Neuromorphic Processing A New Frontier In Scaling

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KERR FERNANDA

Deep Learning for Radar and Communications Automatic Target Recognition Academic Press
Rapid development of microfabrication and assembly of nanostructures has opened up many opportunities to miniaturize structures that confine light, producing unusual and extremely interesting optical properties. This book addresses the large variety of optical phenomena taking place in confined solid state structures: microcavities. Realisations include planar and pillar microcavities, whispering gallery modes, and photonic crystals. The microcavities represent a unique laboratory for quantum optics and photonics. They exhibit a number of beautiful effects including lasing, superfluidity, superradiance, entanglement etc. Written by four practitioners strongly involved in experiments and theories of microcavities, it is addressed to any interested reader having a general physical background, but in particular to undergraduate and graduate students at physics faculties.

2003 IEEE Conference on Electron Devices and Solid-State Circuits Advances in Neuromorphic Hardware Exploiting Emerging Nanoscale Devices Photonics has long been considered an attractive substrate for next generation implementations of machine-learning concepts. Reservoir Computing tremendously facilitated the realization of recurrent neural networks in analogue hardware. This concept exploits the properties of complex nonlinear dynamical systems, giving rise to photonic reservoirs implemented by semiconductor lasers, telecommunication

modulators and integrated photonic chips. CRC Press
Plasma Science and Engineering transforms fundamental scientific research into powerful societal applications, from materials processing and healthcare to forecasting space weather. Plasma Science: Enabling Technology, Sustainability, Security and Exploration discusses the importance of plasma research, identifies important grand challenges for the next decade, and makes recommendations on funding and workforce. This publication will help federal agencies, policymakers, and academic leadership understand the importance of plasma research and make informed decisions about plasma science funding, workforce, and research directions.
Decision Neuroscience John Wiley & Sons
An Analog VLSI System for Stereoscopic Vision investigates the interaction of the physical medium and the computation in both biological and analog VLSI systems by synthesizing a functional neuromorphic system in silicon. In both the synthesis and analysis of the system, a point of view from within the system is adopted rather than that of an omniscient designer drawing a blueprint. This perspective projects the design and the designer into a living landscape. The motivation for a machine-centered perspective is explained in the first chapter. The second chapter describes the evolution of the silicon retina. The retina accurately encodes visual information over orders of magnitude of ambient illumination, using mismatched components that are calibrated as part of the encoding process. The visual abstraction created by the retina is suitable for transmission through a limited bandwidth channel. The third chapter introduces a general method for interchip communication, the address-event representation, which is used for transmission of retinal data. The address-event representation takes advantage of the speed of CMOS relative to biological neurons to preserve the information of biological action potentials using digital circuitry in place of axons. The fourth chapter describes a collective circuit that computes stereodisparity. In this circuit, the processing that corrects for imperfections in the hardware compensates for inherent ambiguity in the environment. The fifth chapter demonstrates a primitive working stereovision system. An Analog VLSI System for Stereoscopic Vision contributes to both computer engineering and neuroscience at a concrete level. Through the construction of a working analog of biological vision subsystems, new circuits for building brain-style analog computers have been developed. Specific neuropysiological and psychophysical results in terms of underlying electronic mechanisms are explained. These examples demonstrate the utility of using biological principles for building brain-style computers and the significance of building brain-style computers for understanding the nervous system.
Spiking Neural Network Learning, Benchmarking, Programming and Executing Artech House
Combining engineering and medicine research projects with biological applications, the contributions in this

