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From Natural to Artificial Neural Computation

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Preface

Neural Computation is the clearest complement of Artificial Intelligence (AI) and Knowledge Based Systems (KBS) in a shared attempt to make the most genuine dimensions of human behaviour computational. Born of biology and with a history of periodic ups and downs, it is now at a critical moment. From one side there is a massive interest but, at the same time, standard models of neural computation and learning are nearly exhausted from the computational viewpoint and some fresh air is needed.

This year, the 25th anniversary of the death of Warren S. McCulloch, is a good occasion to remember that neural computation was born around 1943 when W.S. McCulloch and Walter Pitts proposed a formal neural model based on the logic we would presently call minimal sequential circuit, consisting of a combinational function followed by a delay and interconnect with and without feedback.

In the 1960s, both positive and negative events took place for neural computation. On the one hand, the theory of Artificial Neural Networks (ANN) was consolidated with introduction of the Perceptron, the Adalines, the biological models of learning by conditioned reflex, and pioneering studies on biophysical modeling, associative memories, self-organization, pattern recognition, and intentional calculus. The most negative events were Minsky and Papert's criticism of "Linearly Unrecognizible Patterns" as well as the strong growth of AI.

It is interesting to remember that in this initial period neural and symbolic computation moved in unison with computational developments that initially emerged under the umbrella of Neurocybernetics and later gave way to AI, which dominated in the 1970s.

We thus arrive at the powerful revival of connectionism in the 1980s. Unfortunately, since this *fiorello*, neural computation has been usually understood only as layered networks of weighted sums followed by a decision function of the threshold or sigmoid type where external programming is partially substituted by learning. This vision of the field presents at least the following problems:

(1) It distances itself in an almost irreversible fashion from the biological reality from which it originated, using computational modules that are clearly insufficient for describing what is presently know about real neurons.

(2) There is a lack of methodology and an excess of empiricism in the synthesis processes.

(3) It present itself as an alternative which is not integrable with the symbolic perspective of Artificial Intelligence.

The purpose of the third International Workshop on Artificial Neural Networks (IWANN'95) is to partially contribute to posing and resolving these problems. In order to do this, the workshop focuses on biological modeling, the search for theory and design methodologies, and the establishment of a symbolic-connectionist bridge that can make possible the integration of AI and ANNs, taking the best of both paradigms.

The papers presented correspond to the talks delivered at IWANN'95, organized by the University of Málaga and the Spanish Open University at Madrid (UNED) and held in Torremolinos (Malaga), Spain, 7 - 9 of June, 1995. More than 200 papers were submitted and carefully evaluated by the program committee. After averaging the reviewers' score, 143 papers were accepted for oral presentation and are included in these proceedings. Extended papers originating from invited talks related to some of the topics considered are also included as introductions to the corresponding sections.

This workshop has been organized in collaboration with the Spanish RIG IEEE Neural Network Council, the UK&RI Communication Chapter of IEEE, the Spanish Computer Society Chapter of IEEE, and the AEIA (Spanish Association for Computing and Automation).

Sponsorship has been obtained from DG-XII Human Capital and Mobility (EC), Spanish CICYT and DGICYT (MEC), Junta de Andalucía and the organizing Universities (Málaga and UNED).

We would like to thank all the authors as well as all the members of the international program committee for their labor in the production, evaluation, and refinement of the papers. Furthermore, the editors would like to thank Springer-Verlag, in particular Alfred Hofmann, for excellent cooperation.

The papers published in this volume present the current state in neural computation and are organized in nine sections:

- Neuroscience
- Computational models of neurons and neural nets
- Organization principles
- Learning
- Cognitive science and AI
- Neurosimulators
- Implementation
- Neural networks for perception
- Neural networks for communication and control

Turning our eyes once again to neuroscience, we begin with papers related with computational models of cortical neurons, dendro-dendritic processes, synaptic modulation, and self-organization of receptive fields, among others. Neuroscience is an inexhaustible source of inspiration about new styles of computation.

The second topic is related with the formal tools we use to model neurons and neural nets (analogic, logic, or inferential). You will find papers on high-order Boltzmann machines, propositional logic, inferential rules at the synaptic level, stochastic and collective models, and some contributions to learning by reinforcement and pruning.

The study of organizational principles in biology will increase our understanding of living beings and artificial systems. This includes dynamic formulations, autopoiesis, self-organization, cooperative processes and emergent computation, and synergetic, evolutive optimization, and genetic algorithms. Contributions on this topic have not been so numerous as we would have liked. Nevertheless, several papers on cooperation, competition and self-organization, and genetic algorithms are included.

The structural characteristics necessary for the control by learning of the functioning mode of an ANN are decisive for the advance of neural computation as a consolidated engineering field. Inspiration from biological mechanisms of learning and proposals for new "brain-like" algorithms are more than welcome. You will find a good number of papers in this section. Nevertheless, the panorama is not so diverse and innovative as could be desired. Incremental learning, sensitivity analysis, initialization problems, priming, attentional scanning, fuzzy clustering, and schema-based learning, among others, are some of the topics addressed.

Thus far we have examined neuroscience, models, organization, and learning. The next topic is cognitive science and AI. Here we look at hybrid formulations with papers on modeling linguistic problems, extracting rules from ANNs, and dynamic symbol grounding, among others.

Neurosimulators include languages, environments for simulation, development, and prototype evaluation, and the facilities to connect with the implementation stage. Papers on object oriented simulators, hybrid development environments, and biological and applications oriented tools, as well as neural simulation languages, are included in this section.

As is usually recognized, the implementation of neural networks depends directly on which neural model and learning algorithm we seek to implement. The second part is how to do it. For the first part, it is our deepest feeling that the anatomic and physiological bases of natural neurons offer more inspiration than we have been able to formalize until now. For the second part, VLSI technology, FPGAs, parallel architectures, neurodevices, and optical solutions, to name but a few, give us enough alternatives for implementation, once we have clear and complete functional specifications of what we want to implement. Papers in this section make reference to hardware accelerators, Bayesian networks, associative processors, implementation models, analog cellular networks, coprocessor cards, optimal mapping onto FPGAs, and many other related topics.

The last two sections of the proceedings are related to applications in perception, communication, and control. Perception includes low-level processing segmentation, feature extraction, adaptive filtering, textures, motion analysis, and hybrid symbolic-connectionist architectures for artificial vision. Papers are included on image segmentation, pattern recognition, texture classification, and speech processing. Some papers related to active vision and visual feedback in the control of robots as well as parameters estimation and forecasting have also been included in this section.

The applications of ANNs to control and communication systems cover the topics of systems identification, motion planning and control, adaptive, predictive, and model based control, navigation, real-time applications, modems and codecs, network management, and digital communications. In these proceedings we have papers on identification, movement optimization, visuomotor control of mobile robots, forecasting using Kohonen maps, real-time adaptive control, and digital transmission.

Some of the original objectives for IWANN'95 we feel have been fulfilled, with the result that this volume offers a serious, broad, and comprehensive selection of papers ranging from neuroscience to engineering applications.

Other biological and computational problems in the field of ANNs still remain open. Let us mention again the insufficient complexity of our models of biological neurons and the lack of methodology in analysis and design. In the W.S. McCulloch memorial we would like to be provocative in search of the computational "embodiment" of natural computation from which intelligent behaviour emerges.

Madrid, April 1995

J. Mira
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