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Guest editorial

Artificial neural networks

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During the last decade, a great attention has been given to nonalgorithmic analyses and data processing carried out with soft-computing techniques like expert systems, neural networks, fuzzy logic, and genetic algorithms. These computational paradigms efficiently search the solution space with techniques similar to the way the natural human reasoning works: a sub-optimal solution is, in fact, obtained by means of typical human methods such as similarity, analogy, interpolation, generalization, extrapolation, and multiple-goal optimization. Such approaches become attractive whenever the complexity of the algorithm associated with the solution is too high, or difficultly specifiable or unknown.

Artificial Neural Networks (ANNs) are nonlinear massively parallel computational paradigms inspired by the brain. The computation is collectively performed by a set of interacting processing elements or neurons, which exchange data through a neural interconnection network. Different from traditional computers which implement a pro-

grammed solution for an application, the expected behavior of a neural network is directly learnt through examples and hints.

The training process, necessary to configure the parameters specifying the neural computation, is generally a nontrivial phase. It is necessary to choose the functionality for the neurons, select and dimension the neural network topology, generate the training examples, identify an appropriate learning procedure, and evaluate the neural network final performance. Up to now, there is no general methodology to guide the designer choices towards the determination of an optimal neural network for the given application; the literature mainly provides many examples of successful applications but only few general guidelines, most of the times tailored to specific classes of applications. The experience and the expertise of the designer are therefore fundamental skills to identify an effective and efficient solution.

ANNs have been proved effective in solving many applications, e.g., in signal and image processing, pattern recognition, vision, speech recognition, automotive, robotics, system identification, prediction, and control. Engineering fields that explored and exploited ANNs encompass

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electrical, electronics, telecommunication, aerospace, automation, mechanical, chemical, biomedical, geological, and hydraulic engineering, even if results have been exported also to many other scientific areas and have been used in many real applications. However, despite these positive results, ANNs must not be considered able to solve any kind of problems for which traditional approaches are ineffective.

Advances in integration technologies make, nowadays, feasible the realization of components and systems based on the neural technologies, implemented either in dedicated analog/digital hardware or in software on general-purpose digital architectures. As a consequence, the exploitation of neural technologies will be attractive in the near future for a wide range of applications in the real daily life, in particular whenever the neural components are small and competitive enough with respect either to the traditional algorithmic approaches or, in some cases, to other soft-computing technologies like fuzzy logic.

Some recent results related to the theory, the applications, and the implementation technologies of ANNs have been presented and discussed at the 1996 IEEE International Workshop on Neural Networks for Identification, Control, Robotics, and Signal/Image Processing held in Venice, Italy, during 21–23 August 1996.

Selected papers have been chosen for this special issue to expand preliminary results presented there by the authors. The focus of this issue is on the engineering applications of ANNs, with specific reference to system identification, control, and signal processing.

In *Neural Network Simulation of a Dielectric Ring Resonator Antenna*, the problem of the electromagnetic field modeling is treated as an example of nonlinear system identification. The paper shows that the neural model may be sometimes more computationally compact than traditional algorithmic approaches. This property is useful

for real-time applications, for system monitoring, and for “what if” prediction in machinery, industrial plants, and embedded systems.

Direct Control with Radial Basis Function Networks: Stability Analysis and Applications presents some results in direct control of dynamic nonlinear systems. First, the system is identified by using an RBF neural network and then the neural model is used to derive a neural controller having high accuracy and adaptability as well as generalization ability and noise insensitivity. The stability of the neural control is also treated to certify the equivalence of neural control with more traditional approaches.

The problem of predictive control is discussed in detail in *A Comparison of Nonlinear Predictive Control Techniques Using Neural Network Models*. The goal is to compare and verify the capabilities of some neural paradigms in capturing and linearizing the process behavior. The use of affine neural networks is proved effective with complex nonlinearities and, in particular, to provide an effective technique for model linearization.

The pattern classification problem is one of the widely studied in the literature, due to the ability of the neural networks to generalize the classification of the learnt patterns even in the presence of noisy data. An interesting application case is proposed by *Neural Network Approach to Early Breast Cancer Detection*. The paper shows the usefulness of neural techniques in a nontraditional field. The vital and biological parameters characterizing health and the presence of cancer are translated into a pattern classification problem and solved by using the neural techniques.

Finally, the basic problems in configuring all kinds of neural network – and, in particular, the ones mentioned above – are related to the correct and complete definition of the learning procedure. Selection of the suitable training examples is fundamental and instrumental to achieve a good and effective neural paradigm. *Windowed Active*

Sampling for Reliable Neural Learning shows an interactive approach between examples creation and learning procedure to identify the input stimuli able to significantly explore the system behavior.

The industrial exploitation of results achieved in the neural network research is often straightforward, as the papers included in this special issue clearly point out. Great benefits will be obtained by increasing the ability to deal with the nonlinear and noise affected world and, to this end, neural networks are challenging tools. However, it should be pointed out that whenever an algorithmic approach is more efficient than the neural solution, it should be obviously adopted.

The future trend of soft-computing technologies is directed to integrate soft-computing with more traditional algorithmic solutions into hybrid computing systems. The winning factor for an effective and efficient industrial exploitation will in fact be the synergetic use of the most suited computing technology for each specific sub-problem and their subsequent integration in a cooperative system.

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