volume constitute the efforts of both distinguished scientists and young investigators in various fields of biomedical engineering at Tohoku University, one of Japan's leading scientific research universities. The Tohoku University 21st Century COE Program “Future Medical Engineering Based on Bionanotechnology” is — out of 113 programmes chosen by the Ministry of Education, Culture, Sports, Science and Technology in 2002 – the only one program devoted to biomedical engineering. This book comprises the proceedings of the final closing symposium to be held in January 2007, and summarizes all the efforts of the program in a comprehensive manner. In total, more than 100 authors from the engineering and medical schools of Tohoku University have contributed to this volume, through which readers can understand all the research results carried out under the umbrella of the program. Contents:Cellular Function and Molecular Operation:Progress of Our Research in Auditory Mechnaics (H Wada)Generation of Stable Chinese Hamster Ovary Cell Lines Expressing the Motor Protein Prestin (K Iida et al.)Protection of Outer Hair Cells from Traumatic Noise by Conditioning with Heat Stress (M Murakoshi et al.)Time-Lapse Observation of Neural Epithelium Cell Behavior in Slice Culture (N Nakamura et al.)Nano-Medicine:Development of Novel Medical Engineering Using Micro-Nanomachining (M Esashi)Biomimetic Artificial Myocardium Using Nano Technology (T Yambe)MEMS-Based Fuel Cell for Portable Medical Applications (K-B Min et al.)Lithium Niobate Bulk Micromachining for Medical Sensors (A Randles et al.)Imaging of the Biological Molecule and Structure:Brain Imaging of Quality of Life Using Positron Emission Tomography (M Itoh & M Tashiro)Human Brain Metabolic Changes Induced by Actual Car-Driving (M Jeong et al.)Automatic Medical Image Registration Using Mutual Information (K Kumagai et al.)The Comparison of Brain Structure Between Exercised and Non-Exercised Students (H Sensui et al.)Medical Informatics:Computational Approaches to Hemodynamics Analysis from Micro to Macro Scales (T Yamaguchi)A Fluid-Solid Interaction Study of the Pulse Wave Velocity in Uniform Arteries (T Fukui et al.)CFD Tools in Engineering Design Studies and Medical Sciences (P S Kulkarni)Evaluation of an Index for Cardiac Function During Assitance with a Rotary Blood Pump (D Ogawa et al.)and other papers Readership: Postgraduate students and researchers in biomedical engineering. Keywords:Biomedical Engineering;Cell Biology;Biomechanics;Bionanotechnology;Nanomedicine;Medical Imaging;Computational Medicine;Simulation MedicineKey Features:The first compilation of bionanotechnology-based biomedical engineering research in Tohoku University, which is one of the most active biomedical engineering-oriented universities in JapanUnique combinations and collaborations of researchers from various fields of science and technology, thus enabling truly interdisciplinary researchContributions from young investigators with PhD degrees, who

are promoted by the Programme and are usually inaccessible for ordinary publications

Event-Based Neuromorphic Systems Routledge

Photo-Electroactive Non-Volatile Memories for Data Storage and Neuromorphic Computing summarizes advances in the development of photo-electroactive memories and neuromorphic computing systems, suggests possible solutions to the challenges of device design, and evaluates the prospects for commercial applications. Sections covers developments in electro-photoactive memory, and photonic neuromorphic and in-memory computing, including discussions on design concepts, operation principles and basic storage mechanism of optoelectronic memory devices, potential materials from organic molecules, semiconductor quantum dots to two-dimensional materials with desirable electrical and optical properties, device challenges, and possible strategies. This comprehensive, accessible and up-to-date book will be of particular interest to graduate students and researchers in solid-state electronics. It is an invaluable systematic introduction to the memory characteristics, operation principles and storage mechanisms of the latest reported electro-photoactive memory devices. Reviews the most promising materials to enable emerging computing memory and data storage devices, including one- and two-dimensional materials, metal oxides, semiconductors, organic materials, and more Discusses fundamental mechanisms and design strategies for two- and three-terminal device structures Addresses device challenges and strategies to enable translation of optical and optoelectronic technologies

December 16-18, 2003, New World Renaissance Hotel, 22 Salisbury Road, Tsimshatsui, Kowloon, Hong Kong Woodhead Publishing

