

Agent-based Modeling

Xin Zhou

University of Amsterdam

Behavior Summer School on Agent-based Modelling for Social Science
29 Aug- 09 Sep, 2022



Introduction

What and why

- What is ABM

Agent-based models

ABMs represent individuals, their **behaviors** and their **interactions**.

- Why we need ABM
 - Heterogeneous individuals
 - Sophisticated interactions
 - Dynamic environment
- Social science simulation approaches[1]

What and why

- What is ABM

Agent-based models

ABMs represent individuals, their **behaviors** and their **interactions**.

- Why we need ABM
 - Heterogeneous individuals
 - Sophisticated interactions
 - Dynamic environment
- Social science simulation approaches[1]

What and why

- What is ABM

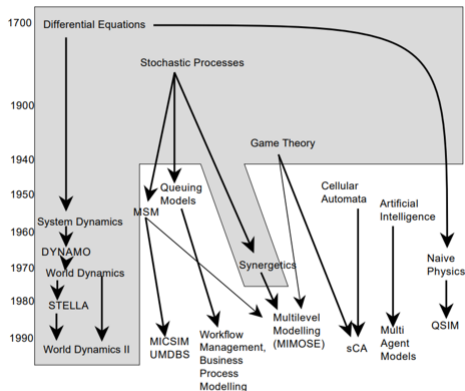
Agent-based models

ABMs represent individuals, their **behaviors** and their **interactions**.

- Why we need ABM
 - Heterogeneous individuals
 - Sophisticated interactions
 - Dynamic environment
- Social science simulation approaches[1]

Development

Figure 1.2: The development of contemporary approaches to simulation in the social sciences (after Troitzsch 1997)



Legend: grey shaded area: equation based models; white area: object, event or agent based models; 'sCA' means cellular automata used for social science simulation; the other names of tools are explained in the respective chapters

Applications

- Computational Social Science
 - Public health / Politics
 - Economics / Marketing
 - Management / Operation Research
 - Microbiology
 - ...

Applications

- Computational Social Science
- Public health / Politics
- Economics / Marketing
- Management / Operation Research
- Microbiology
- ...

Applications

- Computational Social Science
- Public health / Politics
- Economics / Marketing
- Management / Operation Research
- Microbiology
- ...

Applications

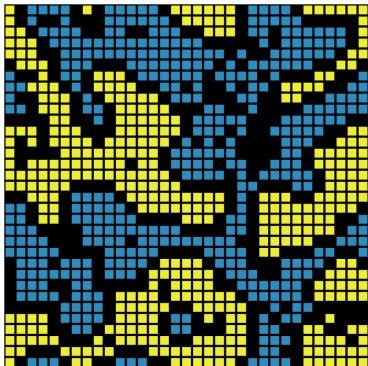
- Computational Social Science
- Public health / Politics
- Economics / Marketing
- Management / Operation Research
- Microbiology
- ...

Applications

- Computational Social Science
- Public health / Politics
- Economics / Marketing
- Management / Operation Research
- Microbiology
- ...

Research Paradigm

Explanation: Shelling model[2]



Research question

What is the mechanism of forming the highly segregated society?

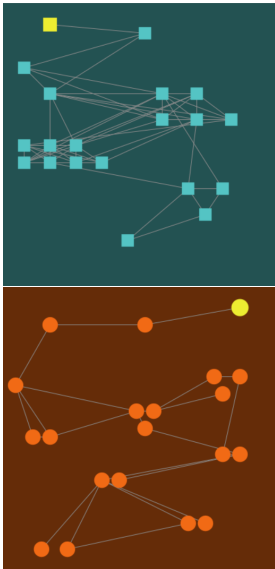
Modeling

Micro-motives:

- Agents desire a fraction p_a of their neighbors to be of the same group
- Check better empty spaces ($p > p_a$) to move to, until everyone is satisfied

Macro-behavior: Segregation

Explanation: Innovation Diffusion model[3]



Research question

What creates the difference in innovation diffusion in different ethnic group?

