Editorial Preface

From Nature to Computing and Back

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INTRODUCTION

Computers are man-made machines designed to manipulate data following a specific set of instructions, normally called programs or algorithms. They appeared due to the need to store and process data in large amounts and in a small period of time. Current computers are based on integrated circuits, performing processing and storage in different places. They can be dedicated or general purpose and, as such, are now ubiquitous in human life.

Nature is a word derived from the Latin *natura*, meaning 'essential quality, innate ability'. It refers to all kinds of vegetables, minerals and animals in the World, being also used to describe the natural environment, e.g., insect societies, forests, clouds, rivers, groups of animals, among many others. From the origin of the Universe to the diversity of species, nature includes everything that emerged and emerges over the physical world, be it material, animate or inanimate, without the need of human interference.

How these two apparently dichotomous terms, nature and computing, come together? There are actually a number of forms nature and computing can be linked together. Nature is full of phenomena, 'things' and processes that can be used as metaphors for the design of effective problem solving techniques. As simple examples, ant colonies are capable of finding the shortest path between the nest and a food source; brains can process information for decision making; immune systems can protect organisms against the attack of invaders; chemical reactions can be used for optimizing processes; and so forth. In the opposite direction, computers can be used to simulate and emulate natural phenomena. For instance, how can we realistically synthesize the shape of a cloud, a mountain, a lighting bolt and a coast? How do we synthesize the behavior of groups of animals, on land, in the air, and under the water? All these phenomena, forms and behaviors, can be synthesized using particular computing techniques, which, altogether, compose an important branch of natural computing. Last, but not least, computers are currently made of silicon, a natural material. What if silicon becomes scarce or obsolete? What if the usefulness of silicon as a computing material reaches its limit? What other natural materials could be used for computing, to complement or even supplement silicon? Nature abounds with resources that could be used as alternative materials for computing, such as molecules and electrons, and the investigation of these gives birth to another important natural computing branch.

Altogether, these three types of links between nature and computing form the so called Natural Computing field of research: 1)

nature-inspired computing; 2) the synthesis of nature by means of computing; and 3) computing with novel materials from nature. Many techniques have been used and proposed for all three subfields, and the main ones are (de Castro, 2007):

1. Nature-inspired computing: artificial neural networks, evolutionary algorithms, swarm intelligence, artificial immune systems, artificial chemistry, and growth and developmental algorithms.
2. Synthesis of nature by means of computing: artificial life, and fractal geometry.
3. Novel computing materials: molecular computation, and quantum computation.

The Motivation to Start This New Journal

The terminology Natural Computing, also known as Natural Computation, became known in science with the publication of the book titled "Natural Computation" by R. Whitman in 1988 (Whitman, 1988). This is an extensive edited book of readings combining computer science, mathematics, robotics, artificial intelligence and other disciplines, which was designed to support a specific MIT course. After this, another book titled "An Introduction to Natural Computation" was written by D. Ballard in 1997 (Ballard, 1997) and also published by the MIT Press. Differently from the previous one, Ballard's book emphasized neural computation almost in its entirety.

Despite these two initial efforts to consolidate the terminology, it only became more widely spread among researchers with the launch of the Natural Computing journal, by Springer, in the year 2002 (Springer, 2002). According to the journal's definition, "Natural Computing refers to computational processes observed in nature, and human-designed computing inspired by nature". Although this definition covers most of the natural computing areas, the one adopted here allows for a broader and better discrimination of the many natural computing areas, providing a clear distinction among them in terms of scope, motivation and design patterns, as introduced by L. de Castro in his book "Fundamentals of Natural Computing: Basic Concepts, Algorithms, and Applications" (de Castro, 2006), and then summarized in an extensive review paper published in the Physics of Life Reviews journal (de Castro, 2007).

Therefore Natural Computing is, above all, an umbrella terminology, used to characterize and identify specific computing techniques that, somehow, bring together nature and computing. Alike Artificial Intelligence, Natural Computing nowadays names a specific discipline taught at many undergraduate and graduate courses over the World, in all continents. Furthermore, if one considers its oldest subfield, artificial neural networks, dated back from 1943 with the work of W. McCulloch and W. Pitts (McCulloch & Pitts, 1943), it is surprising that a single journal exists to date to encompass, in its broadest sense, all that has been made in the field so far.

These facts, altogether, not only justify but also motivate the start of this new journal, the International Journal of Natural Computing Research (IJNCR). It was designed with the mission of serving as a world-leading forum for the publication of scientific and technological papers involving all main areas of natural computing. IJNCR publishes original material, theoretical and experimental applications, and review papers on the process of extracting ideas from nature to develop computational systems or materials to perform computation. Topics to be discussed in this journal include, but are not limited to, artificial chemistry, artificial immune systems, artificial life, artificial neural networks, cellular automata, fractal geometry, genetic and evolutionary algorithms, growth and developmental algorithms, molecular computing, quantum computing, swarm intelligence, cellular computing and synthetic biology. Further and updated information can be found at the journal website: www.igi-global.com/ijncr.

Inaugural Issue Contributions: An Overview

This inaugural issue was idealized to have at least one contribution from each of the three

main natural computing branches. All contributions were invited and prepared by World leading researchers in their areas of expertise. This issue starts by briefly presenting the two contributions from nature-inspired computing, followed by one contribution on the synthesis of nature by means of computing, and then concludes by presenting one contribution on computing with alternative natural materials.

The work by de França et al. (2010), titled *Conceptual and Practical Aspects of the aiNet Family of Algorithms*, provides an extensive review of one of the most well-known classes of artificial immune systems, named immune networks (de França et al., 2010). They present a historical perspective of the many developments of the Artificial Immune Network model named aiNet introduced in 2000 (de Castro & Von Zuben, 2000). The review includes not only the theoretical aspects of the algorithms, but also their many practical applications areas.

In the second contribution to this inaugural issue, titled *Cognitively Inspired Neural Network for Recognition of Situations*, the authors present the so-called Neural Modeling Fields (NMF) and Dynamic Logic (DL), NMF-DL, as a mathematical description of a cognitive process, a generic framework for learning from data (Ilin & Perlovsky, 2010). Their application is on learning and recognition of situations composed of objects. In their proposal, the mind is seen as a layered system with models on each layer sending signals to the above layers.

In the paper authored by A. Gibbons and M. Amos, titled *Wave Propagation in Filamental Cellular Automata*, the authors provide an investigation into a particular type of cellular automata, called filamental cellular automata (Gibbons & Amos, 2010). The automaton has as inputs states of neighbors, which in turn, may determine the next state of the automaton. The investigation emphasizes the types of self-stabilizing cooperative behaviors that can emerge with regards to waves of cellular state changes along a filament of cells.

In the fourth contribution of this inaugural issue, M. Hirvensalo discourses about *Quantum Automata with Open Time Evolution* (Hirvensalo, 2010). It is introduced a finite automaton model consistent with open time quantum evolution and shown that this proposal is a more general case than the other previous ones. Classical closure properties with relation to intersection, union, complement, and inverse morphism are translated into quantum automata with open time evolution.

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