Artificial Intelligence (AI) has found many applications in the past decade due to the ever increasing computing power. Artificial Neural Networks are inspired in the brain structure and consist in the interconnection of artificial neurons through artificial synapses. Training these systems requires huge amounts of data and, after the network is trained, it can recognize unforeseen data and provide useful information. The so-called Spiking Neural Networks behave similarly to how the brain functions and are very energy efficient. Up to this moment, both spiking and conventional neural networks have been implemented in software programs running on conventional computing units. However, this approach requires high computing power, a large physical space and is energy inefficient. Thus, there is an increasing interest in developing AI tools directly implemented in hardware. The first hardware demonstrations have been based on CMOS circuits for neurons and specific communication protocols for synapses. However, to further increase training speed and energy efficiency while decreasing system size, the combination of CMOS neurons with memristor synapses is being explored. The memristor is a resistor with memory which behaves similarly to biological synapses. This book explores the state-

of-the-art of neuromorphic circuits implementing neural networks with memristors for AI applications.

16th International Conference, EANN 2015, Rhodes, Greece, September 25-28 2015.Proceedings Springer

This book covers all major aspects of cutting-edge research in the field of neuromorphic hardware engineering involving emerging nanoscale devices. Special emphasis is given to leading works in hybrid low-power CMOS-Nanodevice design. The book offers readers a bidirectional (top-down and bottom-up) perspective on designing efficient bio-inspired hardware. At the nanodevice level, it focuses on various flavors of emerging resistive memory (RRAM) technology. At the algorithm level, it addresses optimized implementations of supervised and stochastic learning paradigms such as: spike-time-dependent plasticity (STDP), long-term potentiation (LTP), long-term depression (LTD), extreme learning machines (ELM) and early adoptions of restricted Boltzmann machines (RBM) to name a few. The contributions discuss system-level power/energy/parasitic trade-offs, and complex real-world applications. The book is suited for both advanced researchers and students interested in the field.

Acquire advanced AI, machine learning, and deep learning design skills, 2nd Edition Springer Nature

This book sets out to build bridges between the domains of photonic device physics and neural networks, providing a comprehensive overview of the emerging field of "neuromorphic photonics." It includes a thorough discussion of evolution of neuromorphic photonics from the advent of fiber-optic neurons to today’s state-of-the-art integrated laser neurons, which are a current focus of international research. Neuromorphic Photonics explores candidate interconnection architectures and devices for integrated neuromorphic networks, along with key functionality such as learning. It is written at a level accessible to graduate students, while also intending to serve as a comprehensive reference for experts in the field.

Neuromorphic Cognitive Systems Routledge

This three-volume set LNCS 11139-11141 constitutes the refereed proceedings of the 27th International Conference on Artificial Neural Networks, ICANN 2018, held in Rhodes, Greece, in October 2018. The papers presented in these volumes was carefully reviewed and selected from total of 360 submissions. They are related to the following thematic topics: AI and Bioinformatics, Bayesian and Echo State Networks, Brain Inspired Computing, Chaotic Complex Models, Clustering, Mining, Exploratory Analysis, Coding Architectures, Complex Firing Patterns, Convolutional Neural Networks, Deep Learning (DL), DL in Real Time Systems, DL and Big Data Analytics, DL and Big Data, DL and Forensics, DL and Cybersecurity, DL and Social Networks, Evolving Systems – Optimization, Extreme Learning Machines, From Neurons to Neuromorphism, From Sensation to Perception, From Single Neurons to Networks, Fuzzy Modeling, Hierarchical ANN, Inference and Recognition, Information and Optimization,

Interacting with The Brain, Machine Learning (ML), ML for Bio Medical systems, ML and Video-Image Processing, ML and Forensics, ML and Cybersecurity, ML and Social Media, ML in Engineering, Movement and Motion Detection, Multilayer Perceptrons and Kernel Networks, Natural Language, Object and Face Recognition, Recurrent Neural Networks and Reservoir Computing, Reinforcement Learning, Reservoir Computing, Self-Organizing Maps, Spiking Dynamics/Spiking ANN, Support Vector Machines, Swarm Intelligence and Decision-Making, Text Mining, Theoretical Neural Computation, Time Series and Forecasting, Training and Learning.

