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Modelling in the Neurosciences: From Ionic Channels To Neural Networks. Roman R. Poznanski (ed.). Harwood Academic Publishers, Amsteldijk 166, I Floor, 1079 LH, Amsterdam, The Netherlands. 1999. 536 pp. Price not stated.

The brain is often referred to as the most complex structure in the universe. This complexity gives rise to remarkable properties such as the mind and consciousness, as well as to a thriving philosophical debate about their nature. These questions are still out of the reach of neuronal modelling. Nevertheless, modelling has provided intriguing glimpses of how some of the properties of the brain may emerge. Abstract neural networks loosely based on biology exhibit useful (and brain-like) functions such as learning by example, robustness, and the ability to generalize. Realistic neuronal modelling, which this book examines, is beginning to provide the theoretical counterpart of experimental neuroscience, and to answer many questions about the higher functions of the brain.

Both experiments and theoretical studies have shown the need to adopt a multi-level approach to analysing brain function. Even the level of molecular and genetic events can affect the entire central nervous system, and *vice versa*. Most neuronal modelling has focused on the biophysical level: from currents passing through ion channels up to the level of large assemblies of neurons. This description encompasses many levels of neuronal function, and is the domain of this book. Biophysical models of single neurons are conceptually very simple, and are among the most quantitatively accurate models in biology. Highly accurate models can be constructed by subdividing cells into interconnected 'compartments': small cylindrical segments of the neuron, each with its own complement of ion channels. Compartments are represented by an equivalent circuit, which takes into account membrane resistance, capacitance, and ionic conductance. Within each compartment, ion currents are typically described as variable conductances in series with the ionic reversal potential. It is the modulation of these conductances which gives each current its unique character. For example, synaptic currents are often modelled as simple 'alpha-function' responses to an action potential, whereas Ca^{2+}-dependent voltage-gated channels may require multiple state variables as well as Ca-concentration information in an extended Hodgkin–Huxley formulation. Network models can be constructed, then, by assembling several single-neuron models and interconnecting them through synaptic conductances.

Perhaps the most difficult question in such modelling is: how much biological detail is needed to make a model useful ? There are many approaches, from analytical models which assume that a cell merely performs a weighted sum of inputs, to painstakingly detailed models with tens of thousands of compartments for a single neuron. It is an open question as to whether a simplified analytical description of a cell is more informative than a detailed numerical model. Most workers are happy to draw upon results across the spectrum. The introductory chapter, however, contains a somewhat surprising polemic issued from the viewpoint of one of the schools of thought in neuronal modelling, which does justice neither to the diverse viewpoints in the field nor to the otherwise excellent material in the book. The main influence of the editor's strong feelings about the 'right' approach to neuronal modelling is seen in the emphasis on analytical rather than brute-force computational approaches to characterizing different levels of neuronal function.

As the title indicates, successive chapters present models ranging from ion channels, through neuronal substructures and single neurons, to small networks and on to large network simulations. Two early chapters describe statistical approaches to interpreting experimental data at the limit of resolution for ion channels and synapses respectively. Here the application of modelling is to devise descriptions of the system which can then be tested using Monte Carlo methods to find the best fit to the data.

Two particularly interesting chapters address the issue of designing morphologically realistic neurons and networks. Neuronal geometry is a crucial determinant both of electrical properties and of neuronal connectivity. Every neuronal type has certain characteristic branching patterns, which are nevertheless unique from one cell to another. How does one represent the diversity of a subclass of neurons, while retaining the distinguishing features of this subclass ? A return to the biological roots provides a solution to this problem: the neurons are 'grown' according to biologically motivated rules. How does one decide on which connections to make ? It is plausible to think that the spatial separation between dendrites and axons plays a role here, and methods are described to utilize this information efficiently.

Several chapters present exquisitely detailed analyses of passive cable properties of neurons. This is one section where the reader might feel that the simplifying assumptions may render the analysis less useful: few real cells have completely passive dendrites. Such analyses may be more interesting as mathematical exercises than as descriptions of real neurons. Related chapters on active properties of cells also trade calculus for computer time by using analytic expressions to approximate excitable cells, rather than conventional compartmental models. Again, one has to balance analytic convenience against biological realism when 'reducing' cell models; speed should no longer matter. A generic personal computer in 1999 is powerful enough to model a 50-compartment neuron with a full complement of Hodgkin–Huxley-type ion channels in real time, that is, the model will function at the same speed as the real cell would.

Models of specific neuronal systems are well represented in the book. These range from studies of active dendrites to retinal and associative memory networks. Each of these will be useful both as illustrations of a diverse range of modelling techniques, and for workers in the specific system. One would have liked to have seen more examples like the retinal model where the editor's desire to 'bridge the gap between structure and function at the network level' could be realized.

