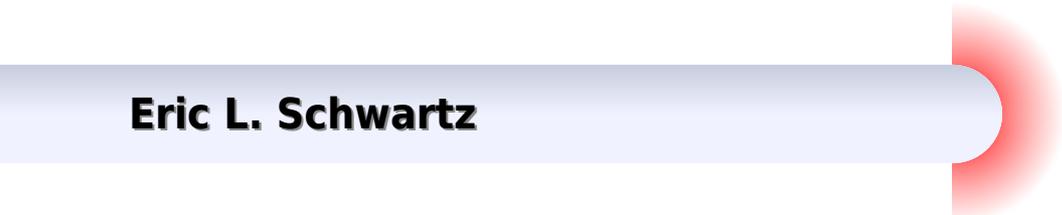# Computational Neuroscience

Eric L. Schwartz

Computational Neuroscience:

Computational Neuroscience Eric L. Schwartz,1993-08-26 The thirty original contributions in this book provide a working definition ofcomputational neuroscience as the area in which problems lie simultaneously within computerscience and neuroscience They review this emerging field in historical and philosophical overviewsand in stimulating summaries of recent results Leading researchers address the structure of thebrain and the computational problems associated with describing and understanding this structure atthe synaptic neural map and system levels The overview chapters discuss the early days of thefield provide a philosophical analysis of the problems associated with confusion between brainmetaphor and brain theory and take up the scope and structure of computationalneuroscience Synaptic level structure is addressed in chapters that relate the properties ofdendritic branches spines and synapses to the biophysics of computation and provide a connectionbetween real neuron architectures and neural network simulations The network level chapters take upthe preattentive perception of 3 D forms oscillation in neural networks the neurobiologicalsignificance of new learning models and the analysis of neural assemblies and local learningrides Map level structure is explored in chapters on the bat echolocation system cat orientationmaps primate stereo vision cortical cognitive maps dynamic remapping in primate visual cortex andcomputer aided reconstruction of topographic and columnar maps in primates The system level chaptersfocus on the oculomotor system VLSI models of early vision schemas for high level vision goal directed movements modular learning effects of applied electric current fields on corticalneural activity neuropsychological studies of brain and mind and an information theoretic view ofanalog representation in striate cortex Eric L Schwartz is Professor of Brain Research and ResearchProfessor of Computer Science Courant Institute of Mathematical Sciences New York UniversityMedical Center Computational Neuroscience is included in the System Development FoundationBenchmark Series   Computational Neuroscience for Advancing Artificial Intelligence: Models, Methods and Applications Alonso, Eduardo,Mondragón, Esther,2010-11-30 This book argues that computational models in behavioral neuroscience must be taken with caution and advocates for the study of mathematical models of existing theories as complementary to neuro psychological models and computational models   From Neuron to Cognition via Computational Neuroscience Michael A. Arbib,James J. Bonaiuto,2016-11-04 A comprehensive integrated and accessible textbook presenting core neuroscientific topics from a computational perspective tracing a path from cells and circuits to behavior and cognition This textbook presents a wide range of subjects in neuroscience from a computational perspective It offers a comprehensive integrated introduction to core topics using computational tools to trace a path from neurons and circuits to behavior and cognition Moreover the chapters show how computational neuroscience methods for modeling the causal interactions underlying neural systems complements empirical research in advancing the understanding of brain and behavior The chapters all by leaders in the field and carefully integrated by the editors cover such subjects as action and motor control neuroplasticity neuromodulation and reinforcement

