Complex Science for a Complex World

Exploring Human Ecosystems with Agents

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Pascal Perez and David Batten (Editors)

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Foreword

Mankind has now entered the Anthropocene, the era in which human activities play as significant a role in shaping the biosphere as do natural processes. We see the signs of this in many places, perhaps most pervasively in the climate change brought on by rapid human perturbations to the planetary carbon cycle. The reaction of thoughtful governments to these signals has been to apply principles of sustainability, resilience and triple-bottom-line accounting to the problem of managing and regulating the interaction of humans and their environment. The science to underpin these efforts must understand and ultimately predict the dynamic behaviour of coupled systems embodying human behaviour and biophysical responses. Unlike the natural systems that environmental and earth sciences have traditionally addressed, these human dominated systems display learning, adaptation and complex non-linear feedbacks. They are 'Complex Adaptive Systems'.

Traditional approaches to modelling and understanding such systems have treated the natural and human parts quite differently. Natural biophysical processes have been approached with confidence by modellers who understood that, however complex a system like the earth's climate might be, it could still be expected to obey physical laws and its behaviour was, at least in principle, predictable. The human component, in contrast, was generally treated as entirely contingent and not subject to regular laws (with the notable exception of economics, whose practitioners make draconian simplifying assumptions about human choices with limited predictive success). This situation has changed drastically in the last decade with the growth of complexity theory and its application to human behaviour and decision making. Many aspects of human behaviour at the levels of large groups or whole societies prove to be amenable to simulation with remarkable fidelity by these techniques.

Still in its infancy, complexity theory tends to employ an eclectic collection of theories and methodologies designed to deepen our limited understanding of the properties of complex adaptive systems. Among such dynamic techniques, agent-based modelling (ABM) is being used increasingly to simulate human ecosystems. Its major advantage is an ability to generate system-wide dynamics from the interaction of a set of autonomous agents interacting in the silicon world of the computer. ABM is particularly well suited for representing social interactions and autonomous behaviours, and for studying their environmental impact at different scales. It also helps us to study the emergence of and interactions within hierarchical social groups, as well as the emergence of adaptive collective responses to changing environments and environmental management policies.

Human ecosystems constitute a subset of complex adaptive systems. They are characterised by very strong, long-term interactions between human communities and their environment. They process flows of matter, energy and information. Nowadays, research on human ecosystems straddles the social, computer and environmental sciences. It has created a space where anthropologists and sociologists meet with programmers and physicists. Until recently, such a creative space could not be found in Australia. This is exactly why the Human Ecosystems Modelling with Agents (HEMA) network was created in early 2002. A growing number of scientists needed a place to breathe in, to debate and to share ideas—a forum in the true Greek tradition.

From a handful of Australian and French scientists at the outset, the HEMA network has become an internationally recognised, steadily growing entity, closely connected to complementary groups like the European Social Simulation Association (ESSA) and the Multi-Agent-Based Simulation (MABS) community in Europe. This success has been achieved with the help of dedicated sponsors such as the Australian Department of Education, Science and Training and the French Embassy in Canberra. Several other research institutions deserve a special mention for their committed efforts: Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) and Centre d'etude du Machinisme Agricole du Génie Rural des Eaux et Forêts (CEMAGREF) in France, and The Australian National University (ANU) and the Commonwealth Scientific and Industrial Research Assocation (CSIRO) in Australia. The latter provided the backbone for the HEMA network, by way of its Centre for Complex Systems Science (CCSS) and, more specifically, the CSIRO Agent Based Modelling (CABM) working group.

This book aims to synthesise the synergistic collection of ideas and applications that have emerged from the HEMA network and the CABM working group over the last three years. In particular, it draws upon the work presented at a series of workshops co-organised by CABM and HEMA scientists. The first CABM/HEMA workshop was held in Melbourne from 11-12 July 2003. Its theme was 'Agent-based modelling of social, economic and biophysical systems'. Then, in May 2004, the 2nd workshop was convened at The Australian National University. On this occasion, the theme was 'Exploring human ecosystems: the next scientific challenge'. Finally, the latest workshop was held from 21-25 March 2005 in Bourg-St. Maurice, a scenic location in the French Alps. Organised by the Modèles et systèmes multi-agent pour la gestion de l'environnement et des territories group (SMAGET), its theme was 'Multi-agent modelling for environmental management'.

In essence, there is an unbroken line between these 3 meetings: a consistent focus on techniques for modelling and managing human ecosystems with the help of virtual agents. By nurturing interest in the application of tools and techniques from complexity theory to the sensitive issue of human intervention in various ecosystems, the HEMA network has championed this important new area of scientific enquiry among a growing community of Australian and European scientists.

John J. Finnigan
Director, Complex System Science Program
CSIRO, Canberra, Australia

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