Computational Techniques to Manage Natural Resources

Diana F. Adamatti, Centro de Ciências Computacionais, Universidade Federal do Rio Grande (FURG), Rio Grande, RS, Brazil

Marilton S. de Aguiar, Centro de Desenvolvimento Tecnológico, Universidade Federal de Pelotas (UFPel), Pelotas, RS, Brazil

ABSTRACT

To manage the natural resource, many aspect must be treat, because this are evolve all flora and fauna in planet. Mainly, how this management could improve the life quality in present and future, for all species (not just for human begins). In literature, there are three computational challenges in natural resources management: data management and communication; data analysis; and optimization and control. In this paper, the authors present four case studies where some techniques could help in the management of natural resources and to solve these challenges.

Keywords: Artificial Intelligence Techniques, Computational Challenges, Forest Fire, Natural Resources Management, Pollution

1. INTRODUCTION

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

The problems created by excessive emission of pollutants are not recent and they had significantly increased due the fast industrial growth. An alternative is to take some preventive measures by knowing the risk of the installation of a new industry on a region. The natural resources management requires that the government, citizens and other actors interact through the support of computing. In this context the simulation appears as a mechanism that plays real systems using computational tools, and support to prevision of future consequences and to assist in decision making (Freitas Filho, 2001; Scire et al., 2000).

Using computational tools is an alternative to predict risks. By this way, these tools can cre-
ate new possibilities to have a better life quality. 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.

The main goal of this paper is presented some case studies that use computational techniques to manage the natural resources, helping the society in the decision-making process. The paper is structured in four sections. In Section 2 we present some research works using Artificial Intelligence techniques such as Fuzzy Sets, Neural Networks and Genetic Algorithms, because two of our case studies involve AI techniques (Cellular Automata and Multi-Agent-Based Simulation). In Section 3 are shown our case studies in this research area. Finally, Section 4 presents some conclusions and some future works in the area.

2. ARTIFICIAL INTELLIGENCE AND THE NATURAL RESOURCES

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. The focus of our studies is on the Cellular Automata (CA) (Burks, 1970) and Multi-Agent-Based Simulation (MABS) techniques (Gilbert & Troitzsch, 1999). In the follow sections, we will present case studies with these techniques with more details. However, many other applications can be done using AI techniques, as neural networks, genetic algorithms or fuzzy sets.

The idea of Neural Networks was inspired from biological nervous systems. In fact, neural networks are an attempt to create systems that work in a similar way to the human brain. The brain consists of tens of billions of neurons densely interconnected. The function of an Artificial Neural Network (ANN) is to produce an output pattern when presented with an input one (Picton, 2000). The ANN has been used in several works related to natural resources management. A good example is the work of Iliadis & Maris (2006). In this work, an ANN performs an effective estimate of the Average Annual Water-Supply on an annual basis, for each mountainous watershed of Cyprus, where there is a lack of drinking water during summer periods. Another example is the work of Ahmad & Simonovic (2005), which presents a framework to show viable alternatives when the hydrologic application requires that an accurate forecast of the stream flow behavior be provided using only the available time series data, and with relatively moderate conceptual understanding of the hydrologic dynamics of the particular watershed under investigation.

The Genetic Algorithms (GAs) were developed generating a population of candidates for the solution of a given problem. According to Goldberg (1989) these algorithms inspired by the natural evolution were initially applied to optimization problems and learning machine. Genetic Algorithms have been used in natural resources management and several works can be cited. In Manoliadis and Karantounias (2003), genetic algorithms are presented as a tool for effective decision support in natural resources management specifically applied to water resources planning and management where techniques based on analytical equations often require significant simplification on the network. In this work, genetic algorithms are used for the representation of the network and a nonlinear optimization model based on AGs has been developed for the calibration of water distribution network models. The decision variables are codified and the search procedure is done in several directions simultaneously different from the traditional gradient-based models that employ unidirectional searches. In Wang et al. (2005), genetic algorithms are employed to find optimal solutions for green building design. This work presents a multi-objective optimization model to assist designers to find better assign alternatives satisfying several conflict criteria like economical and
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