Agent-based modelling in social psychology

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Overview

- Definition of agent-based model

- Examples
  - Social psychology
  - Covid-19 model
  - Predator-prey-model

- Workshop

Agent (Smith & Conrey, 2007)

- **Discrete:**
  - An agent is a self-contained entity with identifiable boundaries.
- **Situated:**
  - An agent exists in and interacts with an environment, e.g. other agents, resources, dangers, etc.
- **Active:**
  - An agent not only is affected by the environment but also affects the environment.

Agent

- **Limited information:**
  - **for example agents can see only their neighbouring agents and only their behaviours**
- **Autonomous goals:**
  - **An agent has its own goals and is self-directed in choosing behaviour to those goals.**

Agent

- **Bounded rationality:**
  - Agents often use relatively simple rules rather than being capable of extensive computations.

- **Adaptation:**
  - In some models agents that can learn or adapt, changing their rules based on experience

Examples from social psychology

- Date choice; Kalick & Hamilton (1986)
- Social segregation; Schelling (1971)
- Bible belt; Iannaccone & Makowsky (2007)
- Group Formation; (Jackson et al., 2017)

Date choice: Empirical evidence

- Attractive people tend to pair up with attractive people ($r=0.5-0.6$)

- Explanation: preference for similar people

- But no empirical evidence

Date choice: ABM

- **Agents:**
  - 500 male 500 female
  - Randomly assigned attractiveness between 1 and 10

- **Behavioural rules:**
  - In a randomly selected couple each agent decides independently whether they want to date
  - If both want to date they are removed

Date choice: ABM

- Two versions:
  - Version 1:
    - Similarity matching
    - Results: unrealistic high correlation
  - Version 2:
    - Attractiveness seeking rule
    - Results: realistic correlation

Date choice: ABM - Results

- Most attractive agents tend to be paired up early

- The average attractiveness of the pool decreases

Lessons

- Simple (minimal) model
- Own behavioural rules
- Iteration over time

Schelling-model: Social segregation

- **Why does social segregation exists if no one wanted to live in a segregated world?**

