UNIVERSITY OF LEEDS

AGENT-BASED MODELLING RECAP

What have we learned this week?

- Agent-based modelling (ABM)
  - *What is it?*
  - *What are the key concepts?*
  - *What is it for? The strengths and weaknesses of the method*
- NetLogo
  - *Key features and concepts*
  - *Using command to interact with an ABM in NetLogo*
- ABM examples in
  - *Biology*
  - *Virus spread*
  - *Social sciences*
- Assignment 2

Aggregate vs. individual-level

- Systems are driven by individuals
  - *(cars, people, ants, trees, whatever)*
- Not controlled by god
- **Bottom-up modelling**
  - *An alternative approach to modelling*
  - *Rather than controlling from the top, try to represent the individuals*
  - *Model the individual behaviour directly*
  - *Let the system evolve by itself*

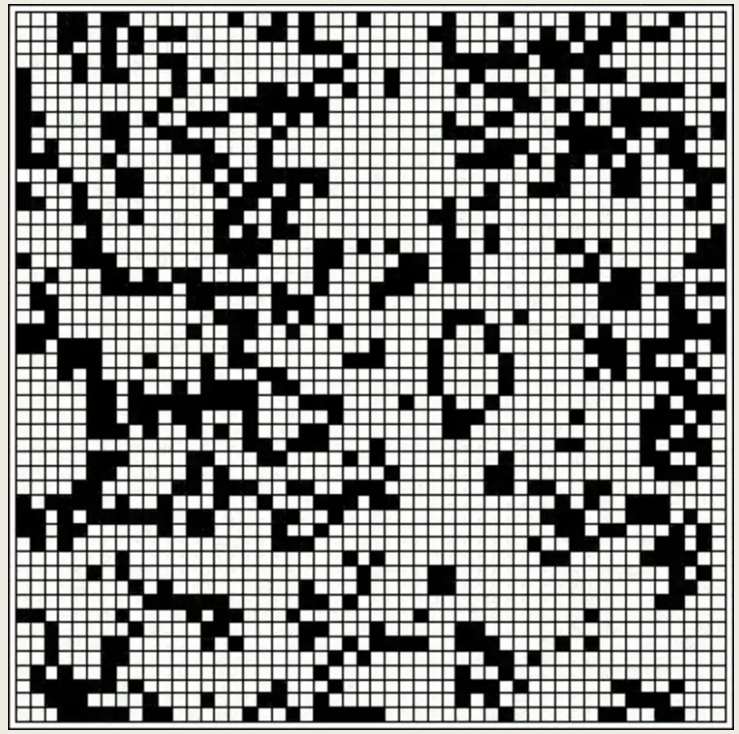
Picture by Wayan Vota
(http://www.flickr.com/photos/dcmetroblogger/)

Properties of an agent

- Autonomy
- Heterogeneity
- Reactivity
- Bounded rationality
- Interactive
- Mobile
- Learning / adaption

Complex systems

- Lots of individual components (individuals, organisations)
- Each have a relationship with other components
- Changes over space
- Changes over time
- Unknown what the outcome is (emergence), sometimes outcome is unexpected



