

# Chapter 19

## Artificial Intelligence Applied to Natural Resources Management

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### ABSTRACT

*There are three computational challenges in natural resources management: data management and communication; data analysis; and optimization and control. The authors believe these three challenges can be dealt with Artificial Intelligence (AI) techniques, because they can manage dynamic activities in natural resources. There are several AI techniques such as Genetic Algorithms, Neural Networks, Multi-Agent Systems or Cellular Automata. In this chapter, the authors introduce some applications of Cellular Automata (CA) and Multi-Agent-Based Simulation (MABS) in natural resources management, because these are areas that the authors approach in their research and these areas can contribute to solve the three computational challenges. Specifically, the CA technique can face the challenge of data analysis because it can be extrapolated and new knowledge will be acquired from an area not known or experienced. Regarding the MABS technique, it can solve the challenge of optimization and control, because it works in an empiric way during the decision-making process, based on experiments and observations.*

### INTRODUCTION

According to Millington (2006), “the Artificial Intelligence (AI) is about making computers able to perform the thinking tasks that humans and animals are capable of”. In this way, computers can already solve many problems, as arithmetic, sorting, searching, etc. Therefore, a philosophical aspect started

the AI motivation in academia: understanding the nature of thought and the nature of intelligence and building software to model how thinking might work. On the other hand, some researches works are motivated by psychology, and they try to understand the mechanics of the human brain and mental processes. In an applied field, engineers try to build algorithms to perform human-like tasks.

Natural resource management is a discipline in the management of natural resources such as land,

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water, soil, plants and animals, with a particular focus on how management affects the quality of life for both present and future generations. The discipline has given rise to the notion of sustainable development, a principle that forms the basis for land management and environmental governance throughout the world. Natural resource management specifically focuses on a scientific and technical understanding of resources and ecology and the life-supporting capacity of those resources (Holzman, 2009).

According to Fuller and colleagues (2007), there are three computational challenges in natural resources management: data management and communication; data analysis; and optimization and control. Computational tools to solve the three challenges of natural resources management could be implemented with AI techniques, because they have flexibility to treat the intrinsic dynamic of natural resources. Many techniques are available in literature, as Genetic Algorithms, Neural Networks, Multi-Agent Systems, Cellular Automata, Planning, Swarm Intelligence, etc. In this chapter, our focus is on Cellular Automata and Multi-Agent Systems, because we work with such techniques in our research works.

Modern resource management increasingly depends on information systems (GIS) for interactive computational steering, high-performance computing for integrated system modeling, and geographically distributed grid computing technologies. For example, computer scientists actively engage in improving techniques for managing the large amounts of data produced by the high throughput sequencing technologies used in genomics. Often the applied computer science involvement with applied biology is mostly limited to solving molecular biologists' data management and analysis problems. Each of these areas contains a diversity of problems, many of which have great economic, social, and political importance. However, a problem might involve all three areas—for example, solutions to the control of exotic species depend on gath-

ering information about organisms' occurrence and spread (data management/communication), understanding spatial and temporal invasion patterns (data analysis), and developing strategies to manage populations of exotic species (optimization and control).

Multi-Agent Systems (MAS) study the behavior of an independent set of agents with different characteristics, evolving in a common environment. Those agents interact with each other, and they try to perform their tasks in cooperative way, sharing information, preventing conflicts and coordinating the execution of activities (Gilbert & Troitzsch, 1999). Additionally, the use of simulation as an auxiliary tool to human-being decision-making is very efficient, because it is possible to verify specific details with great precision. Multi-Agent-Based Simulation (MABS) is the union of Multi-Agent Systems and Simulation and it is especially valuable to match different interdisciplinary perspectives. Typically, it involves researchers from various scientific areas, such as social psychology, computer science, social biology, sociology and economics.

Originally John von Neumann proposed Cellular Automata (CA) (Burks, 1970) as formal models of self-reproducing organisms. The structure studied was mostly on one- or two-dimensional infinite grids, though higher dimensions were also considered. Later, physicists and biologists began to study cellular automata for the purpose of modeling in their respective domains. The approach taken by Wolfram work (Wolfram, 1994) considered CA as models of complex systems, in the sense that simple CA rules can give rise to extremely complicated patterns. The mathematical simplicity in CA description is thought to be a significant advantage for modeling, rather than using systems of differential equations.

The proposal of this chapter is to present some of AI techniques applied to natural resources management. The chapter is structured in five sections. In Section 2 we present some research works using AI techniques such as Fuzzy Sets,

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