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Contents

1. Neural Network Theories, Neural Models

2. Biological Perspectives

Preface

Artificial Neural Networks (ANNs) are massively parallel interconnected networks of simple (usually adaptive) elements which are intended to interact with the objects of the real world in the same way as biological nervous systems do.[1]

The interest in these networks is due to the general opinion that they are able to perform some complicated and creative tasks, such as image and speech recognition, similarly to the way they are performed by human brains. The implementations of these tasks by traditional computing methods have only reached relatively low performances in some limited aspects or environments. Nevertheless, as neural systems show some properties, like association, generalization, parallel searching, and adaptation to changes in the environment, which are analogous to human brain properties, they promise improved results.

One of the most relevant properties of ANNs is the possibility of learning. By learning, a neural network can discover some regular patterns and the relations across them, and organize itself for making those associations. This feature has two very important consequences: the ability to solve problems with algorithms which are very difficult to specify (hard-to-write algorithms), and the capacity to extract statistical models and knowledge-based rules from large data sets. ANNs therefore constitute a clear complement to conventional computers for implementing some non-algorithmic tasks and for interfacing with the statistical nature of the environment. Thus, the emulation of biological functions of behaviour (sensory and motor functions) should be emphasized, without forgetting the implementation of the kind of internal processing loosely called thinking.

Another property that ANNs are expected to improve is processing speed, mainly supported by the massively parallel functioning of all the elements in the network. Although in this context the concept of "instruction" used in computer science has no sense, a neural network could be considered as a MIMD (Multiple Instruction stream–Multiple Data stream) system, because multiple processing elements simultaneously operate with the data which, in parallel, feed the network inputs. The goal is to emulate (in a very simple way) the behaviour of the brain, as P. Treleaven[2] has pointed out:

> To stress the complexity of emulating the brain, it could be considered as a massively parallel computer with as many as 10–100 billion processing elements (neurons), and each neuron is connected with up to 10 000 others. Like the artificial neurons, the biological neurons make very simple computations. The brain is able to solve difficult vision or speech problems in approximately half a second. This is a very surprising thing as the time for a neuron, without considering the transitions across neurons, is in the rank of milliseconds. These circumstances imply that such complicated tasks as speech and vision can be carried out in only 100 processing steps, while a conventional computer would need billions of them.

Moreover, in many cases the study of ANNs has led to theories improving our knowledge of biological nervous system functioning.

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[1] Kohonen, T.: An introduction to neural computing. Neural Networks 1, 3–16 (1988)

[2] Treleaven, P.: Neurocomputers. Int. J. Neurocomputing 1, 1–31 (1989)

The different levels under which the approach to ANNs may be made are the following: [3,4]

1) Basic neuron level. The goals at this level are to determine the basic operation of the nervous system from the behaviour of single neurons and their interconnections, and to obtain models of their operation.

2) Network level. This level considers homogeneous sets of neurons or interconnected processing elements, in which the collective properties that realize useful tasks with the input vectors are researched.

3) Neuronal system level. This level operates over the network subsets considered at the network level in order to implement relatively complex functions or to point out some abstract topics in sensory perception, such as automatic classification, motor control, concept creation, etc.

4) Brain operation level. This level deals with the description of operations, procedures, algorithms and policies usually called "human information processing". These models are intended to describe the basic actions related with cognition, thinking, problem-solving, etc.

Thus, it may be shown that the ANN field is multidisciplinary, involving such disciplines as neurobiology, psychology, physics, mathematics, electronics, and computer science and engineering. As an example of this situation, it should be remembered that two of the best known neural network models (Hopfield networks and Boltzmann machines) have emerged from physics.

Despite the large number of actual (commercial) neural network applications, there are some gaps in our knowledge, and it is necessary to improve the study of some topics related with them, such as:

1) The knowledge of biological nervous systems and the elaboration of new models or the improvement of existing ones.

2) Many networks and learning methods have been developed in an empirical way. It is necessary to strengthen the theoretical study of such networks in order to determine the optimal number of layers and processing elements in each layer, to improve convergence and learning speed, to develop procedures for building the learning pattern sequences, etc.

3) Implementations, either the ones made with software simulators or the ones made using (general-purpose or special-purpose) neurocomputers, need to be improved. The importance should be pointed out of making efficient and modular neuro-chips, in order to reach systems closer to the biological models with real-time parallel processing comparable to natural networks.

4) Development of new applications and improvement of the present ones.

There is no doubt that the research collected in this book represents a clear contribution to the development of these goals.

This book includes invited lectures and the full contributions to the **International Workshop on Artificial Neural Networks (IWANN '91)**, held in Granada, Spain, September 17–19, 1991. This workshop has been sponsored by the Spanish Chapter of the IEEE Computer Society, the "Asociación Española de Informática y Automática (AEIA)" (Spanish Association for Computing and Automation) and the Department of Electronics and Computer Technology of the University of Granada, with no restrictions on the participants. I would like to thank the International Program Committee for its labour in the selection of the contributions here presented. The authors of these papers came from 12 countries.

[3] Greenwood, D.: An overview of neural networks. Behavioral Science 36:1, 1–33 (1991)

[4] Kohonen, T.: State of the art in neural computing. Proc. Int. Conf. Neural Networks 1, 79–90 (1987)

The book is organized into six sections, covering:

– Neural network theories, neural models
– Biological perspectives
– Neural network architectures and algorithms
– Software developments and tools
– Hardware implementations
– Applications

We consider that this book represents a clear contribution to the development of neural network topics, and it gives a good idea of the present trends and the research done in this field. It is a suitable text for engineers and scientists working on Artificial Neural Networks.

Grenoble, July 1991 Alberto Prieto

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3. Neural Network Architectures and Algorithms

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5. Hardware Implementations

6. Applications