

Chapter 1

A Soft Computing Overview: Artificial Neural Networks and Evolutionary Computation

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ABSTRACT

Nature has proved to be the best testing system, where we can analyze the effectiveness of any method of solving problems. It provides one of the most complex problems to be resolved: the survival. Analyzing how the species behave to achieve that survival, soft computing methods try to mimic this behavior to provide meaningful solutions to diverse problems. This chapter offers an introduction the fundamentals that the different soft computing techniques translate from Nature. It includes an approach of the brain behavior (Artificial Neural Networks) or the evolution ideas taken from Darwin' laws (Evolutionary Computation algorithms).

INTRODUCTION

As time passes by, the complexity of the issues that different scientific fields tackle has been growing constantly. Along with this growth, there are the time and effort required to solve these issues by means of conventional techniques, either because at first the way to find a solution is not known, or because, even if it is known, the level of complexity of its implementation is also fairly high.

However, a solution to these issues can be found by observing our environment thoroughly. Perhaps

the greatest challenge that any system may raise is the survival of organisms and species that inhabit it.;and Nature has provided a huge variety of valid solutions to this challenge ever since the beginning of time (Freeman, S & Herron, J, 2002).

And how does Nature provide these solutions? The answer to this question can be found in Darwin's theory of the evolution of species (Darwin, C., 1859): natural selection and survival of the fittest individuals.

Regarding the solutions provided by Nature to the challenge of survival, the human race itself plays a major role because of its predominant position.

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Due to what, exactly? Although the answer to this question can imply numerous nuances, perhaps one of the most widely accepted is the assumption that it is mostly because of human cognitive activity, that is, their highest intellectual capacity.

Both issues, the use of the intellectual capacity and the survival of the the fittest individuals, may be outlined so to conform the foundations of two methods, Artificial Neural Networks (ANNs) (Haykin, S., 1998), and Evolutionary Computation (EC), which, together or separately, provide excellent results in various types of problems.

The present chapter is aimed at giving an overview of each of these methods.

ARTIFICIAL NEURAL NETWORKS

As mentioned above, perhaps the supremacy of human over all the other living creatures is due to his high intellectual capacity and the basis of this capacity lies in the brain. However, reproducing the overall performance of the brain in order to achieve a problem solving system is not feasible at all.

The brain provides action responses to the whole range of stimuli received from the outside world: images, sounds, tastes, smells, temperatures, etc. To this end, it simply uses its collection of neurons (about 10^{11}) and its many synaptic connections between them (from about 1,000 to 10,000 synaptic connections can be found in one neuron). These scales are impossible to reach in a simulation system, but there is a possibility of building more simple models based on each of the major components of the above-mentioned performance: the neurons and interconnection architectures between them.

Both elements make up the basic structure of an ANN. Therefore, an ANN may be considered an attempt to produce learning systems inspired by nature (based on abstract models of how we think and how the brain works).

Biological Basis

Although the outline of the full performance of neurons is still to be discovered, we have quite a good understanding of the whole process.

Broadly speaking, a neuron receives through its extension branches, called dendrites, a series of impulses from its neighbouring neurons. Depending on the overall final intensity of the stimuli, there may be an excitatory or inhibitory effect on the neuron. In the first case, the neuron will cause an output signal which is transmitted through its axon to the dendrites of the neighbouring neurons. Information is stored by means of this exchange of impulses and in the capacity of neurons to be activated or inhibited by a certain set of inputs. Obviously this process occurs at the same time in millions of neurons, so the most fundamental characteristics of the brain: high redundancy, fault tolerance partial adaptability, and so on, are a consequence of this decentralized behaviour.

General Operation

Processing Element

Translation (and simplification) of the performance of a neuron to the field of ANN gives rise to the concept of processing element (PE) (see Figure 1).

Exactly like neurons, a PE is also associated to a number of inputs. The relative importance of each of these inputs is determined according to an adjustment factor called *weight*. Thus, a weight W_{ij} will indicate the relative importance of the input j of the PE i . The total input also called net or activation value – of the PE is determined by applying the adjustment factors to each input and by adding the different terms.

Moreover, each neuron is associated to a number called bias or threshold (θ_i), which can be taken into account as a number indicating from what postsynaptic potential value the neuron produces a significant output.

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