learning vision and language the core of human cognition The book can be used for advanced undergraduate or graduate level courses It presents all necessary background in neuroscience beyond basic facts about neurons and synapses and general ideas about the structure and function of the human brain Students should be familiar with differential equations and probability theory and be able to pick up the basics of programming in MATLAB and or Python Slides exercises and other ancillary materials are freely available online and many of the models described in the chapters are documented in the brain operation database BODB which is also described in a book chapter Contributors Michael A Arbib Joseph Ayers James Bednar Andrej Bicanski James J Bonaiuto Nicolas Brunel Jean Marie Cabelguen Carmen Canavier Angelo Cangelosi Richard P Cooper Carlos R Cortes Nathaniel Daw Paul Dean Peter Ford Dominey Pierre Enel Jean Marc Fellous Stefano Fusi Wulfram Gerstner Frank Grasso Jacqueline A Griego Ziad M Hafed Michael E Hasselmo Auke Ijspeert Stephanie Jones Daniel Kersten Jeremie Knuesel Owen Lewis William W Lytton Tomaso Poggio John Porrill Tony J Prescott John Rinzel Edmund Rolls Jonathan Rubin Nicolas Schweighofer Mohamed A Sherif Malle A Tagamets Paul F M J Verschure Nathan Vierling Claasen Xiao Jing Wang Christopher Williams Ransom Winder Alan L Yuille **Computational Neuroscience in Epilepsy** Ivan Soltesz,Kevin Staley,2011-09-02 Epilepsy is a neurological disorder that affects millions of patients worldwide and arises from the concurrent action of multiple pathophysiological processes The power of mathematical analysis and computational modeling is increasingly utilized in basic and clinical epilepsy research to better understand the relative importance of the multi faceted seizure related changes taking place in the brain during an epileptic seizure This groundbreaking book is designed to synthesize the current ideas and future directions of the emerging discipline of computational epilepsy research Chapters address relevant basic questions e g neuronal gain control as well as long standing critically important clinical challenges e g seizure prediction Computational Neuroscience in Epilepsy should be of high interest to a wide range of readers including undergraduate and graduate students postdoctoral fellows and faculty working in the fields of basic or clinical neuroscience epilepsy research computational modeling and bioengineering Covers a wide range of topics from molecular to seizure predictions and brain implants to control seizures Contributors are top experts at the forefront of computational epilepsy research Chapter contents are highly relevant to both basic and clinical epilepsy researchers Computational Neuroscience James M. Bower,1998 Publishes 103 of the 196 papers presented at the conference representing a cross section of the general areas considered subcellular cellular network systems and methodology Specific topics include perturbative M sequences for auditory systems identification representing odor quality space a *Computational Neuroscience* J.M. Bower,2000-07-08 This volume includes papers originally presented at the 8th annual Computational Neuroscience meeting CNS 99 held in July of 1999 in Pittsburgh Pennsylvania The CNS meetings bring together computational neuroscientists representing many different fields and backgrounds as well as experimental preparations and theoretical approaches The papers published here range across vast levels of scale from cellular mechanisms to cognitive

brain studies The subjects of the research include many different preparations from invertebrates to humans In all cases the work described in this volume is focused on understanding how nervous systems compute The research described includes subjects like neural coding and neuronal dendrites and reflects a trend towards forging links between cognitive research and neurobiology Accordingly this volume reflects the breadth and depth of current research in computational neuroscience taking place throughout the world   *From Computer to Brain* William W. Lytton,2002-10-01 Biology undergraduates medical students and life science graduate students often have limited mathematical skills Similarly physics math and engineering students have little patience for the detailed facts that make up much of biological knowledge Teaching computational neuroscience as an integrated discipline requires that both groups be brought forward onto common ground This book does this by making ancillary material available in an appendix and providing basic explanations without becoming bogged down in unnecessary details The book will be suitable for undergraduates and beginning graduate students taking a computational neuroscience course and also to anyone with an interest in the uses of the computer in modeling the nervous system   **Biophysics of Computation** Christof Koch,2004-10-28 Neural network research often builds on the fiction that neurons are simple linear threshold units completely neglecting the highly dynamic and complex nature of synapses dendrites and voltage dependent ionic currents Biophysics of Computation Information Processing in Single Neurons challenges this notion using richly detailed experimental and theoretical findings from cellular biophysics to explain the repertoire of computational functions available to single neurons The author shows how individual nerve cells can multiply integrate or delay synaptic inputs and how information can be encoded in the voltage across the membrane in the intracellular calcium concentration or in the timing of individual spikes Key topics covered include the linear cable equation cable theory as applied to passive dendritic trees and dendritic spines chemical and electrical synapses and how to treat them from a computational point of view nonlinear interactions of synaptic input in passive and active dendritic trees the Hodgkin Huxley model of action potential generation and propagation phase space analysis linking stochastic ionic channels to membrane dependent currents calcium and potassium currents and their role in information processing the role of diffusion buffering and binding of calcium and other messenger systems in information processing and storage short and long term models of synaptic plasticity simplified models of single cells stochastic aspects of neuronal firing the nature of the neuronal code and unconventional models of sub cellular computation Biophysics of Computation Information Processing in Single Neurons serves as an ideal text for advanced undergraduate and graduate courses in cellular biophysics computational neuroscience and neural networks and will appeal to students and professionals in neuroscience electrical and computer engineering and physics   **Fundamentals of Computational Neuroscience** Thomas Trappenberg,2009-10-29 Computational neuroscience is the theoretical study of the brain to uncover the principles and mechanisms that guide the development organization information processing and mental functions of the nervous system Although not a new area it is

