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Artificial societies and generative social science

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Abstract What is an *artificial society*? What can such models offer the social sciences in particular? We address these general questions, drawing brief illustrations from the specific artificial society we call "Sugarscape."

Key words Agent based models · Artificial life · Social Science

What is an artificial society?

An artificial society is a computer model consisting of (a) a population of autonomous *agents*, (b) a separate *environment*, and (c) *rules* governing the interaction of agents with one another, the interaction of agents with their environment, and the interaction of environmental sites with one another. Let us discuss each of these ingredients in turn.

Agents

Agents are the "people" of artificial societies. An agent is a data structure – in programming parlance, an "object" – that can change, or "adapt," over time. Each agent has "genetic" attributes, "cultural" attributes, and various operating rules governing its interactions with the environment and with other agents. Genetic attributes are hard-wired, fixed for the lifetime of the agent. In Sugarscape, an agent's sex, metabolism, and vision, are genetic. Cultural attributes, by contrast, are not hard-wired; they are transmitted vertically from parents to children, but then change horizontally through contact with other agents. In Sugarscape, individual economic preferences are culturally determined – they can change as agents move around and bump into agents with different tastes. At any time the interacting agents differ in myriad ways – by age, by culture, by wealth, by vision, by economic tastes, by immunocompetence, and so forth: artificial societies are full of diversity.

Environment

Artificial social life unfolds in an environment. The Sugarscape, as the name suggests, is a landscape of generalized renewable resource (sugar) that agents like to eat; indeed they metabolize sugar and need it to live. An artificial society environment is often spatial, such as a two-dimensional lattice, but can be a more abstract, and dynamic, structure, such as the Internet. The point is that it is an external medium with which the agents interact and over which the agents "navigate."

Rules

Finally, there are rules of behavior for the agents and the environment. First, there are rules coupling every site of the environment to its neighbors, as in cellular automata. For example, the rate at which sugar regenerates at a feeding site could be a function of the sugar levels at neighboring sites. Second, there are rules coupling the agents to the environment. The simplest movement rule for Sugarscape agents is: "look around as far as your vision permits; find the site richest in sugar; go there and eat the sugar." Of course, movement under this rule may bring the agent into contact with new neighbors, which brings us to the third set of rules, those governing interagent interactions. In Sugarscape, there are rules governing sex, combat, trade, disease transmission, and cultural transmission between neighbors.

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Social structures emerge

In a typical artificial society experiment, we release an initial population of agents into the simulated environment and watch for self-organization into recognizable macroscopic social patterns. The formation of tribes or the emergence of certain stable wealth distributions are examples. Indeed, the defining feature of an artificial society is precisely that fundamental social structures and group behaviors emerge from the interaction of individual agents operating in artificial environments under simple local rules – rules that place only bounded demands on each agent's information and computational capacity. The shorthand for this is that we "grow" the collective structures from the bottom up.

Our Sugarscape model – available on CD-ROM[1] – integrates population dynamics, migration, combat, trade, cultural transmission, genetics, environmental interactions, immunology, and epidemiology in a spatially distributed artificial society of heterogeneous adaptive agents with limited information, bounded computing capacity, evolving preferences, and other recognizably human attributes and limitations. Our broad aim is to begin the development of a unified evolutionary social science subsuming, and extending, such fields as economics and demography.

The general point, however, is that artificial societies can function as laboratories – CompuTerraria – where we "grow" fundamental social structures *in silico*, thereby revealing simple microgenerators of the macrophenomena of interest. This is a central aim. As social scientists, we are presented with "already emerged" collective phenomena such as settlement patterns, fertility rates, or wealth distributions, and we seek simple local rules that can generate them. We of course use statistics to test the match between the true, observed, structures and the ones we grow; but the ability to grow them, greatly facilitated by modern object-oriented programming, is what is new. Indeed, it holds out the prospect of a new kind of social science.

Generative social science

In particular, from an epistemological standpoint, what sort of science are we doing when we build artificial societies? Clearly, agent-based social science does not seem to be deductive or inductive in the usual senses. But then what is it? We think *generative* is an appropriate term. The aim is to provide initial microspecifications (initial agents, environments, and rules) that are *sufficient to generate* the macrostructures of interest. We consider a given macrostructure to be explained by a given microspecification when the latter's generative sufficiency has been established. We interpret the question, "Can you explain it?" as asking, "Can you grow it?" In effect, we are proposing a generative program for the social sciences and see the artificial society as its principal scientific instrument.

References

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