Self–Organizing Map Formation
Foundations of Neural Computation

Edited by

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Self Organizing Map Formation Foundations Of Neural Computation Computational Neuroscience

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Self Organizing Map Formation Foundations Of Neural Computation Computational Neuroscience:

Self-organizing Map Formation Klaus Obermayer,Terrence Joseph Sejnowski,2001 This book provides an overview of self organizing map formation including recent developments Self organizing maps form a branch of unsupervised learning which is the study of what can be determined about the statistical properties of input data without explicit feedback from a teacher The articles are drawn from the journal Neural Computation The book consists of five sections The first section looks at attempts to model the organization of cortical maps and at the theory and applications of the related artificial neural network algorithms The second section analyzes topographic maps and their formation via objective functions The third section discusses cortical maps of stimulus features The fourth section discusses self organizing maps for unsupervised data analysis The fifth section discusses extensions of self organizing maps including two surprising applications of mapping algorithms to standard computer science problems combinatorial optimization and sorting Contributors J J Atick H G Barrow H U Bauer C M Bishop H J Bray J Bruske J M L Budd M Budinich V Cherkassky J Cowan R Durbin E Erwin G J Goodhill T Graepel D Grier S Kaski T Kohonen H Lappalainen Z Li J Lin R Linsker S P Luttrell D J C MacKay K D Miller G Mitchison F Mulier K Obermayer C Piepenbrock H Ritter K Schulten T J Sejnowski S Smirnakis G Sommer M Svensen R Szeliski A Utsugi C K I Williams L Wiskott L Xu A Yuille J Zhang An Introductory Course in Computational Neuroscience Paul Miller,2018-10-09 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 The Computational Neurobiology of Reaching and Pointing Reza Shadmehr,Steven P. Wise,2004-10-28 An introduction to the computational

biology of reaching and pointing with an emphasis on motor learning Neuroscience involves the study of the nervous system and its topics range from genetics to inferential reasoning At its heart however lies a search for understanding how the environment affects the nervous system and how the nervous system in turn empowers us to interact with and alter our environment This empowerment requires motor learning The Computational Neurobiology of Reaching and Pointing addresses the neural mechanisms of one important form of motor learning The authors integrate material from the computational behavioral and neural sciences of motor control that is not available in any other single source The result is a unified comprehensive model of reaching and pointing The book is intended to be used as a text by graduate students in both neuroscience and bioengineering and as a reference source by experts in neuroscience robotics and other disciplines The book begins with an overview of the evolution anatomy and physiology of the motor system including the mechanisms for generating force and maintaining limb stability The sections that follow Computing Locations and Displacements Skills Adaptations and Trajectories and Predictions Decisions and Flexibility present a theory of sensorially guided reaching and pointing that evolves organically based on computational principles rather than a traditional structure by structure approach The book also includes five appendixes that provide brief refreshers on fundamentals of biology mathematics physics and neurophysiology as well as a glossary of relevant terms The authors have also made supplemental materials available on the Internet These web documents provide source code for simulations step by step derivations of certain mathematical formulations and expanded explanations of some concepts   From Neuron to Cognition via Computational Neuroscience Michael A. Arbib,James J. Bonaiuto,2016-11-11 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   Dynamical Systems in Neuroscience Eugene M. Izhikevich,2010-01-22 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   *Statistical Techniques for Network Security: Modern Statistically-Based Intrusion Detection and Protection* Wang, Yun,2008-10-31 Provides statistical modeling and simulating approaches to address the needs for intrusion detection and protection Covers topics such as network traffic data anomaly intrusion detection and prediction events   *Modeling Neural Circuits Made Simple with Python* Robert Rosenbaum,2024-03-19 An accessible undergraduate textbook in computational neuroscience that provides an introduction to the mathematical and computational modeling of neurons and networks of neurons Understanding the brain is a major frontier of modern science Given the complexity of neural circuits advancing that understanding requires mathematical and computational approaches This accessible undergraduate textbook in computational neuroscience provides an introduction to

