Chapter 5
Biogeographic Computation as Information Processing in Ecosystems

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ABSTRACT

Assuming nature can be investigated and understood as an information processing system, this chapter aims to explore this hypothesis in the field of ecosystems. Therefore, based on the concepts of biogeography, it further investigates a computational approach called biogeographic computation to the study of ecosystems. The original proposal in the literature is built from fundamental concepts of ecosystems and from a framework called a metamodel that allows the understanding of how information processing occurs. This chapter reproduces part of the content of the original proposal and extends and better formalizes the metamodel, including novel experimental results, particularly exploring the role of information and causality in ecosystems, both being considered essential aspects of ecosystems' evolution.

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INTRODUCTION

The Natural Computing of Biogeography

By the 1940s Computer Science was engaged in the study of automatic computing. The necessary formalism for computability followed the initial achievements, with emphasis on information processing, Turing machines and computational complexity. Information processing has gained still more evidence in Computer Science lately, considering both natural and artificial processes (Denning P., 2008).

Indeed, information processes have been perceived in the essence of various phenomena in several fields of science. In the book *The Invisible Future* (Denning P. J., The Invisible Future: The Seamless Integration of Thecnology in Everyday Life, 2001), David Baltimore says "Biology is nowadays an information science". However, if computing is concerned with the study of information processing, in what sense nature processes information? A consistent definition is given by Seth Lloyd (Lloyd S., 2002): "all physical system registers information and, by evolving in time, operating in its context, changes information, transforms information or, if you prefer, processes information". Information here is interpreted as a measure of order, organization, a universal measure applicable to any structure, any system (Lloyd, 2006). Understanding nature as an information processing system is the fundamental basis of Natural Computing (de Castro, 2007). Several researchers, in many fields of science, have already studied nature in such context:

- *Immune systems* (Cohen, Real and artificial immune systems: computing the state of the body, Nature Reviews: Immunology, 2009; de Castro & Timmis, Artificial Immune Systems: A New Computational Intelligence Approach, 2002; Hart & Bersini, 2007);
- *Ecosystems* (de Aguiar, Barange, Baptestin, Kaufman, & Bar-Yam, 2009; Pasti, de Castro, & Von Zuben, 2011);
- *Bees* (Lihoreau, Chittka, & Raine, 2010; Maia & de Castro, 2012);
- *Ants* (Dorigo & Maniezzo, 1996; Pratt, Mallon, & Sumpter, 2002; Vittori, Talbot, & Gautrais, 2006);
- *Genes* (Holland, 2000; Kaufman & Ochumba, 1993);
- *Bacteria* (Mehta, Goyal, & Long, 2009; Xavier, Omar, & de Castro, 2011);
- *Basic laws of nature* (Dowek, 2012);
- *All universe* (Lloyd, 2006);
- Among many others, including (Brent & Bruck, 2006; Denning P. J., 2007; de Castro, 2007; Schwenk & Padilla, 2009).