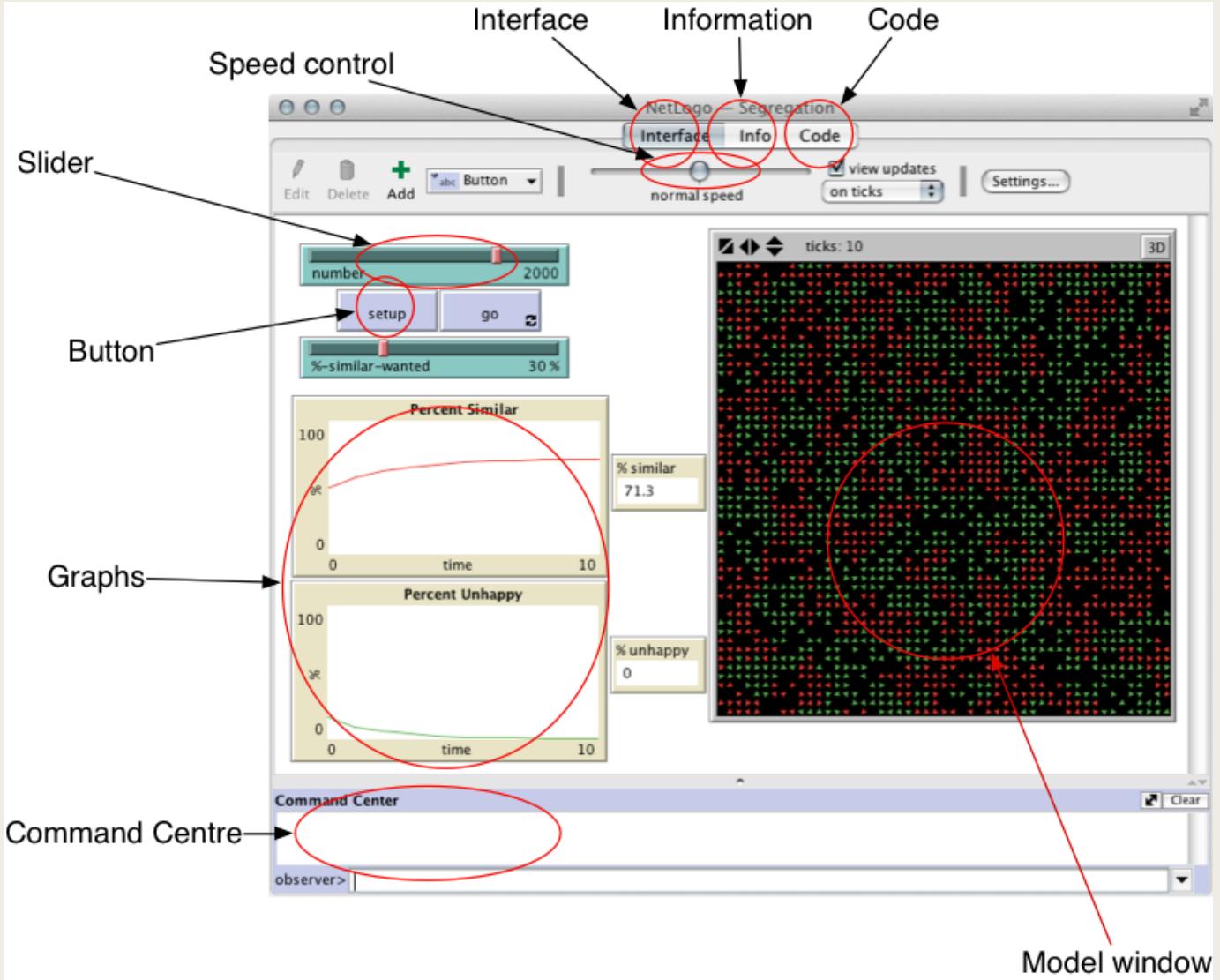
Game of Life: Cellular Automata

Modelling human behaviour in ABM

- Simple rules, rule of thumb
- Rules from experts and practitioners in the systems (specialised systems, e.g. farming, electricity market, auction)
- Rational agent/optimisation
- Bounded rationality with limited information and cognitive capacity
- Psychological theories (e.g. Prospect Theory, Theory of Planned Behaviour)
- Data-driven machine learning approach
- AI models

NetLogo

- Free
- Desktop and web version
- Lots of built-in examples
- Interactive modelling
- Visualisation



