An agent-based model of an epidemic

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- Suppose that an epidemic is spreading in a population.
- We have been asked to predict how the disease might spread in the population.

- Let us call the people of the population "agents".
- Assume that the epidemic sorts people of a population into 3 states: *S*usceptible, *I*nfected, *R*ecovered.
- Assume that time t flows discretely; e.g., day 0, day 1, ...
- Assume that nobody dies $\implies N = S_t + I_t + R_t =$ constant.
- A useful prediction about disease spread: Daily counts $(S_t, I_t, R_t), t = 1, 2, \ldots, T$ from the initial counts (S_0, I_0, R_0).

An agent-based model

- Suppose that the agents live inside a circle of radius R.
- Suppose that, initially, agents are uniformly spread out inside.
- Modeling movements: Each agent performs a random walk.

  For example, normal displacements with standard deviation σ.
- An agent who transgresses outside is teleported to an arbitraty location inside.

Everyday,

- an S-agent becomes an I-agent with probability α if they come into close contact (distance $< r$);
- an I become an R with probability β;
- an R become an S with probability γ.

Interpretation

$$r \equiv \text{infection radius}$$
$$\alpha \equiv \text{probability of catching the infection}$$
$$\beta \equiv \text{probability of recovering from the infection}$$
$$\gamma \equiv \text{probability of losing immunity}$$

Model parameters

- Circle radius $R > 0$
- Infection radius $r > 0$
- Random walk parameter $\sigma > 0$
- State transition probabilities $0 \leq \alpha, \beta, \gamma \leq 1$

All parameters are assumed to be independent of time t.

Simulation parameters

- Number of agents, N
- Time duration, T
- Initial counts (S_0, I_0, R_0)

The accompanying `R` script is an implementation of this model.