented in this volume were carefully reviewed and selected from 47 submissions They were organized in topical sections named artificial life and computational intelligence and optimization algorithms and applications *Cluster Computing For Robotics And Computer Vision* Damian M Lyons,2011-08-05 In this book we look at how cluster technology can be leveraged to build better robots Algorithms and approaches in key areas of robotics and computer vision such as map building target tracking action selection and landmark learning are reviewed and cluster implementations for these are presented The objective of the book is to give professionals working in the beowulf cluster or robotics and computer vision fields a concrete view of the strong synergy between the areas as well as to spur further fruitful exploitation of this connection The book is written at a level appropriate for an advanced undergraduate or graduate student The key concepts in robotics computer vision and cluster computing are introduced before being used to make the text useful to a wide audience in these fields

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