Preface

1. INSPIRING, SYNTHESIZING, COMPUTING … AND MODELING

The main textbook of Natural Computing defines it as "the terminology introduced to encompass … three types of approaches, named, respectively: 1) *computing inspired by nature*; 2) *the [synthesis[1]] of natural phenomena in computers*; and 3) *computing with natural materials*" (de Castro, 2006, p. 1). This very definition requires us to understand better what differentiates one branch from another. Thus, let us first understand the meaning of "inspiring," "synthesizing," and "computing."

The word inspiration means "stimulation or arousal of the mind, feelings, et cetera, to special or unusual activity or creativity" (Collins, 2012). Within Natural Computing, it means to use ideas, such as processes, cellular interactions, patterns, shapes, and other features from a natural system with the goal of designing a computational system to process information. In such cases, it is not necessary to be faithful to the natural phenomena for the *bioinspiration* to be valid. What is pursued here is an effective way of solving a given problem. Examples include neural networks, swarm intelligence, evolutionary computing, and artificial immune systems.

Synthesis, by contrast, means "the combining of the constituent elements of separate material or abstract entities into a single or unified entity" (Dictionary, 2012). Within the Natural Computing context, the synthesis of natural phenomena by means of computing is related to the use of computing to simulate or emulate Nature. Examples of synthetic approaches within the field include fractal geometry, artificial life, and synthetic biology.

Computing is a term with broad interpretation. Simply stated, it is "the activity of using computers and writing programs for them" (Collins, 2012). From a Natural Computing perspective, computing with natural materials means the design of novel computing machines, for instance the use of molecules, photons, and spin glasses to perform computation. This subarea complements the others in the sense that it seeks for alternative or complementary means of computing in a very low level. And this may and will impact computing in the long term.

This perspective of Natural Computing, which has now been advocated for half a decade, though interesting and useful, limits the field and excludes an important subarea of research that, so far, has not been assumed part of the field. This corresponds to the *modeling of natural phenomena*. But what modeling brings to this discussion and, consequently, to the field? Modeling can be defined as "the representation, often mathematical, of a process, concept, or operation of a system, often implemented by a computer program" (Collins, 2012). In this book's context, modeling serves many purposes: provide a deeper and more quantitative description of a system and its corresponding experimental results; models can aid in the critical analysis of hypotheses and understanding of the underlying mechanisms; they can assist in the prediction of behaviors, design of experiments, and can be used to simulate and stimulate new and more satisfactory approaches to natural systems; and models may allow the recovery

of information from experimental results (de Castro, 2006). All these possibilities with modeling open a whole universe of contributions to Natural Computing and, thus, have recently been considered a new part of the field (de Castro et al., 2011).

2. NATURAL COMPUTING: FROM DISCIPLINE TO SCIENCE

In the last issue of the *International Journal of Natural Computing Research*, the authors argued that Natural Computing is in a sort of turning point at the moment (de Castro et al., 2011). The field has matured substantially over the past decade and achieved the status of discipline, with courses, conferences, schools, and meetings available all over the world, in academia and industry. It is now time to discuss the future, the grand challenges, of the field.

A concise, but relevant, definition of what is Natural Computing is provided: "Natural Computing is a science concerned with the investigation and design of the information processing in natural and computational systems" (de Castro et al., 2011). There are some keywords to this definition, and two of them are "science" and "information processing."

Science can be defined as a "systematic knowledge of the physical or material world gained through observation and experimentation" (Collins, 2012) or "any body of knowledge organized in a systematic manner" (Dictionary, 2012). Such definitions of science certainly do apply to the Natural Computing proposal as a New Science, the one focused on the investigation and design of information processing systems in general, including the Nature's ones.

Information processing essentially describes everything that changes or happens in the universe, from rainfall to the printing of text (Wikipedia.com, n.d.). Therefore, Natural Computing and information processing become almost synonymous in terms of achievement, bioinspiration, synthesis of Nature, computing with natural materials, and the modeling of Nature all are a type of information processing. The backward analysis is also valid; information processing is the core of Natural Computing.

From this definition, the authors proposed three grand challenges for the Natural Computing research:

1. Transforming Natural Computing into a transdisciplinary discipline;
2. Unveiling and harnessing information processing in natural systems; and
3. Engineering natural computing systems.

The transdisciplinary version of Natural Computing is the one that unites knowledge from several fields, including Biology, Physics, Chemistry, and Computing, into a single language, understanding computing in natural phenomena and using it for various applications. Unveiling and harnessing information processing in natural systems may lead to a rethinking, and probably redesign, of computing, and provide a new form of interacting with and using Nature. Finally, the last Grand Challenge addresses the problem of how to appropriately engineer Natural Computing systems.

3. THE INTERNATIONAL JOURNAL OF NATURAL COMPUTING RESEARCH

The *International Journal of Natural Computing Research* (IJNCR) provides a forum for researchers to disseminate knowledge on natural computing and to serve as a reference source for state-of-the-art innovative findings. It provides a comprehensive view of all aspects of natural computing with emphasis

on its main branches. Its mission is to serve as a world-leading forum for the publication of scientific and technological papers involving all main areas of natural computing, namely, nature-inspired computing, methods to computationally synthesize natural phenomena, and novel computing paradigms based on natural materials. The journal 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.

The very first issue published contributions on neural networks, artificial immune systems, cellular automata, and quantum computing. Volume 1, Issue 2 was more focused on search and optimization (discrete, continuous, and multi-objective) algorithms inspired by nature, including evolutionary algorithms, differential evolution, memetic algorithms, and artificial bee colonies. Volume 1, Issue 3 was dedicated to cellular automata, from theoretical works to applied research. The last issue of Volume 1 was based on computer vision; its contents included segmentation and pattern recognition.

It is with great pride and pleasure that I deliver this Preface introducing the first book that will bring in a single volume all contributions to the *International Journal of Natural Computing Research*. I am certain that we are living in the border of a turning in the field, with a more holistic and critical perspective being designed.

Leandro Nunes de Castro
Mackenzie University, Brazil

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ENDNOTE

[1] The original definition uses "2) *the simulation and emulation of natural phenomena in computers*," but we chose to replace simulation and emulation by the word "synthesis" as used by the author himself in a later review paper (de Castro, 2007).