

SPRINGER SERIES IN COMPUTATIONAL NEUROSCIENCE

Hippocampal Microcircuits

A Computational Modeler's Resource Book



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Editors

 **Springer**

Hippocampal Microcircuits A Computational Modelers Resource Springer Series In Computational Neuroscience

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Hippocampal Microcircuits A Computational Modelers Resource Springer Series In Computational Neuroscience:

Hippocampal Microcircuits Vassilis Cutsuridis, Bruce Graham, Stuart Cobb, Imre Vida, 2010-02-01 Rich in detail Hippocampal Microcircuits A Computational Modeler s Resource Book provides succinct and focused reviews of experimental results It is an unparalleled resource of data and methodology that will be invaluable to anyone wishing to develop computational models of the microcircuits of the hippocampus The editors have divided the material into two thematic areas Covering the subject s experimental background leading neuroscientists discuss the morphological physiological and molecular characteristics as well as the connectivity and synaptic properties of the various cell types found in the hippocampus Here ensemble activity related to behavior on the part of morphologically identified neurons in anesthetized and freely moving animals lead to insights into the functions of hippocampal areas In the second section on computational analysis computational neuroscientists present models of hippocampal microcircuits at various levels of detail including single cell and network levels A full chapter is devoted to the single neuron and network simulation environments currently used by computational neuroscientists in developing their models In addition to the above the chapters also identify outstanding questions and areas in need of further clarification that will guide future research by computational neuroscientists

Hippocampal Microcircuits Vassilis Cutsuridis, Bruce P. Graham, Stuart Cobb, Imre Vida, 2019-02-04 This is the 2nd edition of a very well received and popular book that reflects the current state of the art of the ongoing research avenues concerning the hippocampus and processing units bridging the gap between single cell activity network activity and global brain function It aims to provide a methodology to anyone interested in developing microcircuit level models of the hippocampus The book is divided into two thematic areas I Experimental background and II Computational analysis In part I leading experimental neuroscientists discuss the morphological physiological and molecular characteristics as well as the connectivity and synaptic properties of the various cell types found in the hippocampus Behaviour related ensemble activity patterns of morphologically identified neurons in anesthetized and freely moving animals provide insights on the function of the hippocampal areas In part II computational neuroscientists present models of the hippocampal microcircuits at various levels of detail e g single cell level network level etc Synaptomics and connectomics models of hippocampal structures are initially discussed Then network models of memory rhythm generation and spatial navigation are presented followed by abstract and biophysical models of synaptic plasticity Network models of hippocampal implicated disorders epilepsy and schizophrenia are then detailed and how their network topologies connectivities and activities change in these diseases Finally two chapters are dedicated to describing simulator environments of single neurons and networks currently used by computational neuroscientists in developing their models and modelling tools to parametrically constrain them This engaging volume is invaluable to experimental and computational neuroscientists electrical engineers physicists mathematicians and others interested in developing microcircuit models of the hippocampus Graduate level students and

trainees in all of these fields can find this book a significant source of information *Reproducibility and Rigour in Computational Neuroscience* Sharon Crook, Andrew P. Davison, Robert Andrew McDougal, Hans Ekkehard Plesser, 2020-07-09