only recently that enough knowledge has been gathered to establish computational neuroscience as a scientific discipline in its own right Given the complexity of the field and its increasing importance in progressing our understanding of how the brain works there has long been a need for an introductory text on what is often assumed to be an impenetrable topic The new edition of Fundamentals of Computational Neuroscience build on the success and strengths of the first edition It introduces the theoretical foundations of neuroscience with a focus on the nature of information processing in the brain The book covers the introduction and motivation of simplified models of neurons that are suitable for exploring information processing in large brain like networks Additionally it introduces several fundamental network architectures and discusses their relevance for information processing in the brain giving some examples of models of higher order cognitive functions to demonstrate the advanced insight that can be gained with such studies Each chapter starts by introducing its topic with experimental facts and conceptual questions related to the study of brain function An additional feature is the inclusion of simple Matlab programs that can be used to explore many of the mechanisms explained in the book An accompanying webpage includes programs for download The book will be the essential text for anyone in the brain sciences who wants to get to grips with this topic   Principles of Computational Modelling in Neuroscience David Sterratt,Bruce Graham,Andrew Gillies,David Willshaw,2011-06-30 The nervous system is made up of a large number of interacting elements To understand how such a complex system functions requires the construction and analysis of computational models at many different levels This book provides a step by step account of how to model the neuron and neural circuitry to understand the nervous system at all levels from ion channels to networks Starting with a simple model of the neuron as an electrical circuit gradually more details are added to include the effects of neuronal morphology synapses ion channels and intracellular signalling The principle of abstraction is explained through chapters on simplifying models and how simplified models can be used in networks This theme is continued in a final chapter on modelling the development of the nervous system Requiring an elementary background in neuroscience and some high school mathematics this textbook is an ideal basis for a course on computational neuroscience   Transcranial Magnetic and Electrical Brain Stimulation for Neurological Disorders Bahman Zohuri,Patrick J. McDaniel,2022-08-20 Transcranial Magnetic and Electrical Brain Stimulation for Neurological Disorders examines the non invasive application of electrical stimulation of the brain to treat neurological disorders and to enhance individual group performance This volume discusses emerging electro technologies such as transcranial direct current alternating current electric fields and pulsed magnetic fields to treat many of these common medical problems Chapters begin by examining foundations of electromagnetic theory and wave equations that underly these technologies before discussing methods to treat disorders the impact of technology and mental health and artificial intelligence Discussing over 40 neurological diseases this book presents coverage of techniques to treat stroke epilepsy Alzheimer s Disease Parkinson s Disease Huntington s Disease depression schizophrenia and many other diseases of the nervous system Compares techniques