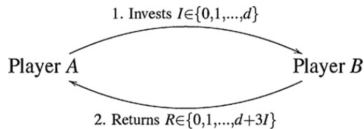
Modeling

Diffusion mechanism:

- Randomly (base line)
- Geodesic distance (Contact network)
- Kinship distance
- #Links between common neighbors
- $\frac{\text{\#adopter in neighbor}}{\text{\#neighbors}}$

Calibration: Which mechanism fits the real data best

Prediction: Influence of selection on cooperation[4]



dynamic1Couples

- Dynamic network
- Broken links are replaced only for isolated agents
- Two way interaction
- Start from random coupling

dynamic1Dense

- Dynamic network
- Broken links are replaced only for isolated agents
- Two way interaction
- Start from dense network

dynamic2Couples

- Dynamic network
- Broken links are replaced only by one of the two formerly linked agents

dynamic2k10

- Two way interaction
- Start from random coupling
- Dynamic network
- Broken links are replaced only by one of the two formerly linked agents
- Two way interaction
- Start from a regular network of degree 10

Research question

What is the mechanism of forming the highly segregated society?

Research Method

Lab experiment:

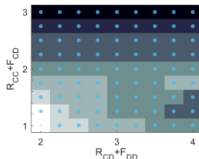
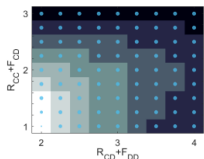
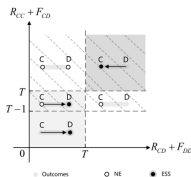
- Play repeated investment game
- Record behavior, calibrate trusting preference α_i , trustworthiness γ_i

ABM:

- Design different interaction mechanism
- Predict and evaluate the influence of selection

Prediction: Proper Incentive Design [5]

		Player Y	
		C	D
Player X	C	R	-T
	D	T	P



Research question

Predicting the influence of incentives

Research Method

Analytical solution:

- Evolutionary Game Theory
- Assumptions: rational agents; infinite population

ABM:

- Relax assumptions
- Introduce income and cost for incentives executor
- Elimination mechanism

Paradigm

- Explanation

- Design model (Theories, observations ...)
- Calibration by real dataset
Estimate the value of variables
- Compare generated data with real data
To what extent your model can **explain** the real world
- Robustness analysis

- Prediction

- Design model (Combine with other methods)
- **Predict** by the generated data
- Calibration?
- Compare?

Paradigm

- Explanation

- Design model (Theories, observations ...)
- Calibration by real dataset
Estimate the value of variables
- Compare generated data with real data
To what extent your model can **explain** the real world
- Robustness analysis

- Prediction

- Design model (Combine with other methods)
- **Predict** by the generated data
- Calibration?
- Compare?

Principles of model design

K.I.S.S or K.I.D

- **K** **I** **S** **S**
Ockham's Razor principle
- **K** **I** **D**
The advantage of ABM

K.I.S.S or K.I.D

- **K** **I** **S** **S**
Keep It Simple and Stupid
Ockham's Razor principle
- **K** **I** **D**
Keep It Descriptive
The advantage of ABM

K.I.S.S or K.I.D

- **K** **I** **S** **S** or **K** **I** **D**
 - **Keep It Simple and Stupid**
Ockham's Razor principle
 - **Keep It Descriptive**
Advantage of ABM

No standard answer

Depends on the research question

- [1] N. Gilbert and K. Troitzsch, *Simulation for the social scientist*. McGraw-Hill Education (UK), 2005.
- [2] T. C. Schelling, “Dynamic models of segregation,” *Journal of mathematical sociology*, vol. 1, no. 2, pp. 143–186, 1971.
- [3] G. Manzo, S. Gabbriellini, V. Roux, and F. N. M’mbogori, “Complex contagions and the diffusion of innovations: Evidence from a small-n study,” *Journal of Archaeological Method and Theory*, vol. 25, no. 4, pp. 1109–1154, 2018.
- [4] G. Bravo, F. Squazzoni, and R. Boero, “Trust and partner selection in social networks: An experimentally grounded model,” *Social Networks*, vol. 34, no. 4, pp. 481–492, 2012.
- [5] X. Zhou, A. Belloum, M. H. Lees, T. van Engers, and C. de Laat, “Costly incentives design from an institutional perspective: Cooperation, sustainability and affluence,” *Proceedings of the Royal Society A*, vol. 478, no. 2265, p. 20 220 393, 2022.

Agent-based Modeling

Xin Zhou

University of Amsterdam

Behavior Summer School on Agent-based Modelling for Social Science
29 Aug- 09 Sep, 2022

