
Introduction To Computational Neuroscience

An Introduction

Exploring the Neural Code

Cell, Network and Data Analysis

Cognitive and Computational Neuroscience

An Introduction to Model-Based Cognitive Neuroscience

Computational Neuroscience

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Neural Control Engineering
Information Processing in Perception and Visual Behaviour

*Introduction To Computational
Neuroscience*

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An Introduction Springer

Introduction to computer modeling of the brain, to understand how people think. Networks of interacting neurons produce complex emergent behavior including perception, attention, motor control, learning, memory, language, and executive functions (motivation, decision making, planning, etc).

MIT Press

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.

Exploring the Neural Code Academic Press

MATLAB for Neuroscientists serves as the only complete study manual and teaching resource for MATLAB, the globally accepted standard for scientific computing, in the neurosciences and psychology. This unique introduction can be used to learn the entire empirical and experimental process (including stimulus generation, experimental control, data collection, data analysis, modeling, and more), and the 2nd Edition continues to ensure that a wide variety of computational problems can be addressed in a single programming environment. This updated edition features additional material on the creation of visual stimuli, advanced psychophysics, analysis of LFP data, choice probabilities, synchrony, and advanced spectral analysis. Users at a variety of levels—advanced undergraduates, beginning graduate students, and researchers looking to modernize their skills—will learn to design and implement their own analytical tools, and gain the fluency required to meet the computational

needs of neuroscience practitioners. The first complete volume on MATLAB focusing on neuroscience and psychology applications. Problem-based approach with many examples from neuroscience and cognitive psychology using real data. Illustrated in full color throughout. Careful tutorial approach, by authors who are award-winning educators with strong teaching experience. *Cell, Network and Data Analysis* MIT Press

This unique, self-contained and accessible textbook provides an introduction to computational modelling in psychology and neuroscience accessible to students with little or no background in computing or mathematics.

Cognitive and Computational Neuroscience Springer Science & Business Media

An anniversary edition of the classic work that influenced a generation of neuroscientists and cognitive neuroscientists. Before *The Computational Brain* was published in 1992, conceptual frameworks for brain function were based on the behavior of single neurons, applied globally. In *The Computational Brain*, Patricia Churchland and Terrence Sejnowski developed a different conceptual framework, based on large populations of neurons. They did this by showing that patterns of activities among the units in trained artificial neural network models had properties that resembled those recorded from populations of neurons recorded one at a time. It is one of the first books to bring together computational concepts and behavioral data within a neurobiological framework. Aimed at a broad audience of neuroscientists, computer scientists, cognitive scientists, and philosophers, *The Computational Brain* is written for both expert and novice. This anniversary edition offers a new

preface by the authors that puts the book in the context of current research. This approach influenced a generation of researchers. Even today, when neuroscientists can routinely record from hundreds of neurons using optics rather than electricity, and the 2013 White House BRAIN initiative heralded a new era in innovative neurotechnologies, the main message of *The Computational Brain* is still relevant.

An Introduction to Model-Based Cognitive Neuroscience

Oxford University Press

Trains researchers and graduate students in state-of-the-art statistical and machine learning methods to build models with real-world data.

Computational Neuroscience MIT Press

This book covers the computer simulation of demyelinating neuropathies and neuronopathies and compares models with clinical findings. Through the approximation of nerve excitation and conduction, the authors show how the versatile structure of nerve fibers relates to different modes of focal prospects, inward and outward currents, conduction velocity, and errant transmission. They also explain how mathematical models elucidate emerging fine distinctions between hereditary and acquired neuronal diseases, including Charcot-Marie-Tooth, chronic inflammatory demyelinating polyneuropathy, Guillain-Barre syndrome, multifocal motor neuropathy, and amyotrophic lateral sclerosis.

[A First Course](#) SAGE

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.

