Agent-based modeling of complex systems

Assignment 6

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Part 1

Implement the agent-based version of the Bass diffusion model (https://en.wikipedia.org/wiki/Bass_diffusion_model).

Use the two-dimensional Watts-Strogatz network as the underlying structure, with size $N = 100$, mean degree $k = 8$ and rewiring probability $\beta \in [0, 1]$, and periodic boundary conditions (https://en.wikipedia.org/wiki/Watts%E2%80%93Strogatz_model).

Precisely, consider a set of N agents, each characterized by an adoption state $A_i \in \{0, 1\}$, for $i = 1, 2, \ldots, N$. Then, a single Monte Carlo step (MCS) consists of N elementary events, each divided into the following substeps:

- Select an agent i randomly.
- If $A_i = 1$, nothing happens.
- If $A_i = 0$, compute the fraction of adopted neighbors of the agent i, F_i. With probability $p + q \times F_i$, set $A_i := 1$.

Parameters p and q are the coefficients of innovation and imitation, respectively. A single simulation starts from given initial conditions and lasts till $\forall_i A_i = 1$.

Part 2

Consider two types of initial conditions: (a) all agents have adoption states set to 0 and (b) 8 randomly determined agents have adoption states set to 1, the rest to 0. Simulate the model for $p \in \{0, 0.01\}$ and $q \in \{0.25, 0.5\}$. Plot:

- Average adoption state in time (single simulation), for each set of parameters, initial conditions and 3 different values of β.
- Time (in MCS) to stabilize as a function of β (averaged over 100 independent simulations), for each set of parameters and initial conditions.

Part 3

Compare simulation results with the original model, i.e. the differential equation:

$$\frac{dF}{dt} = (1 - F)(p + qF).$$

Use the Runge-Kutta method (https://en.wikipedia.org/wiki/Runge%E2%80%93Kutta_methods) to obtain time trajectories from the equation.