Isolation of Topological Uncertainty in Agent-Based Models

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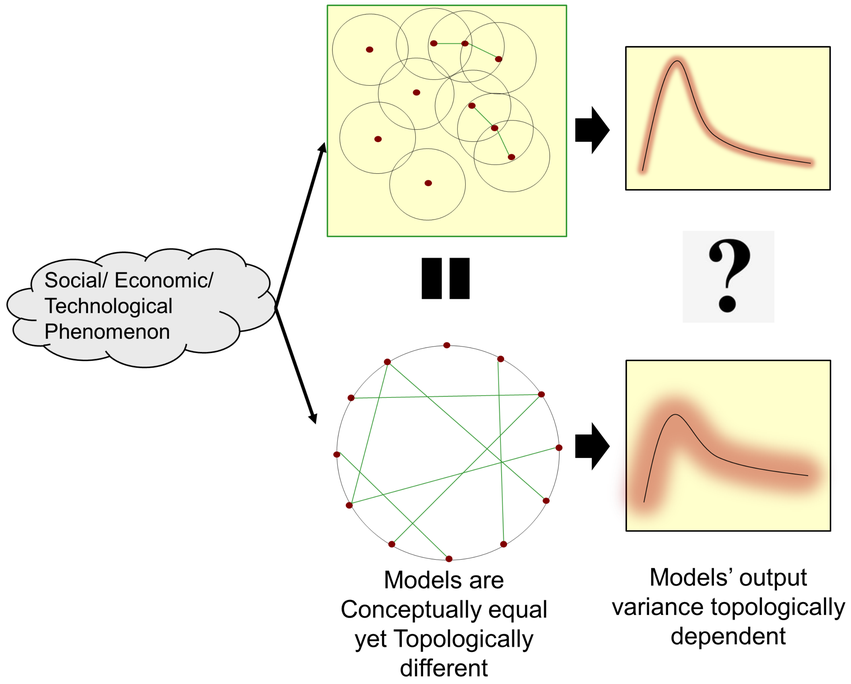
Abstract

- Agent-based modeling (ABM) is a computational modeling methodology, widely used for computational analysis of a range of fields from sociology, to contagion analysis, to economic policy making.
- Agents embody common features with heterogeneous traits.
- Agents interact with each other upon an implementation specific topology.
- **Uncertainty/variance of output of ABMs are dependent on the topology used**



Introduction

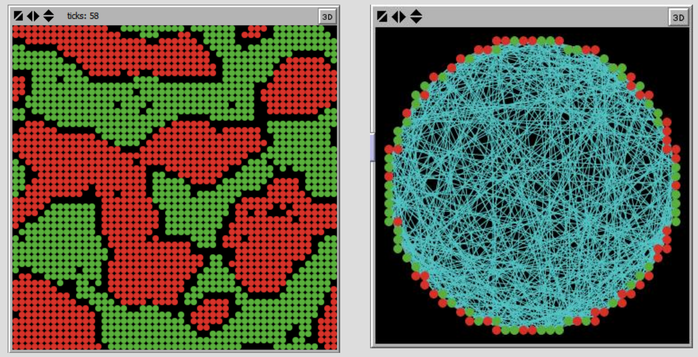
The output of an ABM (time series data, end-state, or visual analysis) is not solely the result of the individual component features. Instead, it has been shown that topology plays a significant role in the output variance produced [1][2][3]. Commonly used topologies in ABM include geographic/grid, random 'soup', network/graph topologies and multi-dimensional grids.

Research Questions

- What proportion of the output variance of agent based models can be attributed to the underlying agent interaction structure used in model design?
- Explaining consistencies in the proportion of output variance caused by using a particular agent interaction topology across ABMs from a variety of application domains
- Are certain topologies prone to producing more emergent variance through interactions $\lim_{S_i}(S_i, St_i)$ [3] than others?

Methodology

- Establish relationship between different topologies and the proportion of output variance attributed to agent-interactions. (topological uncertainty)
- Classical ABMs from several application domains (Schelling's segregation, Sugarscape, representative economics) and models of real-world scenarios as cases (patent-citation models, disease-vector models).
- Each case used developed under common topology. Resulting output variances will be analyzed across each topology-model combination.



Schelling's Social Segregation model being run on two different topologies (left: 2D lattice, right: 8 neighbor Small World Network)

Expected research outcomes

Identification of Patterns in Topological Uncertainty

How does the topology upon while agents interact effect the uncertainty of model output?

Improvement of ABM Predictive Capabilities

Network structure over time will be used to design the networking characteristics of agents in our ABM.

Output of this Study

- An analytic software plugin compatible with ABM simulators like Repast and NetLogo which evaluates the accuracy of the predicted output of an ABM, in terms of its topological uncertainty. .

1. Axtell, R. (2000). Effects of interaction topology and activation regime in several multi-agent systems. Springer.
2. Lee, Ju-Sung, et al. "The Complexities of Agent-Based Modeling Output Analysis." *Journal of Artificial Societies and Social Simulation* 18.4 (2015): 4.
3. Ligmann-Zielinska, A., Kramer, D. B., Cheruvelil, K. S., & Soranno, P. A. (2014). Using uncertainty and sensitivity analyses in socioecological agent-based models to improve their analytical performance and policy relevance. PloS one, 9(10), e109779.

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