

Chapter 3.5

An Artificial Life–Based Vegetation Modelling Approach for Biodiversity Research

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ABSTRACT

The complexity of nature can only be solved by nature's intrinsic problem-solving approach. Therefore, the computational modelling of nature requires careful observations of its underlying principles in order that these laws can be abstracted into formulas suitable for the algorithmic configuration. This chapter proposes a novel modelling approach for biodiversity informatics research. The approach is based on the emergence phenomenon for predicting vegetation distribution patterns in a multi-variable ecosystem where Artificial Life-based vegetation grow, compete, adapt, reproduce and conquer plots of landscape in order to survive their generation. The feasibility

of the modelling approach presented in this chapter may provide a firm foundation not only for predicting vegetation distribution in a wide variety of landscapes, but could also be extended for studying biodiversity and the loss of animal species for sustainable management of resources.

INTRODUCTION

Vegetation modelling is an important topic in the sciences in at least two streams of applications. The former applies the modelling and simulation of vegetation for predicting the impacts of climate change on forestry, studies of forest succession for resource and habitat management, and animal habitat modelling while the latter attempts to reconstruct past landscapes for geological

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studies or for interpretive and mitigation strategies in landscape archaeology. The modelling techniques proposed in this chapter apply to both. A third stream while useful, are limited in its applicability to larger problems at hand. This stream relates to the modelling of the architecture or structure of plants and has been in development since the 1970s, e.g. Honda (1971) and Mech and Prusinkiewicz (1996).

A survey of literature in the two streams of research boundaries has shown differing but quite similar problems. These limitations relate to fine-scale predictions, biotic interactions, biological life-cycle, evolutionary change, species dispersal, discrete space, temporal activity, and three-dimensional analysis. Perhaps the core of the problem is that these models are top-down and centralised, in contrast to the bottom-up and decentralised approach associated with natural systems. Furthermore, application of the model in similar scenarios often yielded inconsistencies. For example, various comparisons of methods for predictive modelling of vegetation revealed that results vary depending on specific situations and that there were inconsistencies in the predictions (Cairns, 2001; Miller & Franklin, 2002; Moisen & Frescino, 2002; Muñoz & Felicísimo, 2004). A survey of the modelling approach of prominent works in the second stream showed that the algorithms used were similarly top-down (Spikins, 1999; 2000). It is difficult to find predictive methods that mimic nature. Prominent agent-based models of plants (Benes & Cordoba, 2003; Deussen, et al., 1998; Lane & Prusinkiewicz, 2002; Lange, et al., 1998) have also been studied to determine their limitations in order that novel modelling strategies may be defined.

While nature has afforded humankind abundant resources and have inspired creative principles in the sciences, it is time that the sciences assist nature with the principles nature has inspired. Artificial Life (Langton, 1990), an experimental science for the study of synthetic systems that exhibit behaviours characteristic of natural liv-

ing systems may be the contributing informatics. Concepts central to Artificial Life are mainly nature-inspired. Artificial Life has not only been used for studying carbon based life forms but in the discipline's formative years as a new science has seen a tremendous increase in the applications of its principles for solving real world problems. It is observed that the increase is due to the fact that nature-inspired principles simply work in real world situations. The reason for the functional cause does not entirely credit the ability of the human species as a more intelligent being capable of creating new approaches for solving problems in their domains, but in their ability to learn from nature by emulating nature's way of problem solving. After all, problem solving is intrinsic in nature. Already researchers have employed self-organisation, a principle in natural systems, for solving problems. In *Swarm Smarts* (Bonabeau and Theraulaz, 2000) software agents mimicking models of ants and social insects were used to solve complex problems such as the rerouting of traffic in a busy telecommunications network, bees were used for devising a technique for scheduling paint booths in a truck factory, and collaboration in ants were used for robot-task collaboration (Kube and Zhang, 1993). The flocking and schooling behaviour of fish and animals were not only used for the entertainment industry (games and movies that require swarm behaviours uses flocking and schooling algorithms) (Woodcock, 2000), but were also used for assistance in tasks that require coordinated movements (Ng, Leng, & Low, 2004; Schaefer, Mackulak, Cochran, & Cherilla, 1998). Decentralised multiple coordinated microbots for sharing information, cooperatively analyse large portions of a planet's surface or subsurface, and provide context for scientific measurements are also in development (Dubowsky, et al., 2005).

Nature-inspired informatics has been used for problem solving in many areas, perhaps it could also assist in solving nature's problem. The aim of this chapter is to investigate the nature-inspired algorithms in which vegetation can be modelled

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