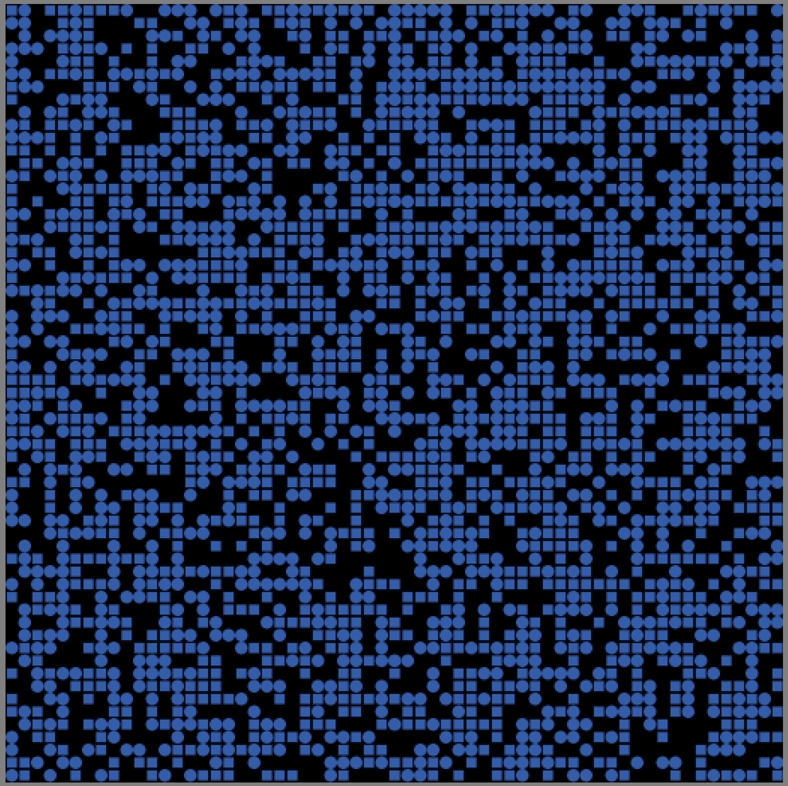
- **Workshop**

Schelling-model: Social segregation

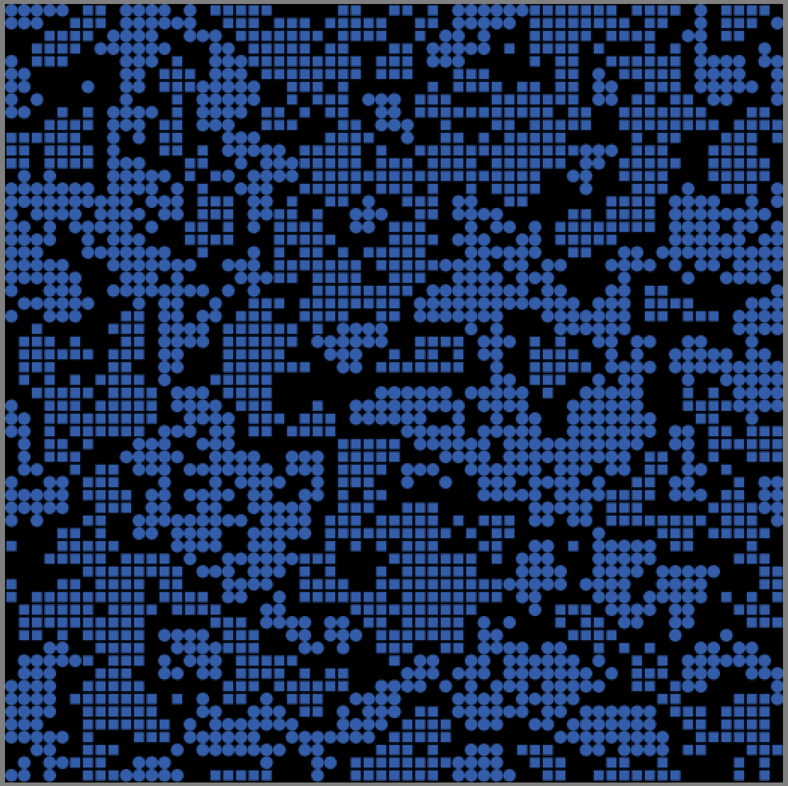
- Agents:
  - Two groups of agents
- Environment:
  - Spatial grid
- Behavioural rule:
  - If in the minority move to another location
- Social segregation even under mild preference for being in the majority