so users can select ideal methods for their experiment Provides a focused tutorial introduction to core diseases of the nervous system including stroke epilepsy Alzheimer s Parkinson s head and spinal cord trauma schizophrenia and more Covers more than 40 diseases from foundational science to the best treatment protocols Includes discussions of translational research drug discovery personalized medicine ethics and neuroscience Provides walk through boxes that guide students step by step through the experiment **Computational Neuroscience** Hanspeter A Mallot,2013-05-23 Computational Neuroscience A First Course provides an essential introduction to computational neuroscience and equips readers with a fundamental understanding of modeling the nervous system at the membrane cellular and network level The book which grew out of a lecture series held regularly for more than ten years to graduate students in neuroscience with backgrounds in biology psychology and medicine takes its readers on a journey through three fundamental domains of computational neuroscience membrane biophysics systems theory and artificial neural networks The required mathematical concepts are kept as intuitive and simple as possible throughout the book making it fully accessible to readers who are less familiar with mathematics Overall Computational Neuroscience A First Course represents an essential reference guide for all neuroscientists who use computational methods in their daily work as well as for any theoretical scientist approaching the field of computational neuroscience *The Computational Brain* Patricia Smith Churchland,Terrence Joseph Sejnowski,1992 The Computational Brain addresses a broad audience neuroscientists computer scientists cognitive scientists and philosophers It is written for both the expert and novice A basic overview of neuroscience and computational theory is provided followed by a study of some of the most recent and sophisticated modeling work in the context of relevant neurobiological research Technical terms are clearly explained in the text and definitions are provided in an extensive glossary The appendix contains a pr cis of neurobiological techniques Jacket **Theoretical Neuroscience** Peter Dayan,Laurence F. Abbott,2005-08-12 Theoretical neuroscience provides a quantitative basis for describing what nervous systems do determining how they function and uncovering the general principles by which they operate This text introduces the basic mathematical and computational methods of theoretical neuroscience and presents applications in a variety of areas including vision sensory motor integration development learning and memory The book is divided into three parts Part I discusses the relationship between sensory stimuli and neural responses focusing on the representation of information by the spiking activity of neurons Part II discusses the modeling of neurons and neural circuits on the basis of cellular and synaptic biophysics Part III analyzes the role of plasticity in development and learning An appendix covers the mathematical methods used and exercises are available on the book s Web site **The MIT Encyclopedia of the Cognitive Sciences (MITECS)** Robert A. Wilson,Frank C. Keil,2001-09-04 Since the 1970s the cognitive sciences have offered multidisciplinary ways of understanding the mind and cognition The MIT Encyclopedia of the Cognitive Sciences MITECS is a landmark comprehensive reference work that represents the methodological and theoretical diversity of this changing field At the core

of the encyclopedia are 471 concise entries from Acquisition and Adaptationism to Wundt and X bar Theory Each article written by a leading researcher in the field provides an accessible introduction to an important concept in the cognitive sciences as well as references or further readings Six extended essays which collectively serve as a roadmap to the articles provide overviews of each of six major areas of cognitive science Philosophy Psychology Neurosciences Computational Intelligence Linguistics and Language and Culture Cognition and Evolution For both students and researchers MITECS will be an indispensable guide to the current state of the cognitive sciences **An Introductory Course in Computational Neuroscience** Paul Miller,2018-10-02 A textbook for students with limited background in mathematics and computer coding emphasizing computer tutorials that guide readers in producing models of neural behavior This introductory text teaches students to understand simulate and analyze the complex behaviors of individual neurons and brain circuits It is built around computer tutorials that guide students in producing models of neural behavior with the associated Matlab code freely available online From these models students learn how individual neurons function and how when connected neurons cooperate in a circuit The book demonstrates through simulated models how oscillations multistability post stimulus rebounds and chaos can arise within either single neurons or circuits and it explores their roles in the brain The book first presents essential background in neuroscience physics mathematics and Matlab with explanations illustrated by many example problems Subsequent chapters cover the neuron and spike production single spike trains and the underlying cognitive processes conductance based models the simulation of synaptic connections firing rate models of large scale circuit operation dynamical systems and their components synaptic plasticity and techniques for analysis of neuron population datasets including principal components analysis hidden Markov modeling and Bayesian decoding Accessible to undergraduates in life sciences with limited background in mathematics and computer coding the book can be used in a flipped or inverted teaching approach with class time devoted to hands on work on the computer tutorials It can also be a resource for graduate students in the life sciences who wish to gain computing skills and a deeper knowledge of neural function and neural circuits   Fundamentals of Computational Neuroscience Thomas P. Trappenberg,2022-11-28 Computational neuroscience is the theoretical study of the brain to uncover the principles and mechanisms that guide the development organization information processing and mental functions of the nervous system Although not a new area it is only recently that enough knowledge has been gathered to establish computational neuroscience as a scientific discipline in its own right Given the complexity of the field and its increasing importance in progressing our understanding of how the brain works there has long been a need for an introductory text on what is often assumed to be an impenetrable topic The new edition of Fundamentals of Computational Neuroscience build on the success and strengths of the previous editions It introduces the theoretical foundations of neuroscience with a focus on the nature of information processing in the brain The book covers the introduction and motivation of simplified models of neurons that are suitable for exploring information

