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Tel: 717/533-8845; Fax 717/533-8661; URL-http://www.idea-group.com

Chapter I

From Biologically Inspired Computing to Natural Computing

Leandro Nunes de Castro, Catholic University of Santos, Brazil

Fernando J. Von Zuben, State University of Campinas, Brazil

ABSTRACT

Biologically inspired computing is just one of the branches of natural computing, which also encompasses artificial life, fractal geometry and computing with natural means (molecular, membrane and quantum computing). This chapter provides a brief and general overview of natural computing, focusing on bio-inspired algorithms. Some relevant literature is cited for guidance purposes and the main objective and scope of the book is described.

INTRODUCTION

During the early days of humanity we used natural resources to provide shelter and food. We soon learned to modify and manage some natural processes so as to breed crops and animals, build artifacts, control power supply, and so forth. We then started to observe and study biological and physical phenomena and patterns in order to better understand and explain nature's functioning. For instance, by learning about the physical laws of motion and gravity it became possible to design aircrafts, and by understanding some basic principles of life it is now possible to manage life in various levels, from creating transgenic food to combating diseases.

With the advent of computers, the way human beings interact with nature changed drastically. We now use nature as a source of inspiration or metaphor for the development of new techniques for solving complex computational and engineering problems; we use computers to simulate and emulate biological organisms; and we have finally begun to search for new materials and means with which to compute. *Natural computing* is the terminology introduced to encompass these three types of approaches (de Castro, 2004), named, respectively: (1) *biologically-inspired computing;* (2) *artificial life and fractal geometry of nature;* and (3) *computing with natural means.*

This book goes beyond the scope of biologically inspired computing, having one of its five parts fully dedicated to artificial life, the second main branch of natural computing. In addition, some chapters discourse about computing with natural means; that is, the use of biological or physical media to store and process information. It thus covers all major branches of natural computing, with a particular emphasis on biologically inspired computing. The following sections provide a brief introduction to these three branches and their main actors. No particular topic is discussed here in detail because each of the other contributed chapters contains the necessary fundamentals for a good understanding of the concepts and developments proposed.

BIOLOGICALLY INSPIRED COMPUTING

Among all natural computing approaches, bio-inspired systems are the oldest and maybe the most popular ones. They arose with two main ideas in mind. First, researchers were interested in modeling natural systems and processes and simulating them in computers. The common goal in this direction is to devise theoretical models, which can be implemented in computers, faithful enough to the biological mechanisms so as to reproduce quantitatively or qualitatively some of their functioning. Theoretical models are supposed to provide a deeper insight and better understanding of the biological phenomena being modeled, to aid in the critical analysis and design of experiments, and to facilitate the recovery of results from laboratory or empirical experimentation. The second idea involves the study of biological phenomena, processes and even theoretical models for the development of computational systems and algorithms capable of solving complex problems. The motivation, in this case, is to provide (alternative) solution techniques, sometimes denoted as heuristics or meta-heuristics (Kochenberger & Glover, 2003), to problems that could not be (satisfactorily) resolved by other more traditional techniques, such as linear, nonlinear, and dynamic programming. In such cases, the computational techniques developed can also be termed *bio-inspired computing* (Mange & Tomassini, 1998), *computing with biological metaphors* (Paton, 1994; Paton et al., 2003) or *biologically motivated computing.*

As biologically inspired computing (BIC) is basically aimed at solving problems, most approaches are not concerned with the creation of accurate models. In many situations, highly abstract models, sometimes called metaphors, are proposed mimicking particular features and mechanisms from biology. What usually happens is that a biological phenomenon or model gives rise to one particular tool and this is then algorithmically or mathematically improved to the extent that, in the end, it bears a very slight relationship with the biological phenomenon that originally motivated the approach.