the mathematical and computational modeling of neurons and networks of neurons Starting with the biophysics of single neurons Robert Rosenbaum incrementally builds to explanations of neural coding learning and the relationship between biological and artificial neural networks Examples with real neural data demonstrate how computational models can be used to understand phenomena observed in neural recordings Based on years of classroom experience the material has been carefully streamlined to provide all the content needed to build a foundation for modeling neural circuits in a one semester course Proven in the classroom Example rich student friendly approach Includes Python code and a mathematical appendix reviewing the requisite background in calculus linear algebra and probability Ideal for engineering science and mathematics majors and for self study **Graphical Models** Michael Irwin Jordan,Terrence Joseph Sejnowski,2001 This book exemplifies the interplay between the general formal framework of graphical models and the exploration of new algorithm and architectures The selections range from foundational papers of historical importance to results at the cutting edge of research Graphical models use graphs to represent and manipulate joint probability distributions They have their roots in artificial intelligence statistics and neural networks The clean mathematical formalism of the graphical models framework makes it possible to understand a wide variety of network based approaches to computation and in particular to understand many neural network algorithms and architectures as instances of a broader probabilistic methodology It also makes it possible to identify novel features of neural network algorithms and architectures and to extend them to more general graphical models This book exemplifies the interplay between the general formal framework of graphical models and the exploration of new algorithms and architectures The selections range from foundational papers of historical importance to results at the cutting edge of research Contributors H Attias C M Bishop B J Frey Z Ghahramani D Heckerman G E Hinton R Hofmann R A Jacobs Michael I Jordan H J Kappen A Krogh R Neal S K Riis F B Rodr guez L K Saul Terrence J Sejnowski P Smyth M E Tipping V Tresp Y Weiss **Bayesian Brain** Kenji Doya,2007 Experimental and theoretical neuroscientists use Bayesian approaches to analyze the brain mechanisms of perception decision making and motor control **Neural Engineering** Chris Eliasmith,Charles H. Anderson,2003 A synthesis of current approaches to adapting engineering tools to the study of neurobiological systems **The Computational Brain, 25th Anniversary Edition** Patricia S. Churchland,Terrence J. Sejnowski,2016-10-28 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   Handbook of Psychology, Behavioral Neuroscience Irving B. Weiner,Randy J. Nelson,Sheri Mizumori,2012-10-16 Psychology is of interest to academics from many fields as well as to the thousands of academic and clinical psychologists and general public who can t help but be interested in learning more about why humans think and behave as they do This award winning twelve volume reference covers every aspect of the ever fascinating discipline of psychology and represents the most current knowledge in the field This ten year revision now covers discoveries based in neuroscience clinical psychology s new interest in evidence based practice and mindfulness and new findings in social developmental and forensic psychology   **Case Studies in Neural Data Analysis** Mark A. Kramer,Uri T. Eden,2016-11-04 A practical guide to neural data analysis techniques that presents sample datasets and hands on methods for analyzing the data As neural data becomes increasingly complex neuroscientists now require skills in computer programming statistics and data analysis This book teaches practical neural data analysis techniques by presenting example datasets and developing techniques and tools for analyzing them Each chapter begins with a specific example of neural data which motivates mathematical and statistical analysis methods that are then applied to the data This practical hands on approach is unique among data analysis textbooks and guides and equips the reader with the tools necessary for real world neural data analysis The book begins with an introduction to MATLAB the most common programming platform in neuroscience which is used in the book Readers familiar with MATLAB can skip this chapter and might decide to focus on data type or method type The book goes on to cover neural field data and spike train data spectral analysis generalized linear models coherence and cross frequency coupling Each chapter offers a stand alone case study that can be used separately as part of a targeted investigation The book includes some mathematical discussion but does not focus on mathematical or statistical theory emphasizing the practical instead References are included for readers who want to explore the theoretical more deeply The data and accompanying MATLAB code are freely available on the authors website The book can be used for upper level undergraduate or graduate courses or as a professional reference A version of this textbook with all of the examples in Python is available on the MIT Press website   *Neural Computation* ,2001 Covers neural computation which encompasses psychology physics computer science neuroscience and artificial intelligence among others It highlights common problems and techniques in modeling the brain and the design and construction of neurally inspired information processing systems   **Visual Cortex and Deep Networks** Tomaso A. Poggio,Fabio Anselmi,2016-09-23 A mathematical framework that describes learning of invariant representations in the ventral stream