processing in large brain like networks Additionally it introduces several fundamental network architectures and discusses their relevance for information processing in the brain giving some examples of models of higher order cognitive functions to demonstrate the advanced insight that can be gained with such studies Each chapter starts by introducing its topic with experimental facts and conceptual questions related to the study of brain function An additional feature is the inclusion of simple Matlab programs that can be used to explore many of the mechanisms explained in the book An accompanying webpage includes programs for download The book will be the essential text for anyone in the brain sciences who wants to get to grips with this topic   Computational Neuroscience James M. Bower,2013-05-03 This volume includes papers presented at the Fifth Annual Computational Neurosci ence meeting CNS 96 held in Boston Massachusetts July 14 17 1996 This collection includes 148 of the 234 papers presented at the meeting Acceptance for mceting presenta tion was based on the peer review of preliminary papers originally submitted in May of 1996 The papers in this volume represent final versions of this work submitted in January of 1997 As represented by this volume computational neuroscience continues to expand in quality size and breadth of focus as increasing numbers of neuroscientists are taking a computational approach to understanding nervous system function Defining computa tional neuroscience as the exploration of how brains compute it is clear that there is al most no subject or area of modern neuroscience research that is not appropriate for computational studies The CNS meetings as well as this volume reflect this scope and di versity   **Brain Computation as Hierarchical Abstraction** Dana H. Ballard,2015-02-20 An argument that the complexities of brain function can be understood hierarchically in terms of different levels of abstraction as silicon computing is The vast differences between the brain s neural circuitry and a computer s silicon circuitry might suggest that they have nothing in common In fact as Dana Ballard argues in this book computational tools are essential for understanding brain function Ballard shows that the hierarchical organization of the brain has many parallels with the hierarchical organization of computing as in silicon computing the complexities of brain computation can be dramatically simplified when its computation is factored into different levels of abstraction Drawing on several decades of progress in computational neuroscience together with recent results in Bayesian and reinforcement learning methodologies Ballard factors the brain s principal computational issues in terms of their natural place in an overall hierarchy Each of these factors leads to a fresh perspective A neural level focuses on the basic forebrain functions and shows how processing demands dictate the extensive use of timing based circuitry and an overall organization of tabular memories An embodiment level organization works in reverse making extensive use of multiplexing and on demand processing to achieve fast parallel computation An awareness level focuses on the brain s representations of emotion attention and consciousness showing that they can operate with great economy in the context of the neural and embodiment substrates   **Neuronal Noise** Alain Destexhe,Michelle Rudolph-Lilith,2012-01-07 Neuronal Noise combines experimental theoretical and computational results to show how noise is inherent to neuronal activity and how noise can be important for

neuronal computations The book covers many aspects of noise in neurons with an emphasis on the largest source of noise synaptic noise It provides students and young researchers with an overview of the important methods and concepts that have emerged from research in this area It also provides the specialist with a summary of the large body of sometimes contrasting experimental data and different theories proposed to explore the computational power that various forms of noise can confer to neurons

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