NetLogo key concepts: Turtles and Patches

Both are agents

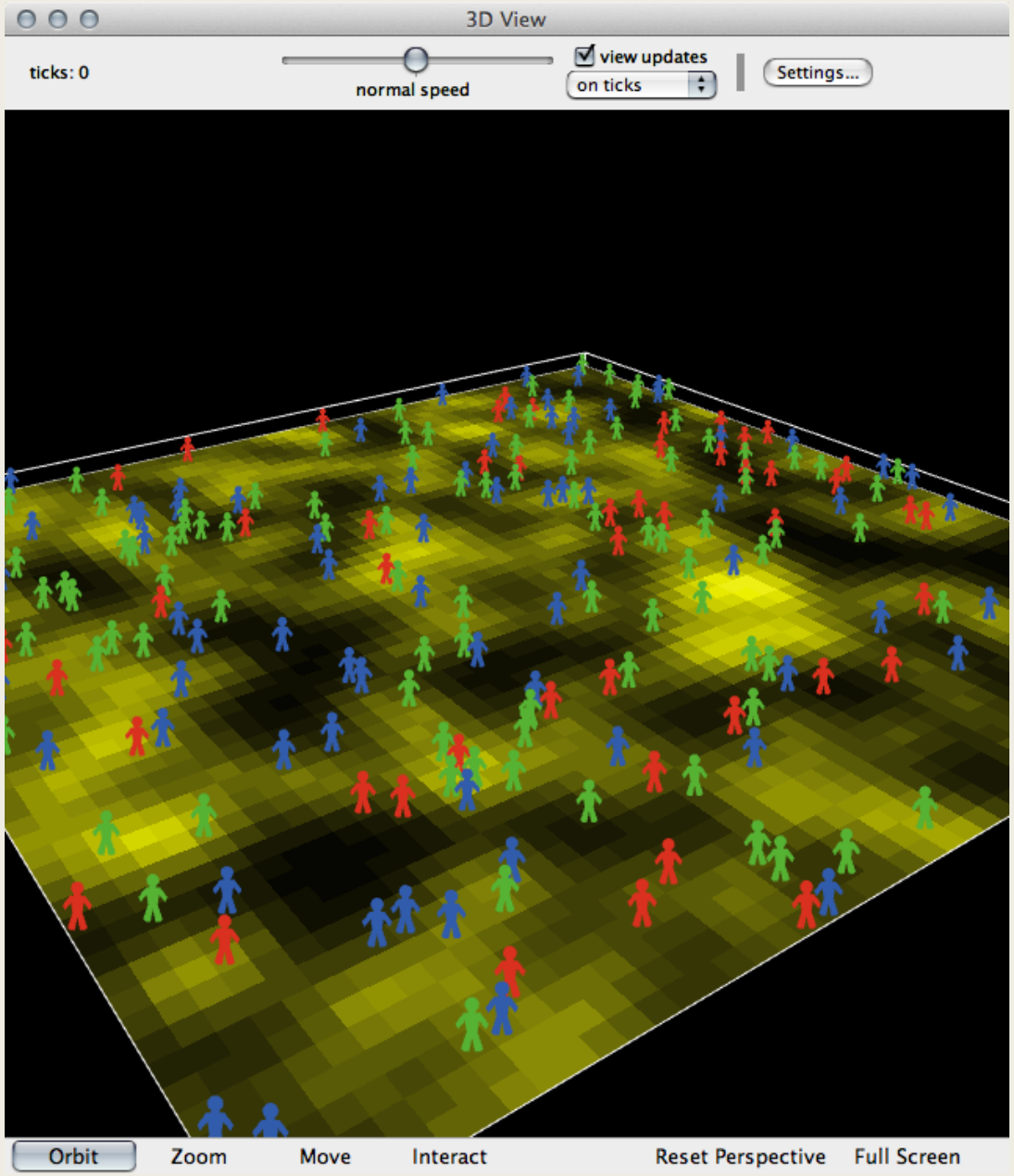
- They have rules that determine their behaviour
- They can interact with other agents

Main differences:

- Patches cannot move
- You can create different types of 'turtle' (e.g. person, dog, cat, car, etc.)

