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This special issue of the journal on Neural Networks contains four papers. These are samples rather than representatives from a growing number of researchers and engineers working on neural networks in Hungary.

Nowadays, thousands of professionals are working on neural networks, world-wide. About two years ago a breakthrough signalled the start of broad practical applications: the Intel 80170 ETANN (Electronically trainable analog neural network was the first programmable, analog, commercially available VLSI chip). This discrete-time analog chip has a speed of the order of GXPS (billion analog operations or crossing per second). It is a fully connected neural network with 64 neurons. Recently, the cellular neural network (CNN) was invented, in Professor Leon O. Chua's Laboratory in Berkeley. It is a locally connected analog processor array. Due to local interconnections the first CNN chip was able to produce about a trillion operations per second, though with fixed templates. The stored program version of the CNN, the so called CNN Universal Machine and supercomputer, provides a new capability: algorithmic programming (like the microprocessor).

In this issue the first paper deals with a very interesting problem: the use of neural networks for nonlinear dynamic system modelling. Improved convergence and modified structures with increased learning speed mark these solutions.

The next paper uses the CNN Universal Machine and give CNN algorithms for depth detection, in particular, a differential random dot stereogram is generated and used. It is shown how to "see" random dot stereograms, discovered by Béla Julesz.

The third paper considers a "classical problem": the capacity of associative memories. The connections among capacity, efficiency and complexity is a key question. The statistical analysis provides interesting a PC, provides workstation speed for CNN simulation and its software support makes possible to develop complex CNN algorithms with different input/output imaging devices.

The fourth paper, based on a short analysis of slowly converging backpropagation-type learning, introduces new transfer function and error measure to improve learning speed.

The fifth paper is an exhaustive, commercial-minded description of the CNN Workstation, a product of the Dual and Neural Computing Systems Lab. of MTA SzTAKI, which provides a development and experimentation environment in the CNN field. Being furnished with numerous external interfaces, simulators and a hardware accelerator board at that, it is the most cost-effective CNN development system for the time being.

I do hope this special issue will not only convey useful information but some readers will start working on neural networks.

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T. ROSKA



Tamás Roska received the Diploma in electrical engineering from the Technical University of Budapest in 1964 and the Ph.D. and D.Sc. degrees in Hungary in 1973 and 1982, respectively. Since 1964 he has held various research positions. During 1964–1970 he was with the Measuring Instrument Research Institute, Budapest, between 1978 and 1982 with the Research Institute for Telecommunication, Budapest

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Visiting Scholar at the Department of Electrical Engineering and Computer Sciences and the Electronics Research Laboratory of the University of California at Berkeley. His main research areas in electronic circuits and systems have been: active circuits, computer aided design, nonlinear circuit and systems, and neural circuits, especially cellular neural networks (CNN). He has published several papers, three textbooks, and held several guest seminars at various universities and research institutions in Europe, USA and Japan. Professor Roska is a member of several Hungarian Scientific Societies, a Fellow of the IEEE. Since 1975 he is member of the Technical Committee on Nonlinear Circuits and Systems of the IEEE Circuits and Systems Society. Between 1987–89 he was the founding Secretary and now he serves as Chairman of the Hungary Section of the IEEE. Recently, he has been Associate Editor of the IEEE Transactions on Circuits and Systems, Guest Co-Editor of a special issue on Cellular Neural Networks of the International Journal of Circuit Theory and Applications and the IEEE Transactions on Circuits and Systems. He is a member of the Editorial Board of the international Journal of Circuit Theory and Applications.

APPLICATION OF NEURAL NETWORKS FOR NONLINEAR DYNAMIC SYSTEM MODELLING

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Recently many neural network structures have been developed for modelling nonlinear dynamic operation. Some of these structures use complex systems which are combined from neural networks and linear dynamic systems [1], [2], others apply such neural networks where the basic processing elements show dynamic behaviour. This paper is dealing with some new possibilities of nonlinear system modelling. Two different approaches are presented: in the first case an inherently static network is modified to show dynamic behaviour, in the second case neural network controlled linear filters are used. The suggested networks are extensions of previously developed neural network based systems. The modifications or extensions improve their properties, increase the learning speed and/or reduce the complexity of the whole systems.

1. INTRODUCTION

One of the important application areas of neural networks is the modelling of nonlinear dynamic systems. In these applications the output to be determined depends not only on the current input but on the previous input and/or output values too.

For solving the problem of dynamic system modelling a complex system of neural network(s) and linear dynamic subsystem(s) seems to be appropriate. In this paper two cases are considered:

- In the first case complex systems are used in which the neural subsystem is directly involved in the input-output mapping. This approach is proposed by Narendra and Parthasarathy [1]. In this case the modelling system is comprising the combination of linear dynamic subsystem(s) and neural network(s). The suggested various combined structures are based on error-backpropagation multilayer networks. It can be used for modelling either linear or nonlinear systems, but the uncontrollable behaviour of the neural network can cause stability and convergence problems especially during the training phase. However, the main drawback of this approach is the extremely slow learning capability of the backpropagation neural nets. This slow trainability is the most serious obstacle of using these networks in real time adaptive applications. In the first part of the paper some modified network structures are suggested based on CMAC. CMAC neural network is a real alternative to backpropagated multilayer networks in nonlinear function approximation. It has advantageous properties like learning without local minima, incremental learning capability and much higher learning speed. Further it has a suitable architecture for hardware realization. The suggested modifications extend the CMAC network and

form from the inherently static network dynamic neural nets.

- In the second case a different architecture is used where the mapping is done by the linear dynamic subsystem only and the neural subsystem is used to adapt (control) the parameters of the linear dynamics (Sztipánovits [2], Sztipánovits and Pataki [3]). In this case the neural network is not involved directly in the input-output signal mapping, instead a basically linear systems is used, where sophisticated analysis and synthesis techniques are available. The role of the neural network is reduced to control the parameters of the linear filter. In the second part of the paper the characteristics of this model are discussed, and some extensions are suggested. The extended networks improve the performance of the neural network based dynamic models especially during the learning phase, and extend the range of applications.

2. THE EXTENSIONS OF THE CMAC NETWORK

CMAC was originally developed by J. Albus in 1975 [4], but until the latest years it had not aroused much interest. Recently many extensions have been proposed e.g. [5], [6], and an increasing number of applications show that in some fields, especially in the area of learning control it can be applied successfully [7]. Here some possible further extensions are presented which form from the inherently static network a dynamic neuron net. While the advantageous properties of the original CMAC network are preserved, the modified networks are more suitable for modelling of nonlinear dynamic systems.

The CMAC network

CMAC (Cerebellar Model Articulation Controller) network can be considered as an associative memory which performs two subsequent mappings. The first one — referred to as memory addressing scheme — projects an input space point into a set of memory addresses. This set of internal addresses can be considered as a binary association vector with active bits at the addressed locations, zeros elsewhere (the terms *association vector* and *memory address set* will both be used). The association vectors always have C active elements, so every point in the input space selects C weights, stored in the addressed memory. The second mapping calculates the output of the network by summing up the selected C weights. In the association vector notation the output is calculated by a linear combiner with binary inputs.