A Student's Introduction to Methods and Procedures

Frontiers Media SA

"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"--

Computational Explorations in Cognitive Neuroscience

IGI Global

The book "*Cognitive and Computational Neuroscience - Principles, Algorithms and Applications*" will answer the following question and statements: System-level neural modeling: what and why? We know a lot about the brain! Need to integrate data: molecular/cellular/system levels. Complexity: need to abstract away higher-order principles. Models are tools to develop explicit

theories, constrained by multiple levels (neural and behavioral). Key: models (should) make novel testable predictions on both neural and behavioral levels. Models are useful tools for guiding experiments. The hope is that the information provided in this book will trigger new researches that will help to connect basic neuroscience to clinical medicine.

Realistic Modeling for Experimentalists An Introductory Course in Computational Neuroscience

This book is intended for use in advanced graduate courses in statistics / machine learning, as well as for all experimental neuroscientists seeking to understand statistical methods at a deeper level, and theoretical neuroscientists with a limited background in statistics. It reviews almost all areas of applied statistics, from basic statistical estimation and test theory, linear and nonlinear approaches for regression and classification, to model selection and methods for dimensionality reduction, density estimation and unsupervised clustering. Its focus, however, is linear and nonlinear time series analysis from a dynamical systems perspective, based on which it aims to convey an understanding also of the dynamical mechanisms that could have generated observed time series. Further, it integrates computational modeling of behavioral and neural dynamics with statistical estimation and hypothesis testing. This way computational models in neuroscience are not only explanatory frameworks, but become powerful, quantitative data-analytical tools in themselves that enable researchers to look beyond the data surface and unravel underlying mechanisms. Interactive examples of most methods are provided through a package of MatLab routines, encouraging a playful approach to the subject,

and providing readers with a better feel for the practical aspects of the methods covered. "Computational neuroscience is essential for integrating and providing a basis for understanding the myriads of remarkable laboratory data on nervous system functions. Daniel Durstewitz has excellently covered the breadth of computational neuroscience from statistical interpretations of data to biophysically based modeling of the neurobiological sources of those data. His presentation is clear, pedagogically sound, and readily useable by experts and beginners alike. It is a pleasure to recommend this very well crafted discussion to experimental neuroscientists as well as mathematically well versed Physicists. The book acts as a window to the issues, to the questions, and to the tools for finding the answers to interesting inquiries about brains and how they function." Henry D. I. Abarbanel Physics and Scripps Institution of Oceanography, University of California, San Diego "This book delivers a clear and thorough introduction to sophisticated analysis approaches useful in computational neuroscience. The models described and the examples provided will help readers develop critical intuitions into what the methods reveal about data. The overall approach of the book reflects the extensive experience Prof. Durstewitz has developed as a leading practitioner of computational neuroscience. " Bruno B. Averbeck *A Comprehensive Approach* Cambridge University Press In this richly illustrated book, it is shown how Shannon's mathematical theory of information defines absolute limits on neural efficiency; limits which ultimately determine the neuroanatomical microstructure of the eye and brain. Written in an informal style this is an ideal introduction to cutting-edge

research in neural information theory.

Advanced Data Analysis in Neuroscience CRC Press

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.

Machine Learning and Statistical Models MIT Press

"For the neuroscientist or psychologist who cringes at the sight of mathematical formulae and whose eyes glaze over at terms like differential equations, linear algebra, vectors, matrices, Bayes' rule, and Boolean logic, this book just might be the therapy needed." - Anjan Chatterjee, Professor of Neurology, University of Pennsylvania "Anderson provides a gentle introduction to computational aspects of psychological science, managing to respect the reader's intelligence while also being completely unintimidating. Using carefully-selected computational demonstrations, he guides students through a wide array of important approaches and tools, with little in the way of prerequisites...I recommend it with enthusiasm." - Asohan Amarasingham, The City University of New York This unique, self-