The book as a whole is at a fairly advanced level and will be most useful to workers already familiar with the basics of neuronal modelling. It provides a number of potentially useful techniques for building models of various scales, from dendrites to networks. One may dispute the claim that 'reduced models of single neurons as discussed in this book will in the next few years constitute neural network models of the future'. Nevertheless, many of the results and analytical methods described in the book will be valuable for developing more realistic and predictive models of neuronal function.

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New Trends in Dynamic Games and Applications. G. J. Olsder (ed.) Birkhauser, Boston. 1995.

Game theory is the analysis of conflict. In any conflicting situation there are two or more individuals who take decisions. Different sets of decisions taken by these individuals lead to different results. Each decision maker, called a player, values the result differently, leading to a conflict among the decision makers. The mathematical analysis of the conflict begins with the pioneering work of von Neumann and Morgenstern (1944), and over the years game theory has become a major interdisciplinary subject dealing with economic, social and political conflicting situations, worst case design in various fields such as communication networks, and in modelling war games. It may be noted that the Nobel Prize in Economics in 1994 went to three game theorists: Nash, Harsayani and Selten, to appreciate the increasing relevance of game theory in economics. A significant feature of game theory is that it has led to new branches of mathematical sciences such as statistical decision theory, linear complementarity theory, etc. This field is undergoing tremendous advances in recent years, most notably in the refinements of the concepts of equilibria, dynamical aspects of approach to equilibria, aspects of 'common knowledge' and 'learning' in games, to mention a few.

Dynamic game is a part of game theory where the game evolves over time. Its root can be traced back to mixed strategies in matrix games which incorporate repeated play of the game with a prescribed relative frequency allotted to each pure action. In such a case, however, the game is played with the same payoff matrices, and therefore the game does not really evolve over the stages. In a typical discrete time dynamic game, the game is played over finite or infinite number of stages. Corresponding to each stage there is a payoff matrix for each player together with a 'motion' among this collection of matrices from stage to stage governed by the current matrix game and the actions chosen there. The evolution of the state of the game which describes the motion is usually modelled by difference equations and thus this class of dynamic games is referred to as difference games. Sometimes there are uncertainties which influence the outcome that cannot be completely predicted. These situations lead to the formulation of stochastic (dynamic) games. There are many situations where the game evolves in continuous time, e.g. in economic games or war games. In these situations the evolutions of the game is described by differential equations. These dynamic games are known as differential games. Dynamic games are all pervasive today since multiagent decision making with conflicting interest has become a part of our life in every way.

The book under review is based on selected papers presented at the Sixth International Symposium on Dynamic Games and Applications, held in St Jovite, Quebec, Canada, during 13–15 July 1995. The importance and timeliness of this symposium cannot be overemphasized. It has brought together several scientists spreading across the disciplines of mathematics, economics and engineering under one umbrella. The present book contains 24 papers, 16 in zero-sum games and 8 in nonzero-sum games. I will briefly describe the main themes of these papers.

Zero-sum games. In this category there are 5 papers on minimax control, 8 papers on pursuit evasion games, and 3 papers are devoted to solution methods.

Minimax controls play an important role in worst case design strategies. In the first paper, Bernhard offers a parallel between stochastic and minimax control of distributed nonlinear systems with partial observation by studying an interesting morphism between ordinary algebra and the so-called max-plus algebra. In the next paper, Friedman studies the H^∞ problem for nonlinear singularly perturbed systems and obtains certain solvability conditions in terms of invariant manifolds. Altman and Gaitsgory study a hybrid differential stochastic game. They establish a pair of stationary strategies which asymptotically determine a saddle point. Pan and Basar also study a hybrid stochastic system, but they work in the framework of H^∞ control. The last paper on minimax control is by Fristed, Lapic and Sudderth. They analyse a stochastic game analogous to the 'big match'.

Pursuit evasion problems analyse war games. The first paper in this theme is by Pesch *et al.* They use a novel neural network framework to analyse the well-known cornered rat game. Lipman and Shinar study a pursuit evasion game with a state constraint arising in anti-ballistic point defence as well as in ship defence scenarios against highly manoeuverable attacking missiles. In the next paper, Lachner *et al.* study a similar problem. But they obtain their results by analysing the corresponding Isaacs equation with multipoint boundary values. Le Menec and Bernhard employ artificial intelligence techniques for the solution of aerial combats. Kumkov and Patsko study a pursuit game with incomplete information where the pursuer employs impulse control. Olsder and Pourtallier study a similar pursuit game with costly and asymmetric information. The next paper by Neveu *et al.* compares the results of an analytical treatment versus a realistic simulation of the same game treated in the previous paper. In the last paper on this topic, Chikrii and Prokopovich study a conflict interaction of n pursuers and m evaders in a multidimensional Euclidean space.

In the solution methods section, Bardi *et al.* present a novel approximation scheme for the Isaacs equation based on viscosity solutions. In the next paper, Tidball proposes a discretization scheme