Why I no longer work with Agents

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My work with ABS dates from the mid-1980s when I published two papers exploring the possibilities of agents in spatial modeling. The first paper developed a formal model of a way-finding agent operating within a complex building where other similar agents were also present. The objective there was to express a sequence of models of human decision of increasing complexity in terms of the formal hierarchy of systems specifications developed by Zeigler (1976). This helped clarify the nature of the relationship between these different models, ranging from elementary stimulus-response to rational decision to reactive and intelligent agents (Couclelis 1986). The second paper described a CA model of urban development in which developers were making investment decisions based on complex rules expressed in predicate calculus (Couclelis 1989). Since that time I have not done any research involving agents even though I have followed with interest the rapid growth of the field. In this note I explain briefly why I became skeptical of the whole paradigm following that early enthusiasm. At the same time I wish to express my willingness, if not hope, to change my mind regarding the relevance of ABS to spatial modeling following this workshop.

As a former engineer turned scientist I am acutely aware of the subtle but profound differences, practical as well as conceptual, between the synthetic stance of the design disciplines and the analytic stance of the sciences. One major difference in practical terms is that when you design something you have direct (partial or total) control on the outcome, whereas when you analyze something that's "out there" you can only hope that you guessed correctly. That distinction is also discussed at length in the Parker et al. review paper under the rubrics of 'generative' vs. 'fitting' (or fitted) models.

My view of how that distinction impacts ABS modeling of land use and land cover change is as follows. ABS models fundamentally involve one or several *agents* interacting with an *environment*. Combined with the 'generative' vs. 'fitted' models distinction (or: designed vs. analyzed) this gives four cases:

1 *Agents and environment both designed*. This describes the 'social laboratories', the self-contained microworlds (such as Sugarscape) that researchers build from scratch. These models can achieve complete validity within the artificial microworlds they set up but outside of these they serve as abstract thought experiments at best (Axelrod).

2 *Agents designed, environment analyzed.* This describes the engineering applications of the ABS paradigm whereby software or hardware robots are designed to operate within pre-existing environments. These are problem-solving applications where

the agents' behavior rules may or may not be anthropomorphic. These kinds of agent models clearly can be extremely effective in practice though they can be often be defeated by the complexity of the real environments within which they operate.

3 *Agents analyzed, environment designed.* This is the case of behavioral experiments where natural subjects (human or animal) are observed within controlled laboratory conditions. Reasonably reliable behavioral and decision rules may be inferred under these circumstances (notably, through the methods of experimental psychology) but it is always questionable whether the rules thus derived will also be valid 'out there' in the real world.

4 *Agents and environment both analyzed*. This is the only one of the four cases that directly concerns land use/ land cover modeling. Here the relevant kinds of models are the traditional types recognized in the philosophy of science: descriptive, predictive or explanatory models. Building a *descriptive* model (i.e., one that fits observations) is technically no trivial task but in principle it can always be done given enough free parameters. Such models can be very useful as data summaries but beyond that their utility is limited. They may sometimes be used as *predictive* models to the extent that trend extrapolation is warranted but true predictive models must be structurally appropriate, i.e., they need to correspond to the mechanisms operating in the real system(s) under study. This requires the existence of formal process theory, which simply is not available in the land use/ land cover field (with or without agents). Predictive models based on theory are by that token also *explanatory* models, though not all explanatory models are also predictive (e.g., the causal relations identified may change over time in unpredictable ways). Reasonably reliable predictive and explanatory models of land use change would be of tremendous value to planning and policymaking but after forty years of efforts in that area the success stories are still quite limited.

ABS modeling meets an intuitive desire to explicitly represent human decision making when modeling systems where we know for a fact that human decision making plays a major role. However by doing so the well-known problems of modeling a highly complex, dynamic spatial environment are compounded by the problems of modeling highly complex, dynamic decision making units interacting with that environment and among themselves in highly complex, dynamic ways. The question is whether the benefits of that approach to spatial modeling exceed the considerable costs of the added dimensions of complexity introduced into the modeling effort. The answer is far from clear and in my mind it is in the negative. But then I am open to being persuaded otherwise.

References cited

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