Results

Initial state

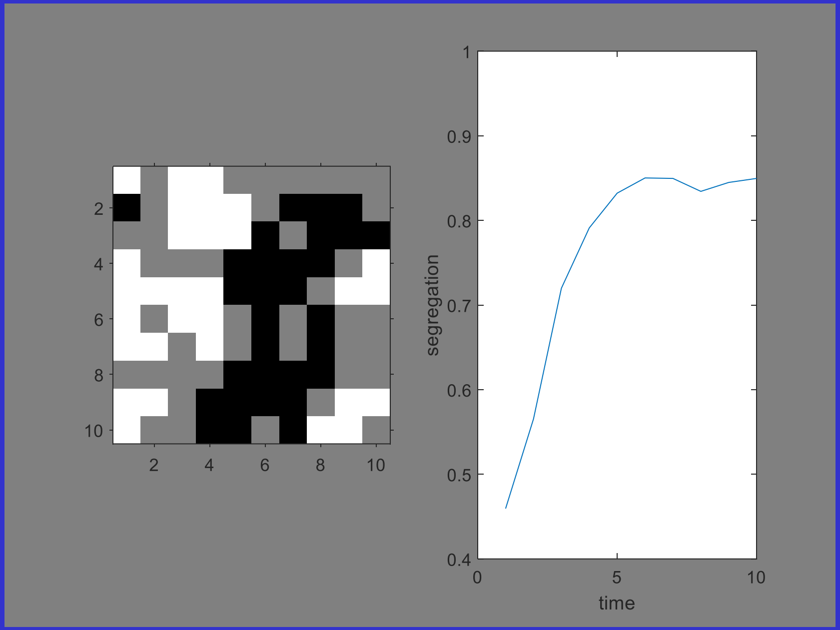


Final state

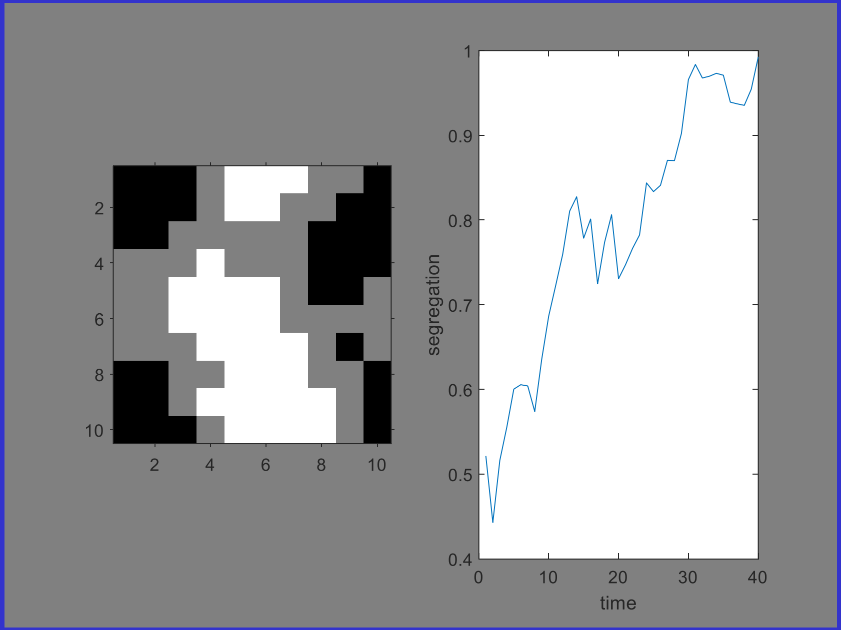


Results

High tolerance



low tolerance



Lessons

- Simple behavioural rule leads to segregation.
- No need to postulate steering authority
- Importance of space
- Simple model

Bible belt

- **Evidence:**
  - Persistence of bible belt despite high levels of mobility
- **Model:**
  - Agents with one of two “religions”
  - Initially environment is split into two regions a majority religion
  - Types of agents: no-conformity or strong conformity

Bible belt: Results

- **Type 1-agent:**
  - **Melting pot**
- **Type 2 – agent:**
  - **Persistence of majority religion**

Let’s have a break

Group Formation (Jackson et al., 2017)

- **Does reciprocity and transitivity lead to group formation?**

Transitivity

- individuals share their friends' opinions of other people
  - E.g., Agent A and Agent B are friends and A likes C then B should also like C.
  - If there is disagreement, usually the one who has not a strong opinion is likely to change their opinion
-

Reciprocity

- **If Agent A helps (or harms) Agent B then Agent B in turn helps (or harms) A.**
  - **Happens more often between close agents (e.g., friends) than distant agents (e.g. foreign pen pals)**

- **Model implementation based on prisoner's dilemma**

Prisoner's dilemma

		Agent A	
payoff		cooperates	defects
Agent B	cooperates	1/1	-3/3
	defects	3/-3	-1/-1

- **Best strategy for individual: defect**
- **Best strategy for group: cooperate**

Agents

- **Closeness of agents represented with a number between 0 and 1.**

closeness	1	2	3	.	.	Number of agents
1	--	0.5	0.2			
2	0.5	--	0.6			
3	0.2	0.6	--			
.	.	.	.	--	.	.
.	.	.	.	.	--	
Number of agents	.	.	.	.	.	--

