NSF/ESRC Agenda Setting Workshop on Agent-Based Modeling of Complex Spatial Systems: April 14-16, 2007

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Statement of interest

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Evolution and Development

My professional background is in genetic algorithms, which I have in the past applied to finite element models and electronic circuits e.g. (Cooper et al. 2006). However, in future I aim to apply similar techniques not to design new technologies, but to assist in the understanding of the social, spatial and economic world around us.

In particular, I have an interest in developmental computation - the process of growth which translates the genotype (the component of the system which evolves), into the phenotype (the component which actually survives or perishes). I believe this process to be essential to the evolution of non-trivial structures. As the *size* of any evolved structure increases, the *search space* of possible structures grows exponentially, so the probability of a given phenotype emerging by genetic processes alone rapidly approaches zero. It is not useful to examine natural and social systems and merely state that they are 'very unlikely'. Growth (as nature's answer to this so-called complexity crisis) is a crucial component in the creation of such systems, and therefore crucial to our understanding of them.

It should be noted that the processes of growth, and evolution, have themselves evolved. To talk usefully about such concepts in the real world we therefore need to step outside the narrow ontology of genetic algorithms (which view most systems as a process of mutation, evaluation and selection) and instead employ ideas from the world of artificial life, which views evolutionary processes as complex emergent systems. I consider Ray (1991) to be a key work in this area; it is a generative study in which computer programs compete with one another for resources and an artificial ecology emerges without any external fitness function. However, traditional complexity science probably has a part to play in formalising the ideas behind this, and game theory is also useful when/if we can assume that agents behave rationally.

Networks and other formalisms

Network formalisms (e.g. random, small-world and scale-free networks) have much potential for modelling the rich levels of interaction present in the real world, as they allow us to study chains of cause and effect which may not relate to spatial proximity - this is of course one of the advantages which agent based models offer us over and above cellular automata. Network formalisms are still a young field, as is shown by the comparatively recent work on for example, weighted networks (Latora & Marchiori 2003) and correlations between network topology and real-world parameters (de Montis et al. 2005). I view this type of study as essential if network formalisms are to be applied to understanding the world around us.

For me, this field also serves to highlight another question: how else can we usefully formalize real-world structures with mathematical abstractions? Network theory seems to be only one of many possibilities; for example, Markov chains have also recently been applied to studying evolutionary processes (Wheeler 2006).

Applications: real tools from a virtual world

Originally my doctoral research proposal (for the Cardiff University School of City and Regional Planning) concerned the agent-based modelling of urban growth; however the scope has widened somewhat. I am currently seeking problems in the fields of spatial economics, economic geography and evolutionary economics. An example is Tassier & Menczer (2001) in which a realistic social network (of employment contacts) emerges by evolutionary processes alone, and is then analysed from a perspective of efficiency. Vromen (2006), as another example, takes an interesting perspective on growth as it relates to the expansion of knowledge, by suggesting that the evolving 'genotype' consists of skills and behavioural routines, while the 'phenotype' consists of the ideas formed by these entities interacting with their environment. However, this is a discursive argument rather than the result of experimental simulation.

Both of the above studies do not deal with the spatial dimension; however, I think plenty of potential exists not only in analysing the *virtual* space of network formalisms, but also in analysing its relation to *real* physical space.

I see two main uses for computer simulation: it can either be seen as a calibrated modelling system, which aims to predict future real-world developments with a high degree of accuracy; or as a virtual world which isn't expected to match reality precisely but which nevertheless can be used to gain insight into generic processes. Except in a few special cases such as traffic simulation, I am skeptical as to the power of the former approach; therefore I am more interested in the study of generic processes, classed as 'theoretical' in Wu (2005). I hope that this will in turn lead to the development of tools which can be applied to the analysis of real data.

References

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