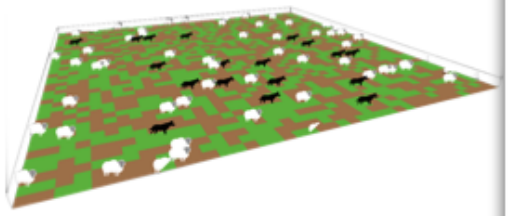
Observer

- The 'god' of a model
- Oversea everything that happens, give orders to turtles or patches, control other things like data input/output, virtual time, etc.



NetLogo built-In Variables

The NetLogo World
Variables



Observer

`ticks`	The number of model iterations (steps)

Variable access

Turtles and patches can read and set observer variables, but not the other way round

Turtles

`xcor`	The turtle's x coordinate
`ycor`	The turtle's y coordinate
`color`	The colour of the turtle
`heading`	The direction that the turtle is facing
`shape`	The shape of the turtle (e.g. 'sheep')

Patches

`pxcor`	The patch's x coordinate
`pycor`	The patch's y coordinate
`pcolor`	The colour of the patch

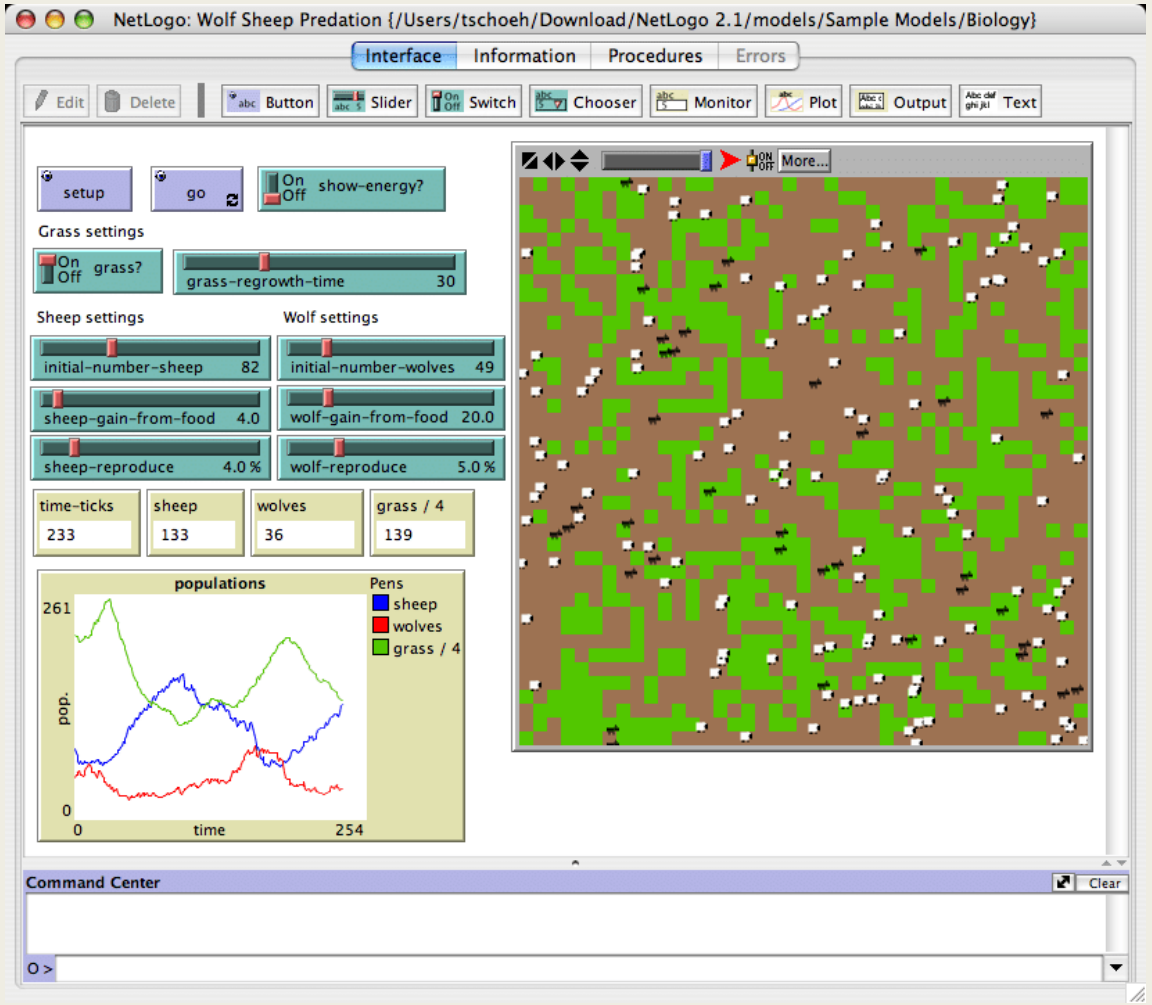
NetLogo examples

- Wolf sheep predator model
- Wealth distribution
- Virus spread
- Neighbourhood segregation
- Many more in the NetLogo library!
- They are not only fun to play with, but can also be very useful for research and solving practical issues
- So, what can we learn from the examples?

Wolf sheep predation – Population oscillation

1. Lots of sheep and few wolves at the beginning,
2. Number of wolves goes up (due to food abundance)
3. Number of sheep goes down (due to many predators)
4. Number of wolves goes down (due to food scarcity)
5. Number of sheep goes up (due to few predators)
6. Back to 1

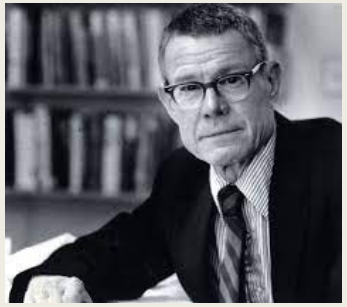
Result: Population oscillation (Lotka Volterra)!



