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# Neural Control Engineering The Mit Press

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Foundations of Neural Networks, Fuzzy Systems, and Knowledge Engineering  
 The Handbook of Brain Theory and Neural Networks  
 Autonomous Robots  
 An Introductory Course in Computational Neuroscience  
 Talking Nets  
 Neural Networks for Control  
 Computational Neuroscience  
 Computational Explorations in Cognitive Neuroscience  
 Neural Control Engineering  
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 Neural Networks Modeling and Control  
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## HOWARD SELAH

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Foundations of Neural Networks, Fuzzy Systems, and Knowledge Engineering CRC Press

Neural networks have become a well-established methodology as exemplified by their applications to identification and control of general nonlinear and complex systems; the use of high order neural networks for modeling and learning has recently increased.

Using neural networks, control algorithms can be developed to be robust to uncertainties and modeling errors. The most used NN structures are Feedforward networks and Recurrent networks. The latter type offers a better suited tool to model and control of nonlinear systems. There exist different training algorithms for neural networks, which, however, normally encounter some technical problems such as local minima, slow learning, and high sensitivity to initial conditions, among others. As a viable alternative, new training algorithms, for example, those based on Kalman filtering, have been proposed. There already exists

publications about trajectory tracking using neural networks; however, most of those works were developed for continuous-time systems. On the other hand, while extensive literature is available for linear discrete-time control system, nonlinear discrete-time control design techniques have not been discussed to the same degree. Besides, discrete-time neural networks are better suited for real-time implementations.

The Handbook of Brain Theory and Neural Networks MIT Press Neural Engineering, 2nd Edition, contains reviews and discussions of contemporary and relevant topics by leading investigators in the field. It is intended to serve as a textbook at the graduate and advanced undergraduate level in a bioengineering curriculum. This principles and applications approach to neural engineering is essential reading for all academics, biomedical engineers, neuroscientists, neurophysiologists, and industry professionals wishing to take advantage of the latest and greatest in this emerging field.

Autonomous Robots MIT Press

Experimental and theoretical neuroscientists use Bayesian approaches to analyze the brain mechanisms of perception, decision-making, and motor control.

*An Introductory Course in Computational Neuroscience* MIT Press  
This text provides students and researchers with a foundation for examining how brain function gives rise to mental activities such as perception, memory and language. It is grouped into sections that cover attention, vision, auditory and somatosensory systems, memory and higher cortical.

*Talking Nets* Springer Science & Business Media

The latest advances in research on intracranial implantation of hardware models of neural circuitry.

*Neural Networks for Control* MIT Press

*Neural Networks for Control* brings together examples of all the most important paradigms for the application of neural networks to robotics and control. Primarily concerned with engineering problems and approaches to their solution through neurocomputing systems, the book is divided into three sections: general principles, motion control, and applications domains (with evaluations of the possible applications by experts in the applications areas.) Special emphasis is placed on designs based on optimization or reinforcement, which will become increasingly important as researchers address more complex engineering challenges or real biological-control problems. A Bradford Book.

Neural Network Modeling and Connectionism series

*Computational Neuroscience* MIT Press

The thirty original contributions in this book provide a working definition of "computational neuroscience" as the area in which problems lie simultaneously within computerscience and neuroscience. They review this emerging field in historical and philosophical overviews and in stimulating summaries of recent results. Leading researchers address the structure of the brain and the computational problems associated with describing and understanding this structure at the synaptic, neural, map, and system levels. The overview chapters discuss the early days of the field, provide a philosophical analysis of the problems associated with confusion between brain metaphor and brain theory, and take up the scope and structure of computational neuroscience. Synaptic-level structure is addressed in chapters that relate the properties of dendritic branches, spines, and synapses to the biophysics of computation and provide a connection between real neuron architectures and neural network simulations. The network-level chapters take up the preattentive perception of 3-D forms, oscillation in neural networks, the neurobiological significance of new learning models, and the analysis of neural assemblies and local learning rides. Map-level structure is explored in chapters on the bat echolocation system, cat orientation maps, primate stereo vision cortical cognitive maps, dynamic remapping in primate visual cortex, and computer-aided reconstruction of topographic and columnar maps in primates. The system-level chapters focus 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 cortical neural activity neuropsychological studies of brain and mind, and an information-theoretic view of analog representation in striate cortex. Eric L. Schwartz is Professor of Brain Research and Research Professor of Computer Science, Courant Institute of Mathematical Sciences, New York University Medical Center. *Computational Neuroscience* is included in the System Development Foundation Benchmark Series.

