

Bridging the Gulf between ABM and CSS: A Three-Tiered Approach

A Perspective for the Workshop on Agent-Based Modeling of Complex Spatial Systems

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That there is a gulf between the agent-based modeling (ABM) and complex spatial systems (CSS) communities is hardly in need of elucidation. Part of the reason for the gap is historical and institutional — these areas originate in different disciplines and are practiced in different quarters of the academia. Add to this the fact that “space” has only recently started to acquire its due status, along with “time,” in our thinking, and one could readily explain the gulf. To connect the two communities, therefore, needs particular institutional efforts and arrangements, of which this workshop is an example. In addition, however, there are other gaps between the two communities, which I would like to characterize as conceptual, methodological, and technical. To bridge the gulf, I suggest, work needs to be done on all three levels. The following is a sketch of my thoughts on each.¹

The Conceptual Level

The conceptual gap has multiple dimensions, but I would like to focus on how the two communities understand the core concepts of “complexity” and “representation.”

Complexity

Complexity is an overused (and these days even abused) term. It means different things to people from different backgrounds and disciplines. For some (e.g., mathematicians and computer scientists) it has to do with quantity, scale, and magnitude, for others (e.g. psychologists and cognitive scientists) with structure, heterogeneity, and interconnection, and for yet others (e.g., biologists) with history, change, and function. The ABM and CSS communities, due to their multidisciplinary make-up, might not fully align with any one of these camps, but I believe that they do have varying understandings of “complexity.” To illustrate this let me use a famous example.

Many decades ago, Herbert Simon made a simple observation, which is probably one of the most frequently cited episodes in modern science. The casual observation had to do with an ant’s movement on beach sand, which Simon used to show how apparently complex behavior would emerge from the interaction of a simple organism (the ant) and a complex environment (the patterns of sand). Confronted with this scenario, the ABM community would mainly see the ant, and the CSS community would probably focus on the sand. I might be oversimplifying here, but the example highlights the differences in perspective.

Representations

Representations are also understood differently by various disciplinary traditions — e.g., as surrogates, precursors, and pointers to action, as mediators for coordination among different actors, as channels of communication, as vehicles of conflict resolution and alliance formation, and so on. Traditional accounts of representation typically focus only on the role of representations as stand-ins for individual activity, and ignore other equally important roles that they play in collective processes. Furthermore, they are based on an epistemological view that takes representations as products of a mapping between an external reality and an internal

¹ These thoughts mostly derive from ongoing research on the modeling of change and movement in GIS that I have been conducting in collaboration with the Redlands Institute.

mechanism. This limits the applicability, if any, of such accounts to the very special case of local, stable and static situations, where individual activity is the focus of attention, and where explicit linguistic forms of representation are dominant. What we are increasingly observing, on the other hand, is a whole set of collective practices, mostly mediated by modern digital information and communication technologies, which involve tacit, distributed, and indirect forms of representation using various mediums of expression (e.g., visual). In short, there is a huge gap between current narrow accounts and the broad aspects of representation.

Here again, the ABM and CSS communities might be wedded to one or the other of the above views of representation, and they need to develop a shared understanding of representations by paying attention to the increasingly multifaceted role that they play in the coordination of activities among temporally, geographically, and semantically dispersed actors.

The Methodological Level

What I call the methodological gap has mostly to do with the way the two communities approach and implement the phenomenon of “change.” Traditionally, GIS views the world as a collection of locations and/or objects with attributes, and cartography views change as the application of rules to layers. Accordingly, the CSS community has a largely “snapshot” view of change as the implied difference between states ($S_1 - S_2 \Rightarrow \Delta s$), as opposed to the “incremental” (or “transitional”) view that sees change as the accrual of effects in transition from one state to the next ($S_1 + \Delta s \Rightarrow S_2$).

As others have shown, this difference in thinking about change has significant consequences, and the two communities need to make their differences as explicit as possible in order to be able to tackle common topics and issues.

The Technical Level

Finally, there are serious differences in terms of the computational techniques and programming environments applied in ABM and CSS. Traditionally, in GIS spatiotemporal information was represented by time-stamping records (data objects), attributes (fields), or attribute values (cells). Later on, there was a shift toward the integration of time and space via events or processes. Although semantically rich and more easily amenable to object-oriented modeling techniques, this integrated approach has proven to be non-trivial and challenging in many ways — e.g., in dealing with multiple scales (resolutions), in maintaining database consistency, and so on. More recently, there is a growing interest in agent-based modeling techniques, although the GIS community is yet to come to grips with agent-based modeling and to fully appreciate its potentials.

To sum up, I believe that there is great potential to be realized in interactions and collaborations between the ABM and CSS communities. In my own work on modeling change and movement in GIS, I have seen a lot of room for the integration of ABM techniques. But there are also serious barriers and challenges that need to be addressed on different levels.