Computational Models of Brain and Behavior Ahmed A. Moustafa, 2017-11-13 A comprehensive Introduction to the world of brain and behavior computational models This book provides a broad collection of articles covering different aspects of computational modeling efforts in psychology and neuroscience Specifically it discusses models that span different brain regions hippocampus amygdala basal ganglia visual cortex different species humans rats fruit flies and different modeling methods neural network Bayesian reinforcement learning data fitting and Hodgkin Huxley models among others Computational Models of Brain and Behavior is divided into four sections a Models of brain disorders b Neural models of behavioral processes c Models of neural processes brain regions and neurotransmitters and d Neural modeling approaches It provides in depth coverage of models of psychiatric disorders including depression posttraumatic stress disorder PTSD schizophrenia and dyslexia models of neurological disorders including Alzheimer s disease Parkinson s disease and epilepsy early sensory and perceptual processes models of olfaction higher systems level models and low level models Pavlovian and instrumental conditioning linking information theory to neurobiology and more Covers computational approximations to intellectual disability in down syndrome Discusses computational models of pharmacological and immunological treatment in Alzheimer s disease Examines neural circuit models of serotonergic system from microcircuits to cognition Educates on information theory memory prediction and timing in associative learning Computational Models of Brain and Behavior is written for advanced undergraduate Master s and PhD level students as well as researchers involved in computational neuroscience modeling research **Spike-timing dependent plasticity** Henry Markram, Wulfram Gerstner, Per Jesper Sjöström, Hebb s postulate provided a crucial framework to understand synaptic alterations underlying learning and memory Hebb s theory proposed that neurons that fire together also wire together which provided the logical framework for the strengthening of synapses Weakening of synapses was however addressed by not being strengthened and it was only later that the active decrease of synaptic strength was introduced through the discovery of long term depression caused by low frequency stimulation of the presynaptic neuron In 1994 it was found that the precise relative timing of pre and postsynaptic spikes determined not only the magnitude but also the direction of synaptic alterations when two neurons are active together Neurons that fire together may therefore not necessarily wire together if the precise timing of the spikes involved are not tightly correlated In the subsequent 15 years Spike Timing Dependent Plasticity STDP has been found in multiple brain regions and in many different species The size and shape of the time windows in which positive and negative changes can be made vary for different brain regions but the core principle of spike timing dependent changes remain A large number of theoretical studies have also been conducted during this period that explore the computational function of this driving principle and STDP algorithms have become the main learning algorithm when modeling neural networks This Research

Topic will bring together all the key experimental and theoretical research on STDP

Advances in the Mathematical Sciences Alyson Deines, Daniela Ferrero, Erica Graham, Mee Seong Im, Carrie Manore, Candice Price, 2018-10-31 Featuring research from the 2017 research symposium of the Association for Women in Mathematics this volume presents recent findings in pure mathematics and a range of advances and novel applications in fields such as engineering biology and medicine Featured topics include geometric group theory generalized iterated wreath products of cyclic groups and symmetric groups Conway Coxeter friezes and mutation and classroom experiments in teaching collegiate mathematics A review of DNA topology and a computational study of learning induced sequence reactivation during sharp wave ripples are also included in this volume Numerous illustrations and tables convey key results throughout the book This volume highlights research from women working in academia industry and government It is a helpful resource for researchers and graduate students interested in an overview of the latest research in mathematics

Principles of Computational Modelling in Neuroscience David Sterratt, Bruce Graham, Andrew Gillies, Gaute Einevoll, David Willshaw, 2023-10-05 Taking a step by step approach to modelling neurons and neural circuitry this textbook teaches students how to use computational techniques to understand the nervous system at all levels using case studies throughout to illustrate fundamental principles Starting with a simple model of a neuron the authors gradually introduce neuronal morphology synapses ion channels and intracellular signalling This fully updated new edition contains additional examples and case studies on specific modelling techniques suggestions on different ways to use this book and new chapters covering plasticity modelling extracellular influences on brain circuits modelling experimental measurement processes and choosing appropriate model structures and their parameters The online resources offer exercises and simulation code that recreate many of the book's figures allowing students to practice as they learn Requiring an elementary background in neuroscience and high school mathematics this is an ideal resource for a course on computational neuroscience

The Oscillatory Nature of Language Elliot Murphy, 2020-11-05 Develops a theory of how language is processed in the brain and provides a state of the art review of current neuroscientific debates

Towards the Next Generation of Deep Brain Stimulation Therapies: Technological Advancements, Computational Methods, and New Targets George C. McConnell, Sabato Santaniello, John Thomas Gale, Rose Taj Faghieh, Caleb Kemere, Martin Han, Justin David Hilliard, 2021-10-04

Complex Networks & Their Applications XIII Hocine Cherifi, Murat Donduran, Luis M. Rocha, Chantal Cherifi, Onur Varol, 2025-04-02 This book highlights cutting edge research in network science offering scientists researchers students and practitioners a unique update on the latest advances in theory and a multitude of applications It presents the peer reviewed proceedings of the XIII International Conference on Complex Networks and their Applications COMPLEX NETWORKS 2024 The carefully selected papers cover a wide range of theoretical topics such as network embedding and network geometry community structure network dynamics diffusion epidemics and spreading processes machine learning and graph neural networks as well as all the main network applications

including social and political networks networks in finance and economics biological networks and technological networks