Springer Handbook of Computational Intelligence Springer Explains current co-design and co-optimization methodologies for building hardware neural networks and algorithms for machine learning applications This book focuses on how to build energy-efficient hardware for neural networks with learning capabilities—and provides co-design and co-optimization methodologies for building hardware neural networks that can learn. Presenting a complete picture from high-level algorithm to low-level implementation details, Learning in Energy-Efficient Neuromorphic Computing: Algorithm and Architecture Co-Design also covers many fundamentals and essentials in neural networks (e.g., deep learning), as well as hardware implementation of neural networks. The book begins with an overview of neural networks. It then discusses algorithms for utilizing and training rate-based artificial neural networks. Next comes an introduction to various options for executing neural networks, ranging from general-purpose processors to specialized hardware, from digital accelerator to analog accelerator. A design example on building energy-efficient accelerator for adaptive dynamic programming with neural networks is also presented. An examination of fundamental concepts and popular learning algorithms for spiking neural networks follows that, along with a look at the hardware for spiking neural networks. Then comes a chapter offering readers three design examples (two of which are based on conventional CMOS, and one on emerging nanotechnology) to implement the learning algorithm found in the previous chapter. The book concludes with an outlook on the future of neural network hardware. Includes cross-layer survey of hardware accelerators for neuromorphic algorithms Covers the co-design of architecture and algorithms with emerging devices for much-improved computing efficiency Focuses on the co-design of algorithms and hardware, which is especially critical for using emerging devices, such as traditional memristors or diffusive memristors, for neuromorphic computing Learning in Energy-Efficient Neuromorphic Computing: Algorithm and Architecture Co-Design is an ideal resource for researchers, scientists, software engineers, and hardware engineers dealing with the ever-increasing requirement on power consumption and response time. It is also excellent for teaching and training undergraduate and graduate students about the latest

generation neural networks with powerful learning capabilities.

Artificial Neural Networks and Machine Learning – ICANN 2018 Springer Science & Business Media

This book presents neuromorphic cognitive systems from a learning and memory-centered perspective. It illustrates how to build a system network of neurons to perform spike-based information processing, computing, and high-level cognitive tasks. It is beneficial to a wide spectrum of readers, including undergraduate and postgraduate students and researchers who are interested in neuromorphic computing and neuromorphic engineering, as well as engineers and professionals in industry who are involved in the design and applications of neuromorphic cognitive systems, neuromorphic sensors and processors, and cognitive robotics. The book formulates a systematic framework, from the basic mathematical and computational methods in spike-based neural encoding, learning in both single and multi-layered networks, to a near cognitive level composed of memory and cognition. Since the mechanisms for integrating spiking neurons integrate to formulate cognitive functions as in the brain are little understood, studies of neuromorphic cognitive systems are urgently needed. The topics covered in this book range from the neuronal level to the system level. In the neuronal level, synaptic adaptation plays an important role in learning patterns. In order to perform higher-level cognitive functions such as recognition and memory, spiking neurons with learning abilities are consistently integrated, building a system with encoding, learning and memory functionalities. The book describes these aspects in detail.

Oxide Spintronics MDPI

Decision Neuroscience addresses fundamental questions about how the brain makes perceptual, value-based, and more complex decisions in non-social and social contexts. This book presents compelling neuroimaging, electrophysiological, lesional, and neurocomputational models in combination with hormonal and genetic approaches, which have led to a clearer understanding of the neural mechanisms behind how the brain makes decisions. The five parts of the book address distinct but inter-related topics and are designed to serve both as classroom introductions to major subareas in decision neuroscience and as advanced syntheses of all that has been accomplished in the last decade. Part I is devoted to anatomical, neurophysiological, pharmacological, and optogenetics animal studies on reinforcement-guided decision making, such as the representation of instructions, expectations, and outcomes; the updating of action values; and the evaluation process guiding choices between prospective rewards. Part II covers the topic of the neural representations of motivation, perceptual decision making, and value-based decision making in humans, combining neurcomputational models and brain imaging studies. Part III focuses on the rapidly developing field of social decision neuroscience, integrating recent mechanistic understanding of social decisions in both non-