*Computational Explorations in Cognitive Neuroscience* MIT Press

A synthesis of biomechanics and neural control that draws on recent advances in robotics to address control problems solved by the human sensorimotor system. This book proposes a transdisciplinary approach to investigating human motor control that synthesizes musculoskeletal biomechanics and neural control. The authors argue that this integrated approach—which

uses the framework of robotics to understand sensorimotor control problems—offers a more complete and accurate description than either a purely neural computational approach or a purely biomechanical one. The authors offer an account of motor control in which explanatory models are based on experimental evidence using mathematical approaches reminiscent of physics. These computational models yield algorithms for motor control that may be used as tools to investigate or treat diseases of the sensorimotor system and to guide the development of algorithms and hardware that can be incorporated into products designed to assist with the tasks of daily living. The authors focus on the insights their approach offers in understanding how movement of the arm is controlled and how the control adapts to changing environments. The book begins with muscle mechanics and control, progresses in a logical manner to planning and behavior, and describes applications in neurorehabilitation and robotics. The material is self-contained, and accessible to researchers and professionals in a range of fields, including psychology, kinesiology, neurology, computer science, and robotics.

*Neural Control Engineering* Wiley-IEEE Press

In *From Molecule to Metaphor*, Jerome Feldman proposes a theory of language and thought that treats language not as an abstract symbol system but as a human biological ability that can be studied as a function of the brain, as vision and motor control are studied. This theory, he writes, is a "bridging theory" that works from extensive knowledge at two ends of a causal chain to explicate the links between. Although the cognitive sciences are revealing much about how our brains produce language and thought, we do not yet know exactly how words are understood or have any methodology for finding out. Feldman develops his theory in computer simulations—formal models that suggest ways that language and thought may be realized in the brain. Combining key findings and theories from biology, computer science, linguistics, and psychology, Feldman synthesizes a theory by exhibiting programs that demonstrate the required behavior while remaining consistent with the findings from all disciplines. After presenting the essential results on language, learning, neural computation, the biology of neurons and neural circuits, and the mind/brain, Feldman introduces specific demonstrations and formal models of such topics as how children learn their first words, words for abstract and metaphorical concepts, understanding stories, and grammar (including "hot-button" issues surrounding the innateness of human grammar). With this accessible, comprehensive book Feldman offers readers who want to understand how our brains create thought and language a theory of language that is intuitively plausible and also consistent with existing scientific data at all levels.

*Handbook of Neural Engineering* Athena Scientific

Although the use of fuzzy control methods has grown nearly to the level of classical control, the true understanding of fuzzy control lags seriously behind. Moreover, most engineers are well versed in either traditional control or in fuzzy control—rarely both. Each has applications for which it is better suited, but without a good understanding of both, engineers cannot make a sound determination of which technique to use for a given situation. A *First Course in Fuzzy and Neural Control* is designed to build the foundation needed to make those decisions. It begins with an introduction to standard control theory, then makes a smooth transition to complex problems that require innovative fuzzy, neural, and fuzzy-neural techniques. For each method, the authors clearly answer the questions: What is this new control method? Why is it needed? How is it implemented? Real-world examples, exercises, and ideas for student projects reinforce the concepts presented. Developed from lecture notes for a highly

successful course titled *The Fundamentals of Soft Computing*, the text is written in the same reader-friendly style as the authors' popular *A First Course in Fuzzy Logic* text. *A First Course in Fuzzy and Neural Control* requires only a basic background in mathematics and engineering and does not overwhelm students with unnecessary material but serves to motivate them toward more advanced studies.

*Cognitive Neuroscience* Springer

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.

*Neural Networks Modeling and Control* MIT Press

A survey of how engineering techniques from control and systems theory can be used to help biologists understand the behavior of cellular systems.

*Discrete-Time High Order Neural Control* Chapman & Hall

The annual conference on Neural Information Processing Systems (NIPS) is the flagship conference on neural computation. These proceedings contain all of the papers that were presented.

*Analysis of Neural Data* Academic Press

A synthesis of biomechanics and neural control that draws on recent advances in robotics to address control problems solved by the human sensorimotor system. This book proposes a transdisciplinary approach to investigating human motor control that synthesizes musculoskeletal biomechanics and neural control. The authors argue that this integrated approach—which uses the framework of robotics to understand sensorimotor control problems—offers a more complete and accurate description than either a purely neural computational approach or a purely biomechanical one. The authors offer an account of motor control in which explanatory models are based on experimental evidence using mathematical approaches reminiscent of physics. These computational models yield algorithms for motor control that may be used as tools to investigate or treat diseases of the sensorimotor system and to guide the development of algorithms and hardware that can be incorporated into products designed to assist with the tasks of daily living. The authors focus on the insights their approach offers in understanding how movement of the arm is controlled

and how the control adapts to changing environments. The book begins with muscle mechanics and control, progresses in a logical manner to planning and behavior, and describes applications in neurorehabilitation and robotics. The material is self-contained, and accessible to researchers and professionals in a range of fields, including psychology, kinesiology, neurology, computer science, and robotics.