Wolf sheep predation – Critical moment, path dependence, irreversibility

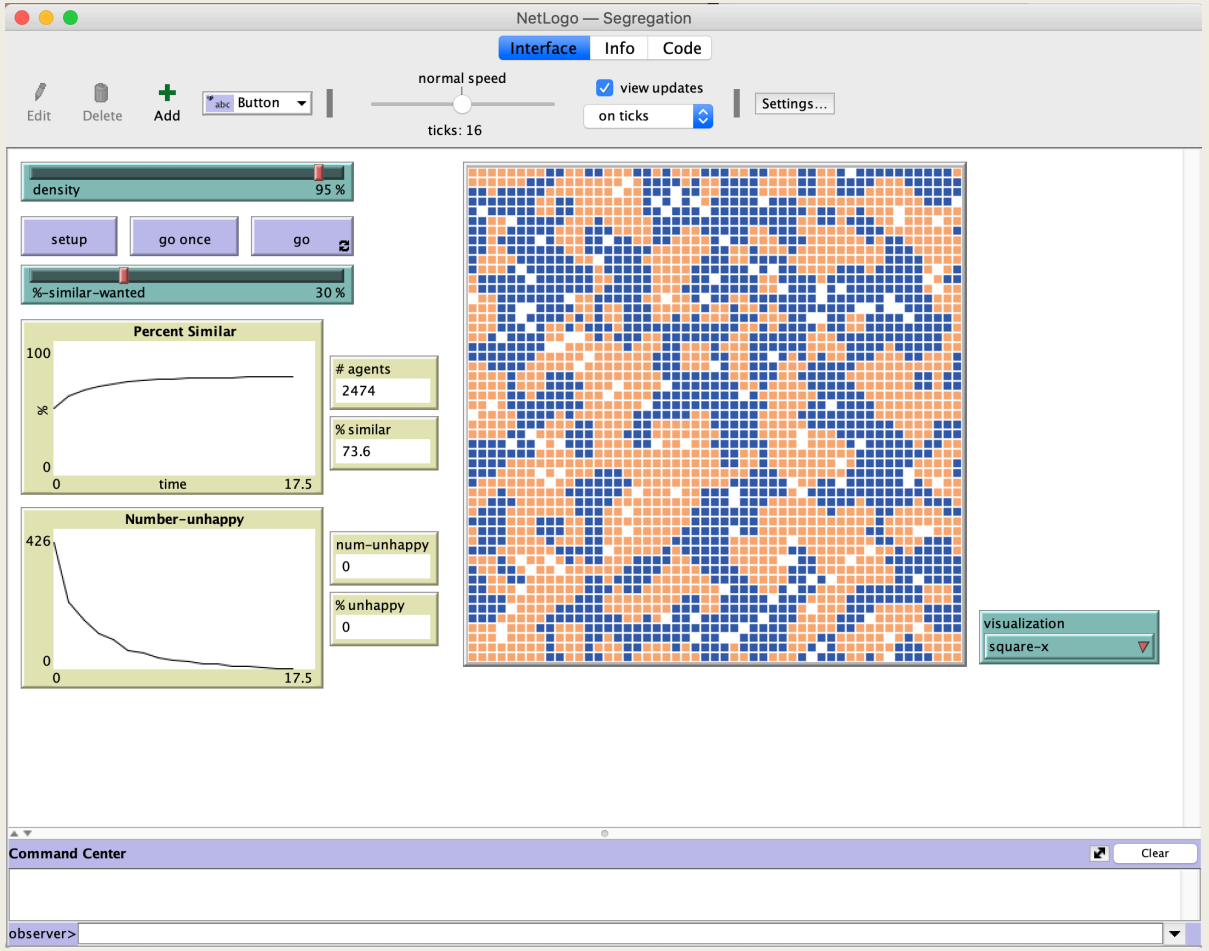
- When there are very few wolves left, the survival of them are critical
- Since the model is stochastic (random encounter between wolf and sheep), sometimes the wolf population survives and start to grow again, and other times it goes extinct