human primates and humans. Part IV covers clinical aspects involving disorders of decision making that link together basic research areas including systems, cognitive, and clinical neuroscience; this part examines dysfunctions of decision making in neurological and psychiatric disorders, such as Parkinson's disease, schizophrenia, behavioral addictions, and focal brain lesions. Part V focuses on the roles of various hormones (cortisol, oxytocin, ghrelin/leptine) and genes that underlie inter-individual differences observed with stress, food choices, and social decision-making processes. The volume is essential reading for anyone interested in decision making neuroscience. With contributions that are forward-looking assessments of the current and future issues faced by researchers, Decision Neuroscience is essential reading for anyone interested in decision-making neuroscience. Provides comprehensive coverage of approaches to studying individual and social decision neuroscience, including primate neurophysiology, brain imaging in healthy humans and in various disorders, and genetic and hormonal influences on decision making Covers multiple levels of analysis, from molecular mechanisms to neural-systems dynamics and computational models of how we make choices Discusses clinical implications of process dysfunctions, including schizophrenia, Parkinson's disease, eating disorders, drug addiction, and pathological gambling Features chapters from top international researchers in the field and full-color presentation throughout with numerous illustrations to highlight key concepts *Neuromorphic Engineering* Institute of Electrical & Electronics Engineers(IEEE) Understand the fundamentals and develop your own AI solutions in this updated edition packed with many new examples Key Features AI-based examples to guide you in designing and implementing machine intelligence Build machine intelligence from scratch using artificial intelligence examples Develop machine intelligence from scratch using real artificial intelligence Book Description AI has the potential to replicate humans in every field. Artificial Intelligence By Example, Second Edition serves as a starting point for you to understand how AI is built, with the help of intriguing and exciting examples. This book will make you an adaptive thinker and help you apply concepts to real-world scenarios. Using some of the most interesting AI examples, right from computer programs such as a simple chess engine to cognitive chatbots, you will learn how to tackle the machine you are competing with. You will study some of the most advanced machine learning models, understand how to apply AI to blockchain and Internet of Things (IoT), and develop emotional quotient in chatbots using neural networks such as recurrent neural networks (RNNs) and convolutional neural networks (CNNs). This edition also has new examples for hybrid neural networks, combining reinforcement learning (RL) and deep learning (DL), chained algorithms, combining unsupervised learning with decision trees, random forests,

combining DL and genetic algorithms, conversational user interfaces (CUI) for chatbots, neuromorphic computing, and quantum computing. By the end of this book, you will understand the fundamentals of AI and have worked through a number of examples that will help you develop your AI solutions. What you will learn Apply k-nearest neighbors (KNN) to language translations and explore the opportunities in Google Translate Understand chained algorithms combining unsupervised learning with decision trees Solve the XOR problem with feedforward neural networks (FNN) and build its architecture to represent a data flow graph Learn about meta learning models with hybrid neural networks Create a chatbot and optimize its emotional intelligence deficiencies with tools such as Small Talk and data logging Building conversational user interfaces (CUI) for chatbots Writing genetic algorithms that optimize deep learning neural networks Build quantum computing circuits Who this book is for Developers and those interested in AI, who want to understand the fundamentals of Artificial Intelligence and implement them practically. Prior experience with Python programming and statistical knowledge is essential to make the most out of this book.

The Algorithmic Unconscious CRC Press This book explains deep learning concepts and derives semi-supervised learning and nuclear learning frameworks based on cognition mechanism and Lie group theory. Lie group machine learning is a theoretical basis for brain intelligence, Neuromorphic learning (NL), advanced machine learning, and advanced artifi cial intelligence. The book further discusses algorithms and applications in tensor learning, spectrum estimation learning, Finsler geometry learning, Homology boundary learning, and prototype theory. With abundant case studies, this book can be used as a reference book for senior college students and graduate students as well as college teachers and scientific and technical personnel involved in computer science, artifi cial intelligence, machine learning, automation, mathematics, management science, cognitive science, financial management, and data analysis. In addition, this text can be used as the basis for teaching the principles of machine learning. Li Fanzhang is professor at the Soochow University, China. He is director of network security engineering laboratory in Jiangsu Province and is also the director of the Soochow Institute of industrial large data. He published more than 200 papers, 7 academic monographs, and 4 textbooks. Zhang Li is professor at the School of Computer Science and Technology of the Soochow University. She published more than 100 papers in journals and conferences, and holds 23 patents. Zhang Zhao is currently an associate professor at the School of Computer Science and Technology of the Soochow University. He has authored and co-authored more than 60 technical papers.

