MODA: Moving Object Detecting Architecture

Valerio Cimagalli, *Member, IEEE* Massimiliano Bobbi, and Marco Balsi, *Student Member, IEEE*

***Abstract*—A new type of cellular neural network is described, which may be classified in the broader category of generalized cellular neural networks (GCNN). Its novelty consists both in the task it performs and in its architecture and way of operation. The input to the network is a two-dimensional picture that is processed continuously in order to detect in real time trajectories of moving objects in a noisy environment. MODA is designed by synthesis, so that it does not require learning, and it performs its task by implementing a nonlinear continuous functional in a vector space. The paper describes the network, its architecture, its equations, and the method of design. In addition the new network is compared with known paradigms of ANN and CNN. Results of simulations are also reported.**

I. Introduction

DETECTION of moving objects in a noisy environment is a major problem in electronic engineering. Indeed, it is a crucial one, and it is well known that complete libraries are full of books and papers on this subject. However, it is still an open problem because of the ever more stringent requirements imposed by ever more sophisticated appliances. Therefore, it is logical that also neural-net computing has been used to improve the solution of this problem.

Until now, contributions describing the usage of neural networks for solving problems related to noise and movement have been classified into the three following categories.

1. It is paramount to take into account the shape of the object, because it is the shape that identifies the object. Reference [1] deals with such a problem by using a CNN [2], [3]. A similar problem where ANN's are successfully used is the enhancement of edges in the case that noise and/or motion are present [4], [5].
2. The dimension of the object is very small with respect to the whole picture, so that it may be considered as a point. For example, it is often the case of radar images or of images generated by an array of infrared sensors. In these cases the problem is that noise generates clusters of points that often completely mask the image of the useful point. To try to detect the true trajectory, one has recourse to some techniques from information theory, which require sophisticated operations such as cross-correlation and optimum filtering, in order to see the future of the trajectory from the known part of it. ANN's are then used to perform more efficiently, and at a higher speed computations traditionally performed by means of sequential computers. Significant examples are given in [6]–[10].
3. ANN's are used as classifying devices after a sequential (off line) signal processing operation and some properties of target and/or noise signature are utilized. As most contributions fall into this category, it is hard to classify them and to give an exhaustive list of references. So we will limit ourselves to quote some in different areas [11]–[16].

In this paper we will describe a new neural architecture that differs from the known solutions as follows.

1. it solves the problem outlined above in 2) only by neural computation, without any preprocessing. Therefore it represents a novel and broader use of CNNs that allows to take full advantage of the peculiar properties on ANNs. Hence:
2. computation is done by massively parallel analog circuitry, whose speed allows real time operation, and
3. it is largely insensitive to the signal-to-noise ratio.

The input pattern to MODA is a two-dimensional matrix and its elements may assume any real positive (positiveness is assumed for sake of simplicity, but this hypothesis is inessential) value in a continuous range and are allowed to vary continuously in time. The proposed architecture has three peculiar features: i) the input pattern is processed continuously, i.e., in order to obtain the output, it is not needed that the network evolve from an initial to a final state (its output is a functional of the input); ii) all the information needed for the network to accomplish its task is stored in its architecture and no training is needed; iii) only local connections are present, so it may be considered as a new type of CNN. More exactly we might say that it pertains to the category of generalized CNN's (GCNN's).

The paper is organized as follows.

In Section II we will exactly state the problem we faced. Sections III and IV are the core of the paper. In Section III we will introduce the basic concept of spatio-temporal coincidence and show how a novel architecture can be devised. In such an architecture a neuron corresponds to a path connecting two adjacent elements of the input matrix, that in such a way is "spread" into a larger one. This "spreading" allows us to detect spatial coincidence. Instead, temporal coincidence is detected by a particular processing operated by each neuron. Spatio-temporal coincidence detection is then defined formally.

The analog circuit realizing the wanted dynamical behavior of a neuron is shown in Section IV. Also the rules for designing the parameters of the circuit and finding suitable values of the weights are given. The electrical behavior of a neuron was tested by using SPICE, while the functional behavior of a

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The authors are with the Department of Electronical Engineering, University of Rome "La Sapienza," I-00184 Rome, Italy.

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We cannot conclude without pointing out two questions that still need to be investigated further. The first is the intersection of two quasi-parallel trajectories. The second is the robustness of the net, especially with respect to the possibility that closed loops could accidentally occur. Simulations induce optimism, but a theoretical approach will be necessary.

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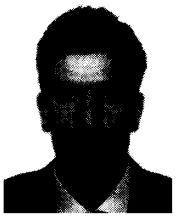
Valerio Cimagalli (A'55–M'59) received the Dott.Ing. degree in electrical engineering from the University of Rome "La Sapienza" in 1954 and the Libera Docenza in electronics from the Italian Ministry of Education in 1961.

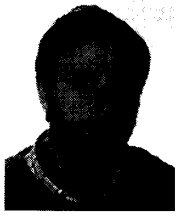
After his graduation in 1954, he joined the Fondazione Ugo Bordoni (a private research foundation working for the Italian Post and Telecommunication Ministry). In the same year, he founded the teaching of circuit theory. Then, in 1963, he joined the University of Rome "La Sapienza," where he holds the position of full professor of electronic circuit theory. His scientific interest has been devoted to circuit theory applied to telecommunication apparatus and nonlinear circuits. In the past, he made some contributions in the field of active synthesis and multivariable circuit theory. For some years he has been working on chaos and neural networks.

In 1973–74 Dr. Cimagalli served as chairman of the Middle & South Italy Section of IEEE. He is also a member and past chairman of the Scientific Council of the Institute for Electronic Circuits of the Italian National Research Council (CNR).



Massimiliano Bobbi received the Dott.Ing. degree in electronic engineering from the University of Rome "La Sapienza," in 1992.

His research interest is in general circuit theory and neural networks applied to telecommunication systems.



Marco Balsi (S'92) received the Dott.Ing. degree in electronic engineering from the University of Rome "La Sapienza," *cum laude*, in 1991.

In the same year he visited for three months the Dual and Neural Computing Systems Laboratory of the Hungarian Academy of Sciences in Budapest. Currently, he is with the Department of Electronical Engineering of the University of Rome "La Sapienza," where he is working towards the Dottorato di Ricerca (Ph.D.) degree. His research interests include cellular neural networks, learning, information storage and processing in neural networks, and chaos.