Behavioural rules

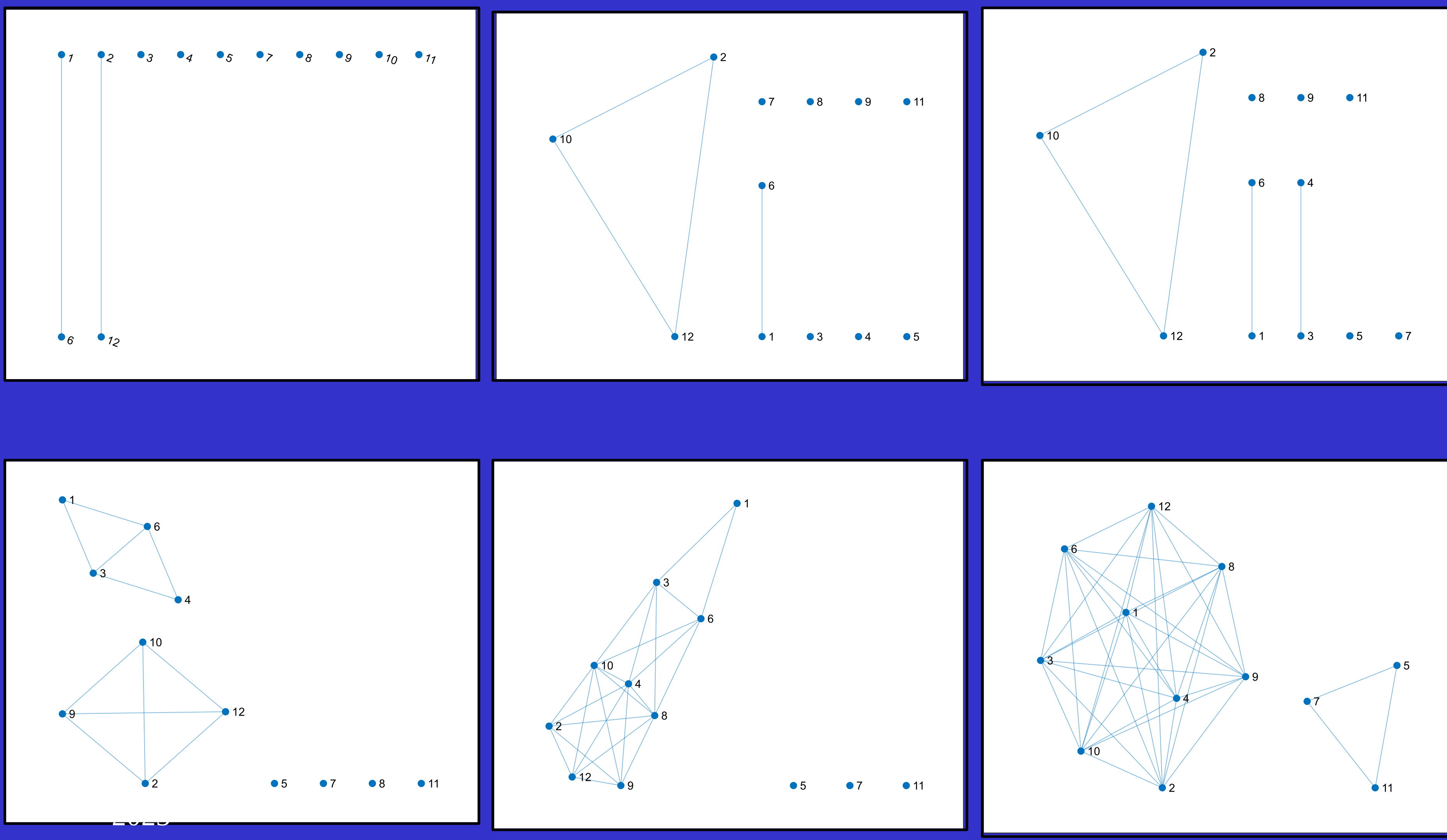
- Closeness ~ probability of interaction
- Prisoner's dilemma:
  - Closeness ~ cooperation
- Reciprocity:
  - If both agents cooperate their closeness increases
  - If both agents defect their closeness decreases
  - Otherwise: no change

Behavioural rules

- **Transitivity:**
  - **Only if both agents cooperate**
  - **Compare their closeness to other agents**
  - **Whoever has a weaker opinion (closeness) changes their mind.**

- **Stops until the closeness stops changing**

Result: time course



Summary

- Bridge between microscopic assumptions and macroscopic pattern

- Importance of space

- Iterations over time

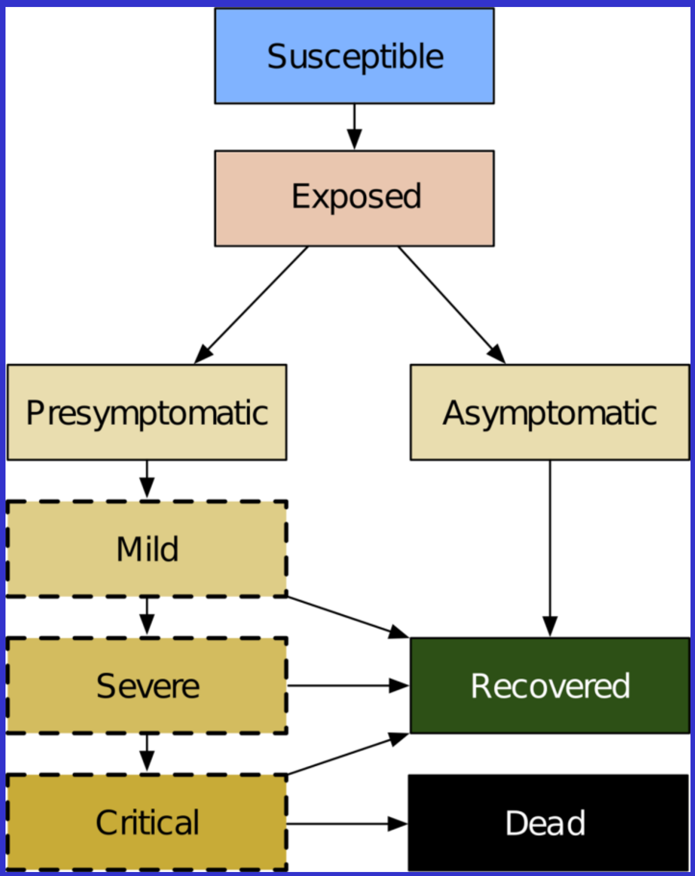
- Suitable for modelling social behaviour

