

S P I K E S

EXPLORING THE NEURAL CODE

Fred Rieke

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Spikes Exploring The Neural Code Computational Neuroscience

Ole Richter



Spikes Exploring The Neural Code Computational Neuroscience:

Spikes Fred Rieke, David Warland, Rob De Ruyter Van Steveninck, William Bialek, 1999-07-26 What does it mean to say that a certain set of spikes is the right answer to a computational problem In what sense does a spike train convey information about the sensory world **Spikes** begins by providing precise formulations of these and related questions about the representation of sensory signals in neural spike trains The answers to these questions are then pursued in experiments on sensory neurons Intended for neurobiologists with an interest in mathematical analysis of neural data as well as the growing number of physicists and mathematicians interested in information processing by real nervous systems **Spikes** provides a self contained review of relevant concepts in information theory and statistical decision theory Our perception of the world is driven by input from the sensory nerves This input arrives encoded as sequences of identical spikes Much of neural computation involves processing these spike trains What does it mean to say that a certain set of spikes is the right answer to a computational problem In what sense does a spike train convey information about the sensory world **Spikes** begins by providing precise formulations of these and related questions about the representation of sensory signals in neural spike trains The answers to these questions are then pursued in experiments on sensory neurons The authors invite the reader to play the role of a hypothetical observer inside the brain who makes decisions based on the incoming spike trains Rather than asking how a neuron responds to a given stimulus the authors ask how the brain could make inferences about an unknown stimulus from a given neural response The flavor of some problems faced by the organism is captured by analyzing the way in which the observer can make a running reconstruction of the sensory stimulus as it evolves in time These ideas are illustrated by examples from experiments on several biological systems Intended for neurobiologists with an interest in mathematical analysis of neural data as well as the growing number of physicists and mathematicians interested in information processing by real nervous systems **Spikes** provides a self contained review of relevant concepts in information theory and statistical decision theory A quantitative framework is used to pose precise questions about the structure of the neural code These questions in turn influence both the design and analysis of experiments on sensory neurons **Spikes** Fred Rieke, 1996 **Lectures in Supercomputational Neuroscience** Peter Graben, Changsong Zhou, Marco Thiel, Jürgen Kurths, 2007-10-19 Computational Neurosciences is a burgeoning field of research where only the combined effort of neuroscientists biologists psychologists physicists mathematicians computer scientists engineers and other specialists e g from linguistics and medicine seem to be able to expand the limits of our knowledge The present volume is an introduction largely from the physicists perspective to the subject matter with in depth contributions by system neuroscientists A conceptual model for complex networks of neurons is introduced that incorporates many important features of the real brain such as various types of neurons various brain areas inhibitory and excitatory coupling and the plasticity of the network The computational implementation on supercomputers which is introduced and discussed in detail in this book will enable the

readers to modify and adapt the algorithm for their own research. Worked out examples of applications are presented for networks of Morris-Lecar neurons to model the cortical connections of a cat's brain supported with data from experimental studies. This book is particularly suited for graduate students and nonspecialists from related fields with a general science background looking for a substantial but hands-on introduction to the subject matter.

Neural Codes and Distributed Representations L. F. Abbott, Terrence Joseph Sejnowski, 1999 Since its founding in 1989 by Terrence Sejnowski, *Neural Computation* has become the leading journal in the field. *Foundations of Neural Computation* collects by topic the most significant papers that have appeared in the journal over the past nine years. The present volume focuses on neural codes and representations, topics of broad interest to neuroscientists and modelers. The topics addressed are how neurons encode information through action potential firing patterns, how populations of neurons represent information, and how individual neurons use dendritic processing and biophysical properties of synapses to decode spike trains. The papers encompass a wide range of levels of investigation from dendrites and neurons to networks and systems.

Synaptic Circuits and Functions in Bio-inspired Integrated Architectures Ole Richter, 2024-10-15 Based upon the most advanced human-made technology on this planet, CMOS integrated circuit technology, this dissertation examines the design of hardware components and systems to establish a technological foundation for the application of future breakthroughs in the intersection of AI and neuroscience. Humans have long imagined machines, robots, and computers that learn and display intelligence akin to animals and themselves. To advance the development of these machines, specialised research in custom-built hardware designed for specific types of computation which mirrors the structure of powerful biological nervous systems is especially important. This dissertation is driven by the quest to harness biological and artificial neural principles to enhance the efficiency, adaptability, and intelligence of electronic neurosynaptic and neuromorphic hardware systems. It investigates the hardware design of bio-inspired neural components and their integration into more extensive scale and efficient chip architectures suitable for edge processing and near-sensor environments. Exploring all steps to the creation of a custom chip, this work selectively surveys and advances the state of the art in bio-inspired mixed-signal subthreshold integrated design for neurosynaptic systems in a practical fashion. Further, it presents a novel asynchronous digital convolutional neuronal network processing pipeline integrated with a vision sensor for smart sensing. In conclusion, it sets forth a series of open challenges and future directions for the field, emphasizing the need for a robust future proof base for bio-inspired design and the potential of asynchronous stream processor architectures.

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.

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.

Analysis of Parallel Spike Trains Sonja Grün, Stefan Rotter, 2010-08-18 Solid and transparent data analysis is the most important basis for reliable interpretation of experiments. The technique of parallel spike train recordings using multi electrode arrangements has been available for many decades now but only recently gained wide popularity among electro physiologists. Many traditional analysis methods are based on firing rates obtained by trial averaging and some of the assumptions for such procedures to work can be ignored without serious consequences. The situation is different for correlation analysis the result of which may be considerably distorted if certain critical assumptions are violated. The focus of this book is on concepts and methods of correlation analysis synchrony patterns rate covariance combined with a solid introduction into approaches for single spike trains which represent the basis of correlations analysis. The book also emphasizes pitfalls and potential wrong interpretations of data due to violations of critical assumptions.