contained and accessible textbook provides an introduction to computational modelling neuroscience accessible to readers with little or no background in computing or mathematics. Organized into thematic sections, the book spans from modelling integrate and firing neurons to playing the game Rock, Paper, Scissors in ACT-R. This non-technical guide shows how basic knowledge and modern computers can be combined for interesting simulations, progressing from early exercises utilizing spreadsheets, to simple programs in Python. Key Features include: Interleaved chapters that show how traditional computing constructs are simply disguised versions of the spread sheet methods. Mathematical facts and notation needed to understand the modelling methods are presented at their most basic and are interleaved with biographical and historical notes for context. Numerous worked examples to demonstrate the themes and procedures of cognitive modelling. An excellent text for postgraduate students taking courses in research methods, computational neuroscience, computational modelling, cognitive science and neuroscience. It will be especially valuable to psychology students.

A Student's Introduction to Methods and Procedures MIT Press

An understanding of the nervous system at virtually any level of analysis requires an understanding of its basic building block, the neuron. This book provides the solid foundation of the morphological, biochemical, and biophysical properties of nerve cells that is needed by advanced undergraduates and graduate students, as well as researchers in need of a thorough reference. * Highly referenced for readers to pursue topics of interest in greater detail * Unique coverage of the application of

mathematical modeling and simulation approaches not found in other textbooks * Richly illustrated, four color presentation throughout * Includes CD-ROM of all of the illustrations

From Molecules to Networks MIT Press

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.

From Computer to Brain Springer Nature

Explains the relationship of electrophysiology, nonlinear dynamics, and the computational properties of neurons, with each concept presented in terms of both neuroscience and mathematics and illustrated using geometrical intuition. In order to model neuronal behavior or to interpret the results of modeling studies, neuroscientists must call upon methods of nonlinear dynamics. This book offers an introduction to nonlinear dynamical systems theory for researchers and graduate students in neuroscience. It also provides an overview of neuroscience for mathematicians who want to learn the basic facts of electrophysiology. Dynamical Systems in Neuroscience presents a systematic study of the relationship of electrophysiology, nonlinear dynamics, and computational properties of neurons. It emphasizes that information processing in the brain depends not only on the electrophysiological properties of neurons but also on their dynamical properties. The book introduces dynamical systems, starting with one- and two-dimensional Hodgkin-Huxley-type models and continuing to a description of bursting systems. Each chapter proceeds from the simple to the complex, and provides sample problems at the end. The book explains all necessary mathematical concepts using geometrical intuition; it includes many figures and few equations, making it especially suitable for non-mathematicians. Each concept is presented in terms of both neuroscience and mathematics, providing a link

between the two disciplines. Nonlinear dynamical systems theory is at the core of computational neuroscience research, but it is not a standard part of the graduate neuroscience curriculum—or taught by math or physics department in a way that is suitable for students of biology. This book offers neuroscience students and researchers a comprehensive account of concepts and methods increasingly used in computational neuroscience. An additional chapter on synchronization, with more advanced material, can be found at the author's website, www.izhikevich.com.

Data-Driven Computational Neuroscience BoD – Books on Demand

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.

[Principles of Neural Information Theory](#) MIT Press

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.

Simulated Demyelinating Neuropathies and Neuronopathies Cambridge University Press

A guide to computational modeling methods in neuroscience, covering a range of modeling scales from molecular reactions to large neural networks. This book offers an introduction to current methods in computational modeling in neuroscience. The book describes realistic modeling methods at levels of complexity ranging from molecular interactions to large neural networks. A “how to” book rather than an analytical account, it focuses on the presentation of methodological approaches, including the selection of the appropriate method and its potential pitfalls. It is intended for experimental neuroscientists and graduate students who have little formal training in mathematical methods, but it will also be useful for scientists with theoretical backgrounds who

want to start using data-driven modeling methods. The mathematics needed are kept to an introductory level; the first chapter explains the mathematical methods the reader needs to master to understand the rest of the book. The chapters are written by scientists who have successfully integrated data-driven modeling with experimental work, so all of the material is accessible to experimentalists. The chapters offer comprehensive coverage with little overlap and extensive cross-references, moving from basic building blocks to more complex applications.

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