Bio-inspired Audio Processing, Models and Systems Walter de Gruyter GmbH & Co KG This book brings together leading investigators who represent various aspects of brain dynamics with the

goal of presenting state-of-the-art current progress and address future developments. The individual chapters cover several fascinating facets of contemporary neuroscience from elementary computation of neurons, mesoscopic network oscillations, internally generated assembly sequences in the service of cognition, large-scale neuronal interactions within and across systems, the impact of sleep on cognition, memory, motor-sensory integration, spatial navigation, large-scale computation and consciousness. Each of these topics require appropriate levels of analyses with sufficiently high temporal and spatial resolution of neuronal activity in both local and global networks, supplemented by models and theories to explain how different levels of brain dynamics interact with each other and how the failure of such interactions results in neurologic and mental disease. While such complex questions cannot be answered exhaustively by a dozen or so chapters, this volume offers a nice synthesis of current thinking and work-in-progress on micro-, meso- and macro- dynamics of the brain.

The Fourth Industrial Revolution Springer Science & Business Media

Advances in Neuromorphic Hardware Exploiting Emerging Nanoscale DevicesSpringer

Advances in Neuromorphic Hardware Exploiting Emerging Nanoscale Devices Frontiers Media SA

Intelligence Science: Leading the Age of Intelligence covers the emerging scientific research on the theory and technology of intelligence, bringing together disciplines such as neuroscience, cognitive science, and artificial intelligence to study the nature of intelligence, the functional simulation of intelligent behavior, and the development of new intelligent technologies. The book presents this complex, interdisciplinary area of study in an accessible volume, introducing foundational concepts and methods, and presenting the latest trends and developments. Chapters cover the Foundations of neurophysiology, Neural computing, Mind models, Perceptual intelligence, Language cognition, Learning, Memory, Thought, Intellectual development and cognitive structure, Emotion and affect, and more. This volume synthesizes a very rich and complex area of research, with an aim of stimulating new lines of enquiry. Presents a complex, interdisciplinary area in an accessible way, including the latest trends and developments Brings together disciplines such as neuroscience, cognitive science and artificial intelligence Gives the latest methods and theories in the development of new intelligent technologies Reflects upon the most important achievements in the study of natural and artificial intelligence Contextualizes intelligence research within the history and progress of twenty-first century science

Memristors for Neuromorphic Circuits and Artificial Intelligence Applications Springer

The Army Research Laboratory (ARL) is the corporate laboratory for the U.S. army, which bridges scientific and military communities. The ARL is critical in maintaining the United States' dominant military

power through its advanced research and analysis capabilities. The National Academies of Sciences, Engineering, and Medicine's Army Research Laboratory Technical Assessment Board (ARLTAB) conducts biennial assessments of the scientific and technical quality of the facilities. These assessments are necessary to ensure that the ARL's resources and quality of programs are maximized. 2017-2018 Assessment of the Army Research Laboratory includes findings and recommendations regarding the quality of the ARL's research, development, and analysis programs. The report of the assessment is subdivided by the ARL's Science and Technology campaigns, including Materials Research, Sciences for Lethality and Protection, Information Sciences, Computational Sciences, Sciences for Maneuver, Human Sciences, and Analysis and Assessment. This biennial report summarizes the findings for the 2017-2018 period.

27th International Conference on Artificial Neural Networks, Rhodes, Greece, October 4-7, 2018, Proceedings, Part I

John Wiley & Sons

Between the 18th and 19th centuries, Britain experienced massive leaps in technological, scientific, and economical advancement