Catalyzing Inquiry at the Interface of Computing and Biology National Research Council, Division on Engineering and Physical Sciences, Computer Science and Telecommunications Board, Committee on Frontiers at the Interface of Computing and Biology, 2005-12-01 Advances in computer science and technology and in biology over the last several years have opened up the possibility for computing to help answer fundamental questions in biology and for biology to help with new approaches to computing. Making the most of the research opportunities at the interface of computing and biology requires the active participation of people from both fields. While past attempts have been made in this direction circumstances today appear to be much more favorable for progress. To help take advantage of these opportunities this study was requested of the NRC by the National Science Foundation the Department of Defense the National Institutes of Health and the Department of Energy. The report provides the basis for establishing cross disciplinary collaboration between biology and computing including an analysis of potential impediments and strategies for overcoming them. The report also presents a wealth of examples that should encourage students in the biological sciences to look for ways to enable them to be more effective users of computing in their studies.

Encyclopedia of Neuroscience, Volume 1 Larry R. Squire, 2009-06-12 The Encyclopedia of the Neuroscience explores all areas of the discipline in its focused entries on a wide variety of topics in neurology neurosurgery psychiatry and other related areas of neuroscience. Each article is written by an expert in that specific domain and peer reviewed by the advisory board before acceptance into the encyclopedia. Each

article contains a glossary introduction a reference section and cross references to other related encyclopedia articles Written at a level suitable for university undergraduates the breadth and depth of coverage will appeal beyond undergraduates to professionals and academics in related fields Neural Computation ,2006 *Emergent neural computation from the interaction of different forms of plasticity* Cristina Savin,Matthieu Gilson,Friedemann Zenke,2016-03-22 From the propagation of neural activity through synapses to the integration of signals in the dendritic arbor and the processes determining action potential generation virtually all aspects of neural processing are plastic This plasticity underlies the remarkable versatility and robustness of cortical circuits it enables the brain to learn regularities in its sensory inputs to remember the past and to recover function after injury While much of the research into learning and memory has focused on forms of Hebbian plasticity at excitatory synapses LTD LTP STDP several other plasticity mechanisms have been characterized experimentally including the plasticity of inhibitory circuits Kullmann 2012 synaptic scaling Turrigiano 2011 and intrinsic plasticity Zhang and Linden 2003 However our current understanding of the computational roles of these plasticity mechanisms remains rudimentary at best While traditionally they are assumed to serve a homeostatic purpose counterbalancing the destabilizing effects of Hebbian learning recent work suggests that they can have a profound impact on circuit function Savin 2010 Vogels 2011 Keck 2012 Hence theoretical investigation into the functional implications of these mechanisms may shed new light on the computational principles at work in neural circuits This Research Topic of Frontiers in Computational Neuroscience aims to bring together recent advances in theoretical modeling of different plasticity mechanisms and of their contributions to circuit function Topics of interest include the computational roles of plasticity of inhibitory circuitry metaplasticity synaptic scaling intrinsic plasticity plasticity within the dendritic arbor and in particular studies on the interplay between homeostatic and Hebbian plasticity and their joint contribution to network function **COMPLIFE 2007** Arno Siebes,2007-09-26 The focus of the symposium was on computational methods for modeling analysis and exploration of all aspects of life sciences ranging from effects on the molecular level to complex interactions networks Of prime importance for this truly interdisciplinary event is the integration of the three disciplines Computer Science Biology and Chemistry These proceedings contain contributions regarding applications aspects as well as new theoretical developments *Statistical analysis of multi-cell recordings: linking population coding models to experimental data* Matthias Bethge,Philipp Berens,Jakob Macke,2012-01-01 Modern recording techniques such as multi electrode arrays and 2 photon imaging are capable of simultaneously monitoring the activity of large neuronal ensembles at single cell resolution This makes it possible to study the dynamics of neural populations of considerable size and to gain insights into their computations and functional organization The key challenge with multi electrode recordings is their high dimensional nature Understanding this kind of data requires powerful statistical techniques for capturing the structure of the neural population responses and their relation with external stimuli or

behavioral observations Contributions to this Research Topic should advance statistical modeling of neural populations Questions of particular interest include 1 What classes of statistical methods are most useful for modeling population activity 2 What are the main limitations of current approaches and what can be done to overcome them 3 How can statistical methods be used to empirically test existing models of probabilistic population coding 4 What role can statistical methods play in formulating novel hypotheses about the principles of information processing in neural populations This Research Topic is connected to a one day workshop at the Computational Neuroscience Meeting 2009 in Berlin <http://www.cnsorg.org/2009/workshops.shtml> and <http://www.kyb.tuebingen.mpg.de/bethge/workshops/cns2009>

Smart Engineering System Design Cihan H. Dagli, 2005 The newest volume in this series presents refereed papers in the following categories and their applications in the engineering domain Neural Networks Complex Networks Evolutionary Programming Data Mining Fuzzy Logic Adaptive Control Pattern Recognition Smart Engineering System Design These papers are intended to provide a forum for researchers in the field to exchange ideas on smart engineering system design [Graphic Design USA](#), 1998

Forthcoming Books Rose Arny, 1996-06 [Network](#), 2007 *Medical and Health Care Books and Serials in Print*, 1997

Consciousness in Four Dimensions Richard M. Pico, 2002 Richard M Pico unveils a revolutionary new approach to understanding consciousness that pinpoints its origins in the brain Called Rbiological relativity S the approach combines the laws of physics to the latest breakthroughs in neuroscience molecular biology and computational theory to create a coherent four dimensional model for explaining the origins of life and the emergence of complex biological systems from the living cell to the thinking brain

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