Anatomy and Plasticity in Large-Scale Brain Models Markus Butz, Wolfram Schenck, Arjen van Ooyen, 2017-01-05
Supercomputing facilities are becoming increasingly available for simulating activity dynamics in large scale neuronal networks On today s most advanced supercomputers networks with up to a billion of neurons can be readily simulated However building biologically realistic full scale brain models requires more than just a huge number of neurons In addition to network size the detailed local and global anatomy of neuronal connections is of crucial importance Moreover anatomical connectivity is not fixed but can rewire throughout life structural plasticity an aspect that is missing in most current network models in which plasticity is confined to changes in synaptic strength synaptic plasticity The papers in this Ebook which may broadly be divided into three themes aim to bring together high performance computing with recent experimental and computational research in neuroanatomy In the first theme fiber connectivity new methods are described for measuring and data basing microscopic and macroscopic connectivity In the second theme structural plasticity novel models are introduced that incorporate morphological plasticity and rewiring of anatomical connections In the third theme large scale simulations simulations of large scale neuronal networks are presented with an emphasis on anatomical detail and plasticity mechanisms Together the articles in this Ebook make the reader aware of the methods and models by which large scale brain networks running on supercomputers can be extended to include anatomical detail and plasticity *Neuroscience, computing, performance, and benchmarks: Why it matters to neuroscience how fast we can compute* Felix Schürmann, Omar Awile, James Courtney Knight, Thomas Nowotny, James B. Aimone, Markus Diesmann, 2023-04-26 *Computational Modelling of the Brain* Michele Giugliano, Mario Negrello, Daniele Linaro, 2022-04-26 This volume offers an up to date overview of essential concepts and modern approaches to computational modelling including the use of experimental techniques related to or directly inspired by them The book introduces at increasing levels of complexity and with the non specialist in mind state of the art topics ranging from single cell and molecular descriptions to circuits and networks Four major themes are covered including subcellular modelling of ion channels and signalling pathways at the molecular level single cell modelling at different levels of spatial complexity network modelling from local microcircuits to large scale simulations of entire brain areas and practical examples Each chapter presents a systematic overview of a specific topic and provides the reader with the fundamental tools needed to understand the computational modelling of neural dynamics This book is aimed at experimenters and graduate students with little or no prior knowledge of modelling who are interested in learning about computational models from the single molecule to the inter areal communication of brain structures The book will appeal to computational neuroscientists engineers physicists and mathematicians interested in contributing to the field of neuroscience Chapters 6 10 and 11 are available open access under a Creative Commons Attribution 4 0 International License via link [springer.com](https://www.springer.com) **Analysis and Modeling of Coordinated Multi-neuronal Activity** Masami Tatsuno, 2014-11-13 Since information in the brain is

processed by the exchange of spikes among neurons a study of such group dynamics is extremely important in understanding hippocampus dependent memory These spike patterns and local field potentials LFPs have been analyzed by various statistical methods These studies have led to important findings of memory information processing For example memory trace replay a reactivation of behaviorally induced neural patterns during subsequent sleep has been suggested to play an important role in memory consolidation It has also been suggested that a ripple sharp wave event one of the characteristics of LFPs in the hippocampus and spiking activity in the cortex have a specific relationship that may facilitate the consolidation of hippocampal dependent memory from the hippocampus to the cortex The book will provide a state of the art finding of memory information processing through the analysis of multi neuronal data The first half of the book is devoted to this analysis aspect Understanding memory information representation and its consolidation however cannot be achieved only by analyzing the data It is extremely important to construct a computational model to seek an underlying mathematical principle In other words an entire picture of hippocampus dependent memory system would be elucidated through close collaboration among experiments data analysis and computational modeling Not only does computational modeling benefit the data analysis of multi electrode recordings but it also provides useful insight for future experiments and analyses The second half of the book will be devoted to the computational modeling of hippocampus dependent memory

Brain Dynamics

Hermann Haken, 2008-01-04 This is an excellent introduction for graduate students and nonspecialists to the field of mathematical and computational neurosciences The book approaches the subject via pulsed coupled neural networks which have at their core the lighthouse and integrate and fire models These allow for highly flexible modeling of realistic synaptic activity synchronization and spatio temporal pattern formation The more advanced pulse averaged equations are discussed

Embracing the Song of Term: An Psychological Symphony within **Hippocampal Microcircuits A Computational Modelers Resource Springer Series In Computational Neuroscience**

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