Short Communication

Computational Ecology: an emerging ecological science

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Received 21 February 2011; *Accepted 29 March 2011*; *Published online 1 April 2011*
IAEES

Abstract
Computational ecology is an emerging science to integrate and synthesize computation intensive areas in ecology. It was clearly defined and described in an earlier study. Aims and scope of computational ecology are further refined in present discussion.

Keywords computational ecology; science; discipline; aims and scope.

1 Introduction

Ecology is a science to study the relationship between organisms and their environments. This concept was first put forward by Haeckel as early as 1866. Through more than one hundred years' development, ecology has become a major branch of knowledge. This is especially so since the early 1990s: ecology has evolved to be one of the centers of modern science. There are many sub-disciplines for ecology. Depending on the organizational levels of organisms, ecology is divided into molecular ecology, physiological ecology, population ecology, community ecology, ecosystems ecology, landscape ecology, etc.; according to the differences in taxonomy of organisms to be studied, there are plant ecology, animal ecology, microbial ecology, insect ecology, etc.; based on differences in landscape and habitat categories, there are terrestrial ecology, marine ecology, wetland ecology, or forest ecology, grassland ecology, etc.; if we focus on application categories, they are agro-ecology, urban ecology, pollution ecology, etc., and if we categorize in terms of scientific disciplines, there are mathematical ecology, environmental ecology, chemical ecology, physiological ecology, economic ecology, behavioral ecology, etc. Among the known ecological disciplines, only mathematical ecology is a pure quantitative science. Mathematical ecology stresses the mathematical analysis of ecological issues, mostly by developing analytical models and equations.

2 Computational Ecology

Due to the complexity, nonlinearity and uncertainty of ecological problems, simple mathematical models or equations are far from enough to address them. As the knowledge of ecology and computational science advances, intensive computation is playing an increasingly important role in ecological studies. Various theories and methods based on intensive computation, like artificial neural networks, agent-based modeling, systems simulation, numerical approximation, etc., are increasingly used in ecology. As a consequence, an ecological discipline, computational ecology, was clearly proposed and defined to integrate and synthesize computation intensive areas in ecology (Zhang, 2010).

Aims and scope of computational ecology were defined (Zhang, 2010) and further refined bellow:

(1) Computational ecology is a science focusing mainly on ecological researches, constructions and applications of theories and methods of computational science including computational mathematics, statistical simulation, operational research, etc. Intensive computation is a major feature of computational ecology. Most of the issues in computational ecology start from modeling, followed by intensive computation based on the model (iteration, repetition, randomization, training, etc.). It aims at the simulation, approximation, prediction, recognition, and classification of ecological issues. With computational ecology as a unified platform, we are able to not only apply theories and methods of computational science to ecology, but also construct new theories and methods for computational science. Computational ecology is a public interface, membrane, or gate between ecology and computational science.

(2) Ecology is the main body of computational ecology. Various sciences are involved in computational ecology, including computational mathematics (such as numerical methods), artificial intelligence (artificial neural networks, genetic algorithms, machine learning, etc.), computer science (algorithm design, software development, etc.), probability theory, statistics, operational research, optimization theory, combinatorics, differential equations, functional analysis, algebraic topology, differential geometry, and others.

(3) The research areas of computational ecology involve, but not limited to, the following aspects:

(A) Computation intensive methods, numerical and optimization methods, differential and difference equation modeling and simulation, prediction, recognition, classification, statistical computation (Bayesian computing, randomization, bootstrapping, Monte Carlo techniques, stochastic process, etc.), agent-based modeling, individual-based modeling, artificial neural networks, knowledge based systems, machine learning, data exploration, network analysis and computation, databases, ecological modeling and computation using Geographical Information Systems, satellite imagery, and other computation intensive theories and methods.

(B) Artificial ecosystems, artificial life, complexity of ecosystems and virtual reality.

(C) The development, evaluation and validation of software and algorithms for computational ecology. The development and evaluation of apparatus, instruments and machines for ecological and environmental analysis, investigation and monitoring based on the software of computational ecology.

Computational ecology is an emerging ecological science. Development of this science is dependent upon efforts from all scientists working in computation intensive ecological studies.

Reference

Zhang WJ. 2010. Computational Ecology: Artificial Neural Networks and Their Applications. World Scientific, Singapore