- The model outputs are therefore path dependent (depend on a few critical moments)
- In the case of wolf extinction, the result is irreversible (does not matter how long you run the model after extinction, no wolf will return)

Schelling segregation model: Unexpected emergent outcomes



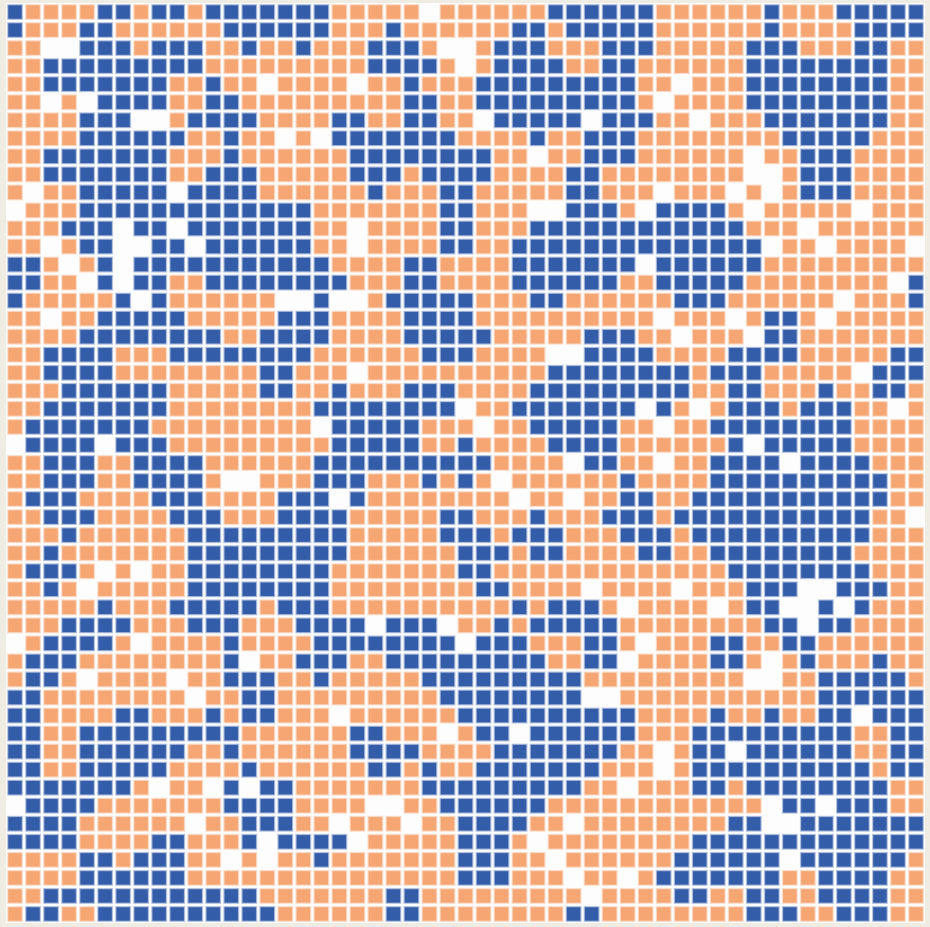
Thomas Schelling, an American economist and Nobel Laureate

