

Preface

The importance of computational modeling as a research approach in neuroscience is recognized today by most researchers in the field. Computational neuroscience is generally associated with simulations in electrophysiology and neural dynamics. Recently, an increasing number of neuroscientists have begun to use computer models to study and describe neuroanatomy, its subcellular bases, and its relationship with neuronal activity and function. Other researchers began importing accurate and quantitative descriptions of neuronal structure and connectivity into computer simulations of neuronal and network physiology. Perhaps owing to the broad range of scales spanned by these studies, from subcellular structures to very large assemblies of interconnected neurons, computational neuroanatomy literature is sparse and distributed among the many technical journals in neuroscience. Nevertheless, a common theme is easily recognized in all these research projects: the use of computer models, simulations, and visualizations to gain a deeper understanding of the complexity of nervous system structures. Neuroanatomy constitutes a central aspect of neuroscience, and the continuous growth of affordable computer power makes it possible to model and integrate the enormous complexity of neuroanatomy. It is not surprising that computational neuroanatomy research projects are stirring considerable interest in the scientific community. *Computational Neuroanatomy: Principles and Methods* is the first comprehensive volume discussing the principles and describing the methods of computational approaches to neuroanatomy.

Computational neuroanatomy is potentially as vast and diverse a field as neuroanatomy itself. In an attempt to capture this diversity, each chapter of this book is contributed by different authors. Each subject is presented and discussed by the experts who first defined the problems, implemented the methods to solve them, and formulated the principles underlying the solutions (brief biographies of the book's authors are provided at the end of the book). Principles and methods of computational neuroanatomy are explained through direct examples of recent or ongoing research. All chapters were peer-reviewed by the editor, by contributors of other chapters, and by "external" reviewers (who are acknowledged at the end of this Preface).

Most chapters are enhanced by electronic material included in the companion CD-ROM. Such material includes software packages used in computational neuroanatomy, step-by-step explanation of the algorithms implemented in such programs, and examples of data files. In addition, given the important contribution of computer graphics to neuroanatomical models, results reported in the book are further illustrated by animations and movies in the CD-ROM. While only black and white figures are reproduced in print, high-resolution color images are contained in the disk. Finally, the CD provides links to web sites containing updates and additional information.

Computational Neuroanatomy: Principles and Methods may be used as a back-to-back text by readers interested in learning the basic strategies, results, and language of

computational neuroanatomy, or as a unique reference to consult for key material (both conceptual and technical) in these new areas of investigation. Active researchers and graduate students should be able to read the chapters as if they were published in a high-quality scientific journal. Advanced undergraduate students and interested non-academic thinkers with a background in neuroscience or computer science will also find this volume highly accessible.

The book was edited with particular attention to the expected diversity in background of the readership. A natural audience for this publication consists of all neuroanatomists interested in novel technology. The use of computers can aid neuroanatomical investigation and understanding, and the material of this book can be an inspiring source of research ideas as well as a basic guide to keep up to date with computational developments. As a rapidly growing field, computational neuroanatomy is of interest for the neuroscience community in general, and this book provides a review of many leading research paths. On the other hand, computer scientists and engineers are turning with ever deeper interest to biological architectures. Nervous systems are still remarkably superior to digital computers and artificial neural networks in a variety of computational and cognitive tasks, and a crucial reason is their structure. This book constitutes an intellectual bridge between information technology and neuroanatomy. Finally, the tremendous impact that computer graphics has had and will continue to have in education makes this material also useful for academic instructors involved with brain science, including neurologists, psychologists, biologists, and physicists.

Structural and functional human brain imaging and mapping is contributing enormously to the advancement of neuroscience. Neuroimaging is obviously anatomical in nature, and it involves a great deal of computational analysis and processing. However, most of the aspects of computational neuroanatomy described in this book revolve around the neuron as a fundamental brick of brain structure and function. Readers interested in the issues of computational neuroanatomy related to brain mapping should refer to the excellent recent publications specifically dedicated to neuroimaging.

Naturally, different research groups focus on different scales. Consequently, this book is organized in three main parts. Part One deals with single neurons and their internal structures, particularly dendritic morphology and its interaction with single-cell electrophysiology. Part Two discusses neuronal assemblies, axonal connectivity, and large-scale, anatomically accurate networks. Finally, Part Three tackles the major issues of integration of the massive knowledge necessary to describe (and generate) completely accurate neuroanatomical models at the system level. A detailed description of each chapter is beyond the scope of this preface. However, the first introductory chapter provides a review of several recent developments in computational neuroanatomy and introduces the subsequent chapters in this context. In addition, a summary of the contents is provided by the abstracts of each chapter.

Acknowledgment

I wish to extend my gratitude to all the people who made this book possible.

The publisher, Humana Press, demonstrated considerable courage in commissioning a book in such a novel and unexplored field. The help provided by the Humana support staff in all the phases of organization and editing was outstanding.

The time I spent wearing the Editor's hat really belonged to my wife, Rebecca, and to my two sons, Benjamin and Ruben. They were extremely patient and gave me much of the support and inspiration necessary for the completion of this book.

Rarely does a researcher have the fortune to meet and be mentored by such a nurturing advisor as Dr. James L. Olds. Without him this book would simply not exist.

The many authors of this book, of course, deserve the lion's share of the credit. Not only did they contribute chapters of great quality and substance, they also provided each other with invaluable feedback by cross-reviewing the manuscripts.

I am also deeply indebted to many external reviewers who read earlier versions of the chapters. They include Kim "Avrama" Blackwell (George Mason University), Jean-Marie Bouteiller (University of Southern California), Ann Butler (Krasnow Institute for Advanced Study), Mark Changizi (Duke University), Barry Condon (University of Virginia), Bard Ermentrout (University of Pittsburgh), Rebecca Goldin (University of Maryland), Kristin Jerger (Krasnow Institute for Advanced Study), Huo Lu (California Institute of Technology), Gianmaria Maccaferri (Emory University), Michael Moseley (Stanford University), Tay Netoff (Boston University), Kimberlee Potter (Armed Forces Institute of Pathology Annex), Bruce Rasmussen (George Washington University), and Charles Schroeder (Albert Einstein College of Medicine).

As pointed out by several contributors, the reviewers' insightful comments were instrumental in ensuring the highest quality of this book.

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