*Nonlinear Control Engineering* MIT Press

Methods by which robots can learn control laws that enable real-time reactivity using dynamical systems; with applications and exercises. This book presents a wealth of machine learning techniques to make the control of robots more flexible and safe when interacting with humans. It introduces a set of control laws that enable reactivity using dynamical systems, a widely used method for solving motion-planning problems in robotics. These control approaches can replan in milliseconds to adapt to new environmental constraints and offer safe and compliant control of forces in contact. The techniques offer theoretical advantages, including convergence to a goal, non-penetration of obstacles, and passivity. The coverage of learning begins with low-level control parameters and progresses to higher-level competencies composed of combinations of skills. *Learning for Adaptive and Reactive Robot Control* is designed for graduate-level courses in robotics, with chapters that proceed from fundamentals to more advanced content. Techniques covered include learning from demonstration, optimization, and reinforcement learning, and using dynamical systems in learning control laws, trajectory planning, and methods for compliant and force control. Features for teaching in each chapter: applications, which range from arm manipulators to whole-body control of humanoid robots; pencil-and-paper and programming exercises; lecture videos, slides, and MATLAB code examples available on the author's website. An eTextbook platform website offering protected material[EPS2] for instructors including solutions.

*Human Robotics* MIT Press

Continual improvements in data collection and processing have had a huge impact on brain research, producing data sets that are often large and complicated. By emphasizing a few fundamental principles, and a handful of ubiquitous techniques, *Analysis of Neural Data* provides a unified treatment of analytical methods that have become essential for contemporary researchers. Throughout the book ideas are illustrated with more than 100 examples drawn from the literature, ranging from electrophysiology, to neuroimaging, to behavior. By demonstrating the commonality among various statistical approaches the authors provide the crucial tools for gaining knowledge from diverse types of data. Aimed at experimentalists with only high-school level mathematics, as well as computationally-oriented neuroscientists who have limited familiarity with statistics, *Analysis of Neural Data* serves as both a self-contained introduction and a reference work.

*Learning for Adaptive and Reactive Robot Control* MIT Press

An examination of the link between the vigor with which we move and the value that the brain assigns to the goal of the movement. Why do we reflexively run toward people we love, but only walk toward others? In *Vigor*, Reza Shadmehr and Alaa Ahmed examine the link between how the brain assigns value to things and how it controls our movements. They find that brain regions thought to be principally involved in decision making also affect movement vigor—and that brain regions thought to be principally responsible for movement also bias patterns of decision making. Shadmehr and Ahmed first consider the relationship of value and vigor from a behavioral and mathematical perspective, considering a series of fascinating observations—including, for example, data showing that people in certain cities tend to walk

faster than those living elsewhere—through the lens of optimal foraging theory. They then go on to explore the neural basis of vigor and valuation, synthesizing results from experiments that have measured activity in various brain structures and neuromodulators, including dopamine and serotonin. They speculate that in the future, technologies may be able to predict our personal preferences by measuring our movements; through the vigor with which we move, we unwittingly reveal one of our well-guarded secrets: how much we value the object of our attention.

*From Molecule to Metaphor* Springer

Choice Outstanding Academic Title, 1996. In hundreds of articles by experts from around the world, and in overviews and "road maps" prepared by the editor, *The Handbook of Brain Theory and Neural Networks* charts the immense progress made in recent years in many specific areas related to great questions: How does the brain work? How can we build intelligent machines? While many books discuss limited aspects of one subfield or another of brain theory and neural networks, the Handbook covers the entire sweep of topics—from detailed models of single neurons, analyses of a wide variety of biological neural networks, and connectionist studies of psychology and language, to mathematical analyses of a variety of abstract neural networks, and technological applications of adaptive, artificial neural networks. Expository material makes the book accessible to readers with varied backgrounds while still offering a clear view of the recent, specialized research on specific topics.

*Vigor* MIT Press

After providing basic background on transplantation, brain structure, and development, the book discusses Parkinson's

disease, the use of transplants to influence localized brain functions, circuit reconstruction, and genetic engineering and other future technologies.

*A First Course in Fuzzy and Neural Control* MIT Press

*Neural Networks in Robotics* is the first book to present an integrated view of both the application of artificial neural networks to robot control and the neuromuscular models from which robots were created. The behavior of biological systems provides both the inspiration and the challenge for robotics. The goal is to build robots which can emulate the ability of living organisms to integrate perceptual inputs smoothly with motor responses, even in the presence of novel stimuli and changes in the environment. The ability of living systems to learn and to adapt provides the standard against which robotic systems are judged. In order to emulate these abilities, a number of investigators have attempted to create robot controllers which are modelled on known processes in the brain and musculo-skeletal system. Several of these models are described in this book. On the other hand, connectionist (artificial neural network) formulations are attractive for the computation of inverse kinematics and dynamics of robots, because they can be trained for this purpose without explicit programming. Some of the computational advantages and problems of this approach are also presented. For any serious student of robotics, *Neural Networks in Robotics* provides an indispensable reference to the work of major researchers in the field. Similarly, since robotics is an outstanding application area for artificial neural networks, *Neural Networks in Robotics* is equally important to workers in connectionism and to students for sensorimotor control in living systems.