Agent-based Modeling in NetLogo

Jan Lorenz, 6.6.2018
Agent-based model

Agent Based Models (ABM) are used

- to **model**
- a **complex system** by decomposing it
- in small entities (**agents**) and
- by focusing on the **relations** between agents and with the environment.
Agent-based modeling (ABM)

- Social Sciences
  - From Factor to Actors
    - “ABMs explore the simplest set of behavioral assumptions required to generate a macro pattern of explanatory interest.”
    - “ABMs provide theoretical leverage where the global patterns of interest are more than the aggregation of individual attributes, but at the same time, the emergent pattern cannot be understood without a bottom-up dynamical model.”
  - Generative Social Science
    - “If you didn’t grow it, you didn’t explain its emergence.”
Agent-based Modeling

Given a macroscopic phenomenon we try to explain it in the following way:

- We situate an initial population of autonomous heterogeneous agents
- in a relevant spatial environment;
- allow them to interact according to simple local rules, and thereby
- generate—or “grow”—the macroscopic regularity from the bottom up.

( Epstein, 1999)
Agent-based modeling

- Social Psychology
  - **Variable-based vs. agent-based models**

Relations between variables  ➞  Relations between individuals

![Diagram of relations between variables and individuals](image)
Agent-based modeling

- Political Science and Economics
  - Agent-based model as a dynamic model of backward looking learning agents instead of a static model of forward looking strategic agents

Evolutionary of learning in a game-theoretic setup vs. equilibria in classical games

Multi-agent systems (MAS)

A computerized system composed of multiple interacting intelligent agents.

- Largely overlaps with ABM
- MAS ... typically in engineering to solve a problems
- ABM ... typically in science to theorize and reach deeper scientific understanding of dynamic processes
Agent-based vs. density-based

- Density-based: Characterize points in space by densities of quantities of interest
- Examples:
  - Weather model
  - Climate models
- Sometimes distinguished (wrongly) agent-based vs. equation-based
- Note: For an ABM one might derive density-based description
Agent-based simulation: NetLogo

NetLogo (free, open-source)
https://ccl.northwestern.edu/netlogo/


History

- **Logo**, an educational programming language (1967)
- A turtle creeps over the screen via commands and draws lines
Example: Segregation

Phenomenon: Ethnic segregation

Potential reasons:
- racist laws?
- racist people?
Example: Segregation

- Situate an initial population of autonomous heterogeneous agents: Residents of different color which can decide to move.
- in a relevant spatial environment;
  They live in a rectangular grid.
- allow them to interact according to simple local rules, and thereby
  Residents are happy when a certain fraction of similars are in their environment. Unhappy residents move out.
- “grow” the macroscopic regularity from the bottom up. → NetLogo

Example: Segregation

- Results
  - Initially Segregation (= Average percentage similar in neighborhood) is 50.
  - With individual who want at least 30% similar we end up with Segregation = 75!
    - 40% → Segregation = 84 and all happy
    - 50% → Segregation = 86 and all happy
    - 70% → Segregation = 98 and some remain unhappy
    - 80% → Segregation = 50 and almost all unhappy
NetLogo Programming Environment

Controls:
For Parameters
Sliders, Choosers, ... Buttons to execute code

Plots and Monitors to measure aggregate properties

World in square patches where agents can live and act
NetLogo Programming

- **Agents: Turtles, Patches, Observer, Links**

- **Turtles**
  - Create, Die, Inspect (right click)
  - Properties: set … color, shape, xcor, ycor
  - Movements, heading
  - pen-down and pen-up

- **Patches**
  - coordinates, pcolor

- **Patches and Turtles**
  - ask turtles [set pcolor red]
  - ask patches with [pxcor > 0] [ask turtles-here [die]]
NetLogo Programming

- Procedures / Reporters (functions)
- Variables
  - Agent-specific and global
  - Defined or Built-in
    - color, xcor, ycor, shape, ...
- Central way of programming:
  - Ask Agentsets!

Use NetLogo “Programming Guide” and “NetLogo Dictionary” to learn:
https://ccl.northwestern.edu/netlogo/docs/
Extensions: Segregation

- 20% → Segregation = 56 and all happy
- 30% → Segregation = 75 and all happy
- 40% → Segregation = 84 and all happy
- 50% → Segregation = 86 and all happy
- 70% → Segregation = 98 and some remain unhappy
- 80% → Segregation = 50 and almost all unhappy

- More ethnicities
- Majority / Minority setting
- Heterophily instead of homophily
- Sometimes there are other reasons for moving
Segregation Results (in Perspective)

- The segregation model shows a strong *driving force* towards segregation.
- That does not mean that racist laws and people do not exist.
- But they need not be the only reason.
- One probably needs active action (moving people?) to work against segregation.
Example: Matching Hypothesis

Phenomenon:

Attractive people have attractive partners
When measured on human-judged attractiveness scales correlations are between 0.38 and 0.53. Even higher for stable relations.

Potential reason:

- Matching hypothesis: “... men and women of similar attractiveness levels are drawn to one another as romantic partners …”

Example: Matching Hypothesis

- Situate an initial population of autonomous heterogeneous agents: Individuals with attractiveness from 1 to 10.
- in a relevant spatial environment; Individuals can date random others.
- allow them to interact according to simple local rules, and thereby Individuals form couple if they both want it. Individual decision is random event based on the attractiveness of the other. Sure for 10’s, very unlikely for 1’s.
- “grow” the macroscopic regularity from the bottom up. → NetLogo

Matching Results (in Perspective)

- Couple formation based on pure mutual attractiveness assessment creates high correlation of attractiveness of partners
- No need for the matching hypothesis
- Still it might exist, e.g. as an unconscious compensation mechanism, or expectation mgmt
- The attractiveness assessment from average outsiders need not coincide with individual one. Attractiveness of YOUR partner is also your decision ...
Example: Filter bubbles

Phenomenon:

*Individuals form filter bubbles / echo chambers*

Potential Reasons:

- technological filters
- social filters
- individual cognitive filters
Example: Filter Bubbles

Attitude space

Agents
- individual
- bit of information

Links
- friendship
- infolink
- sharer of information

Outcome variables
- mean distance info. bits
- mean distance info. sharers
- mean distance friends

NetLogo → 1,2,3
Filter Bubble Results (in Perspective)

- A cognitive filter with unbiased news creates some clustering of individuals in attitude space.
- With (additional) social posting smallest (even random) clusters reinforce themselves and densify to closed bubbles.
- No need that all your friends share your attitudes.
Conclusion

- Agent-based modeling helps to understand emergent properties
- This helps to not misinterpret data especially from the web and draw appropriate conclusions from it
- Agent-based modelers need
  - scientific knowledge to model behavior
  - mathematical understanding of systems dynamics
  - programming skills
Back Up: NetLogo Programming

- Links are a special type of agents which connect two turtles.
- NetLogo Models Library
  - Preferential Attachment