Agent-Based Modelling in NetLogo
Previously

- Modelling cycle, brief intro ABM/SD
- Formulating a model in the ODD protocol
- Today: Agent-Based Modelling in NetLogo
ABM key aspects

- Agent types and numbers
- Communication
- Shared environment
- Spatial/Network component?
- Scheduling/ordering
Simple Economy example

- Scenario: initially everyone has the same wealth. At each time step, each person gives $1 to someone else chosen at random, if they have money to give.

- Question: what happens to the wealth distribution over time?

- Initialisation: set up 500 agents each with $100

- Agent behaviour: as in scenario above

- Observation
  - The distribution of wealth across the population
  - The total wealth of the top 10% and of the bottom 50%
turtles-own [ wealth ] ;; turtles have one variable - wealth

to setup
  clear-all ;; set everything to defaults
  create-turtles 500 [ ;; create 500 turtles
    set wealth 100 ;; each with $100
  ]
  reset-ticks ;; initialise time steps
end

to go
  ask turtles with [ wealth > 0 ] [ transact ] ;; if have $, give one away
  tick ;; one time step done
end

to transact
  ;; give a dollar to another turtle
  set wealth wealth - 1
  ask one-of other turtles [ set wealth wealth + 1 ]
end

;; report the total wealth of the top 10% of turtles
to-report top-10-pct-wealth
  report sum [ wealth ] of max-n-of (count turtles * 0.10) turtles [ wealth ]
end

;; report the total wealth of the bottom half of turtles
to-report bottom-50-pct-wealth
  report sum [ wealth ] of min-n-of (count turtles * 0.50) turtles [ wealth ]
end
Simple Economy: run
Agent types

- **Turtle** – what you think of as an agent
  - Has x, y coordinates

- **Link** – link between two Turtles
  - Can be directed or undirected

- **Patch** – spatial area
  - Has x, y coordinates

- **The observer**
  - That’s you, using the GUI
  - BehaviourSpace to automate
Turtles

- A class of turtle is called a breed
- Declared at the beginning of the code
- Different breeds have different variables
  - Breed not fixed!
- Set of turtles is an agentset
- Can ‘hatch’ new turtles
  - Same breed
  - Same variable values
Properties

- unique id for each turtle in NetLogo

who
heading
xcor
ycor
shape
size
color
hidden?
Links

• Used to pass/process information between turtles
• Undirectional – only one between any two turtles
• Directional – can be one in each direction between any two turtles
• No self-links
• Good for modelling non-spatial networks
• Set of links is an agentset
• Can have breeds (types) of links
  – Modifies rules above
  – e.g.: undirected-link-breed [streets street]
Patches

- Notionally a 2D grid
  - Good for modelling many physical-world systems
- Cannot move – x and y coordinates are fixed
- Can ‘sprout’ new turtles
  - Any breed
- Agentset – ‘patches’
- Variables
  - pcolor, plabel, plabel-color, pxcor, pycor
- No breeds
  - Differentiate patches using patch variables
Observer

• Basically the GUI
• GUI connected to code
  – Input/Control: Button, Slider, Switch, Chooser
  – Output/View: Plot, Monitor, Model Settings

• Only agent able to arbitrarily ‘create’ turtles
  – But patches can ‘sprout’ and ‘hatch’
Observer – example

- Link to details on COMSES Model Library
- Link to ODD on Github
- Exploration of how collective action may or may not help with resource distribution in a climate change context
- Run in NetLogo
Example – urban land use in East Anglia

• Endogenising the planning process

Source: Lilibeth Acosta-Michlik and Corentin Fontaine; funded by the Tyndall Centre
agents

interactions

feedback

actions

patches
Residential agents

- Socio-economic data analysis
- Agent profiles (household types) & location trends

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Household agent location preferences

Demographics and coastal zone pressures
Residential model runs

1. 14% cities
2. 20% suburbs
3. 39% periurban & rural
4. 25% coast

Model run animation
Infrastructure provision
Built environment (Type 2: "implementors")

Top-down (Type 1: "policy developers")
- Environmental organisations
- Governmental organisations
- Property developers

Bottom-up: (Type 3 "lobbyists")
- Community forums
- Cultural/natural heritage
- Infrastructure provision
- Environmental organisations
- Governmental organisations
- Property developers
ABM as Computational Laboratory

- Testing hypotheses
- Testing methodologies
- Is your ABM deterministic or has it got a stochastic component?
- How many simulations is enough?
- How do we interpret model results?
- Statistical analysis of results
Analysis of ABM Output

• Plot agent attributes
• Plot number of agents of certain type
• Spatial pattern metrics
  - temporal considerations (at a time or over time)