- Sample Models>Social Science>Segregation
- Both orange and blue agents prefer to live in a diverse neighbourhood
- An orange agent wants to live near ***at least some*** orange agents; A blue agent wants to live near ***at least some*** blue agents
- **Result: A highly segregated space!**



Schelling's segregation model: Unexpected outcomes emerge from a complex system

- But wait, no one prefers segregation, everyone prefers diversity!
- Segregation emerges as a result of interactions in a complex system (not by anyone's design or preference)
- A complex system can surprise you with unexpected outcomes!



Assignment 2 – Scenario

You have been recruited to advise on the development of a new supermarket. The designers would like advice on how best to organise the layout of the supermarket, considering the movement of individuals around the store and different purchasing (consumer) behaviour i.e. who is likely to come to the store, how will they navigate the store, whom will they interact with in the store, and what are they likely to buy.

Assignment 2

- Your task is to evaluate the insight that an agent based model, operationalised via NetLogo software, could afford the retailer. You may wish to include some of the following points:
- What type of data will you need? How will you need to prepare the data?
- What insights will the data give you?
- How might you use evidence from other research (i.e. literature)?
- How will these insights (from data and/or literature) be used in the ABM?

Assignment 2

- Also consider:
- What type of shopping behaviour to include?
- How would you model the shopping environment?
- What types of interactions could there be in a supermarket?
- What insight can the ABM give you that other approaches you have seen will not?
- What are the limitations with using ABMs?

Assignment 2

- Not expected to build an ABM for this assignment
- But the demonstration of working prototypes will be looked favourably on
- Draw on the insights from the practicals and lectures, as well as from your own background research
- Include academic references within your presentation (these should be included on a slide at the end of the presentation but do not need to be discussed explicitly)

Assignment 2 - Presentation

- Present your findings in a boardroom style setting in which you are pitching for funds from their organisation to implement their strategy
- Presentations will be pre-recorded via MS Teams **without editing**
- 10 minutes or less
- Multiple team members are encouraged to present (in Teams they can do so by gaining control of the Powerpoint presentation)
- Joint team effort is encouraged
- Presentations will **not** be marked on the sophistication of your video editing skills

Assignment 2 - Live Q&A

- Online live Question & Answer (Q&A) session
- 5-10 minutes each group
- 2-3 questions, may have follow-up questions
- All group members are expected to call in the Q&A session from their personal computer with cameras turned on
- Multiple group members are encouraged to answer the questions
- Questions may come from any of the instructors in the panel (similar to a boardroom style setting)