offering both theoretical development and applications The ventral visual stream is believed to underlie object recognition in primates Over the past fifty years researchers have developed a series of quantitative models that are increasingly faithful to the biological architecture Recently deep learning convolution networks which do not reflect several important features of the ventral stream architecture and physiology have been trained with extremely large datasets resulting in model neurons that mimic object recognition but do not explain the nature of the computations carried out in the ventral stream This book develops a mathematical framework that describes learning of invariant representations of the ventral stream and is particularly relevant to deep convolutional learning networks The authors propose a theory based on the hypothesis that the main computational goal of the ventral stream is to compute neural representations of images that are invariant to transformations commonly encountered in the visual environment and are learned from unsupervised experience They describe a general theoretical framework of a computational theory of invariance with details and proofs offered in appendixes and then review the application of the theory to the feedforward path of the ventral stream in the primate visual cortex   Human Learning: Biology, Brain, and Neuroscience Aaron S. Benjamin,J. Steven de Belle,Bruce Etnyre,Thad A. Polk,2008-08-15 Human learning is studied in a variety of ways Motor learning is often studied separately from verbal learning Studies may delve into anatomy vs function may view behavioral outcomes or look discretely at the molecular and cellular level of learning All have merit but they are dispersed across a wide literature and rarely are the findings integrated and synthesized in a meaningful way Human Learning Biology Brain and Neuroscience synthesizes findings across these levels and types of learning and memory investigation Divided into three sections each section includes a discussion by the editors integrating themes and ideas that emerge across the chapters within each section Section 1 discusses general topics in human learning and cognition research including inhibition short term and long term memory verbal memory memory disruption and scheduling and learning Section 2 discusses cognitive neuroscience aspects of human learning Coverage here includes models skill acquisition declarative and non declarative memory age effects on memory and memory for emotional events Section 3 focuses on human motor learning This book is suitable for cognitive neuroscientists cognitive psychologists kinesthesiologists and graduate courses in learning Synthesizes research from a variety of disciplines levels and content areas Provides section discussions on common findings between chapters Covers motor and verbal learning

Computational Maps in the Visual Cortex Risto Miikkulainen,James A. Bednar,Yoonsuck Choe,Joseph Sirosh,2006-01-16 For more than 30 years the visual cortex has been the source of new theories and ideas about how the brain processes information The visual cortex is easily accessible through a variety of recording and imagining techniques and allows mapping of high level behavior relatively directly to neural mechanisms Understanding the computations in the visual cortex is therefore an important step toward a general theory of computational brain theory   **Fundamentals of Cognitive Radio** Peyman Setoodeh,Simon Haykin,2017-07-06 A comprehensive treatment of cognitive radio networks and the

specialized techniques used to improve wireless communications The human brain as exemplified by cognitive radar cognitive radio and cognitive computing inspires the field of Cognitive Dynamic Systems In particular cognitive radio is growing at an exponential rate Fundamentals of Cognitive Radio details different aspects of the human brain and provides examples of how it can be mimicked by cognitive dynamic systems The text offers a communication theoretic background including information on resource allocation in wireless networks and the concept of robustness The authors provide a thorough mathematical background with data on game theory variational inequalities and projected dynamic systems They then delve more deeply into resource allocation in cognitive radio networks The text investigates the dynamics of cognitive radio networks from the perspectives of information theory optimization and control theory It also provides a vision for the new world of wireless communications by integration of cellular and cognitive radio networks This groundbreaking book Shows how wireless communication systems increasingly use cognition to enhance their networks Explores how cognitive radio networks can be viewed as spectrum supply chain networks Derives analytic models for two complementary regimes for spectrum sharing open access and market driven to study both equilibrium and disequilibrium behaviors of networks Studies cognitive heterogeneous networks with emphasis on economic provisioning for resource sharing Introduces a framework that addresses the issue of spectrum sharing across licensed and unlicensed bands aimed for Pareto optimality Written for students of cognition communication engineers telecommunications professionals and others Fundamentals of Cognitive Radio offers a new generation of ideas and provides a fresh way of thinking about cognitive techniques in order to improve radio networks   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   Nature Reviews ,2001

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