Symbiosis, 18 (1995) 159–160
Balaban, Philadelphia/Rehovot

Book Review

Circuit Complexity and Neural Networks

I. Parberry. 1994, The MIT Press, Foundation of Computing Series.

One of the basic problems with neural networks is that they do not always scale well. The aim of this book is the examination of this issue, namely, how well do neural networks scale in terms of *resources* as the *problem size* increases? The focus of the manuscript is on *computation* rather than the usual emphasis on *learning*, the motivation being that the former is a necessary precursor to the latter: a neural network cannot learn to compute a function unless it is physically capable of computing it. The branch of Computer Science known as *computational complexity theory* is applied to the study of neural networks, with a particular emphasis on *circuit complexity*. Resources of interest include network size, running time and synaptic weight sizes.

The book starts off with an introduction to computational complexity, presenting the classical circuit model which serves as a basis for studies carried out thereon. This model consists of a feed-forward network (circuit) of simple logical gates (AND, OR, NOT) with fan-in 2. In the following chapters, the basic model is enhanced to include threshold logic, gates with larger fan-in, networks with limited depth, cyclic networks and probabilistic networks. The final chapter discusses a few issues pertaining to learning.

The basic questions explored are what kinds of computations can be carried out by various network models and what are the required resources. For example, chapter four considers upper and lower bounds on the synaptic weights necessary to realize all boolean linear threshold functions. This is an important problem which bears directly on technological issues concerning neural network implementations. Other chapters are devoted to discovering exactly which functions can be computed (with certain size and depth bounds) by circuits with gates that compute certain types of linear threshold functions.

0334-5114/95/$05.50

For example, chapter six deals with shallow networks, i.e., networks of small depth, which are usually favored by neural network researchers.

As noted by the author, the intended audience is mixed, including computational complexity specialists as well as non-specialists. Thus, while a background in computer science (especially in computational complexity and circuit complexity) is required in order to fully comprehend all the detailed theorems (approximately 150), an understanding of the major concepts is possible with a more general background in the area of neural networks. It should be noted that the book is not intended as a general introduction of the field.

Overall, the issues of computability and computational complexity, explored by Parberry, are important in the area of neural networks. These issues complement the more traditional lines of research, namely learning and generalization, thus enhancing our understanding of the potentialities and limitations of such networks. The book provides an overview for those who are interested in the major issues and an in-depth exposition for complexity specialists.

Moshe Sipper
Department of Computer Science, Tel Aviv University,
Tel Aviv 69978, Israel. E-mail. moshes@math.tau.ac.il