Agent-based model of COVID-19

- Kerr, C. C., Stuart, R. M., Mistry, D., Abeysuriya, R. G., Rosenfeld, K., Hart, G. R., Núñez, R. C., Cohen, J. A., Selvaraj, P., Hagedorn, B., George, L., Jastrzębski, M., Izzo, A. S., Fowler, G., Palmer, A., Delport, D., Scott, N., Kelly, S. L., Bennette, C. S., … Klein, D. J. (2021). Covasim: An agent-based model of COVID-19 dynamics and interventions. In M. Marz (Ed.), PLOS Computational Biology (Vol. 17, Issue 7, p. e1009149). Public Library of Science (PLoS). https://doi.org/10.1371/journal.pcbi.1009149

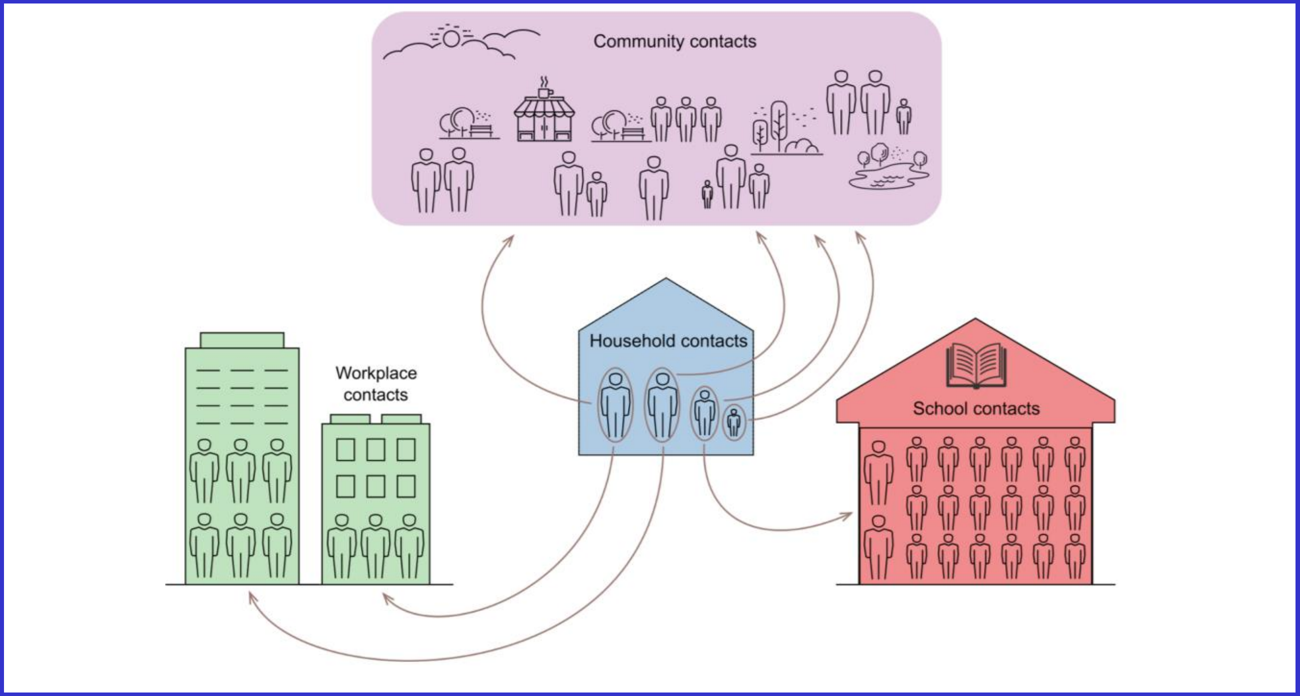
- **Purpose:**
  - Projection of epidemic trends
  - Exploration of interventions (social distancing, vaccinations, etc.)

State of an agent



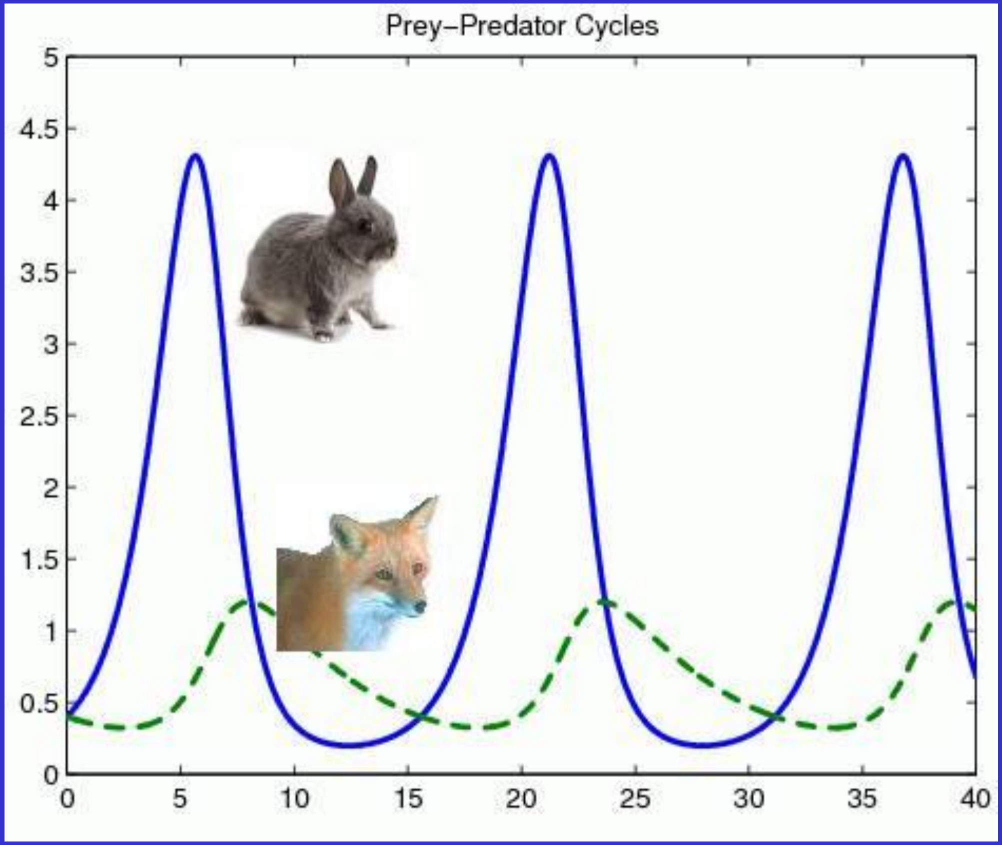
- Yellow shading indicates that the individual infectious
- Dash board indicate symptomatic states.
- Examples of parameters:
  - Length of time after exposure before turning infectious
  - Time from infectiousness onset to recovery for asymptomatic cases
- Stochastic parameters

Contact



Community contacts
Household contacts
Workplace
contacts
School contacts

Predator-prey cycle



http://www.scholarpedia.org/article/Predator-prey_model

Predator-prey-model: Lotka-Volterra-model

- Population-model
- http://www.scholarpedia.org/article/Predator-prey_model
- Non-linear dynamic system, e.g. Lotka-Volterra-model

Lotka-Volterra-model

$$\frac{dx}{dt} = x * (b - p * y)$$
$$\frac{dy}{dt} = y * (r * x - d)$$

x: population size of prey

y: population size of predator

b: growth rate of prey per individual

d: death rate of predator per individual

p * y: the effect of predation on prey per individual

r * x: growth rate of predator in response to prey population

Predator-prey-model: ABM

http://www.scholarpedia.org/article/Agent_based_modeling

- Two types of agent move randomly in the world

- Prey:
  - Check if it is time to reproduce

- Predator:
  - if lands on a prey, eats and increases energy
  - if not, energy decreases

  - if enough energy, reproduces
  - if out of energy, removed from world

CONCLUSION