CSYS5010 Introduction to Complex Systems

Week 2a Introduction to ABM and NetLogo

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Review of last lecture

- Understanding of examples of complex systems
- Ability to define complex systems
- Understanding of features of complex systems, such as emergence and self-organisation

This week session outcomes

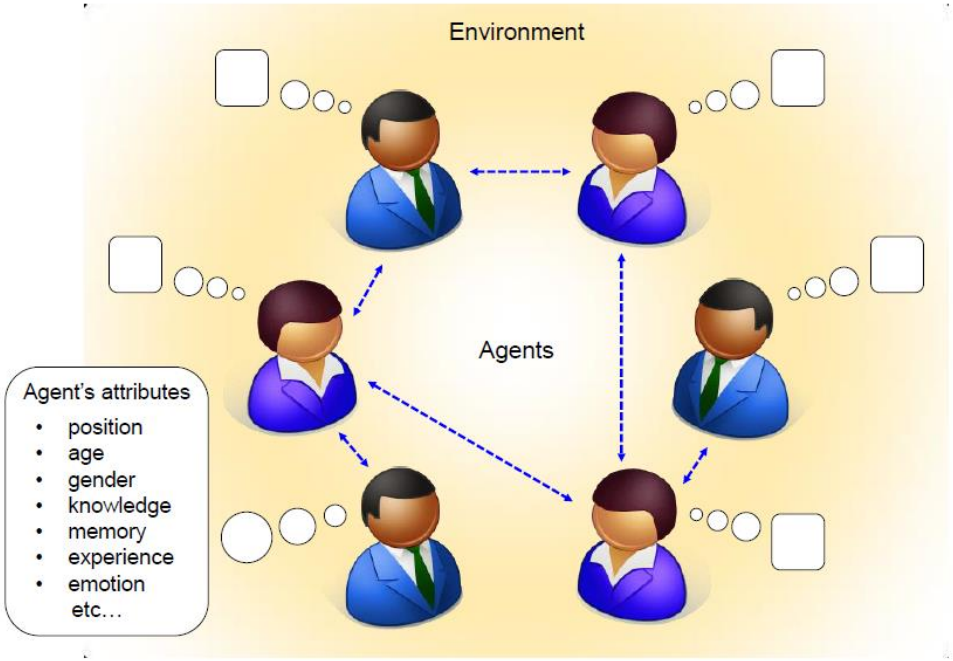
- What is and why Agent-Based Modelling?
- Building simple models with NetLogo
- Continuing exploring emergent behaviour

- Primary references:
  - chapter 0 to 2 of “An Introduction to Agent-Based Modelling: Modeling Natural, Social, and Engineered Complex Systems with NetLogo ”, Uri Wilensky and William Rand 2015

What is Agent-Based Modelling?

- Watch a Sandtable Video

Agent Based Modelling – computational modelling where a dynamic phenomenon is modelled in terms of discrete **agents** and their **interactions.**



Schematic illustration of ABM (Sayama, Introduction to Complex systems, fig 19.1)

Applications of ABM

There are numerous applications of ABM. Some examples include:

- spread of disease (epidemology)
- interaction between species (ecology)
- traders behaviour in markets (economics)
- interaction among employees and their performance improvement (organizational science)
- consumer behaviour (business)
- cell growth and morphogenesis (developmental biology)
- collective behaviour of materials (physics)
- Traffic modelling (transportation planning)
- Crowd dynamics modelling (transportation, civil engineering)
- …

Why Agent Based Modelling?

Pros	Cons
Easy to understand; do not require specialist technical knowledge	Usually not analytically tractable
Great interactivity with users	Computationally intensive
Availability of detailed data and powerful computers allows construction of models with millions of agents	

Equation Based Modelling (EBM)

- EBMs is another way of modelling dynamical phenomena.
- EBMs are formulated in terms of **ordinary differential equations, partial differential equations** of **difference equations**. These could be deterministic or stochastic.
- Examples: predator-prey models (logistic equation), SIR model in epidemiology, Navier-Stokes equation in fluid mechanics …
- Often describe the dynamics at an aggregate level rather than the microscopic level as do ABMs.
- EBM will be covered in more detail in **weeks 6 and 7**.

Examples of Programming Languages

- NetLogo, C++, Python, Java, Fortran, Matlab, Mathematica
- many more …
- Some pros and cons of Netlogo

Pros	Cons
Specifically designed for ABM	Scalability issues such as difficulties in organizing large amount of code
Intuitive interface	NetLogo's simplicity is deceptive. Lots of details are hidden.
Simple syntax – easy to learn	Only one interface.
Excellent documentation	Lack of sophisticated debugging tools
Extensive model library	

NetLogo – Useful Links

- NetLogo Homepage
  - https://ccl.northwestern.edu/netlogo/
- NetLogo Manual
  - https://ccl.northwestern.edu/netlogo/docs/
    - Programming guide
    - NetLogo dictionary

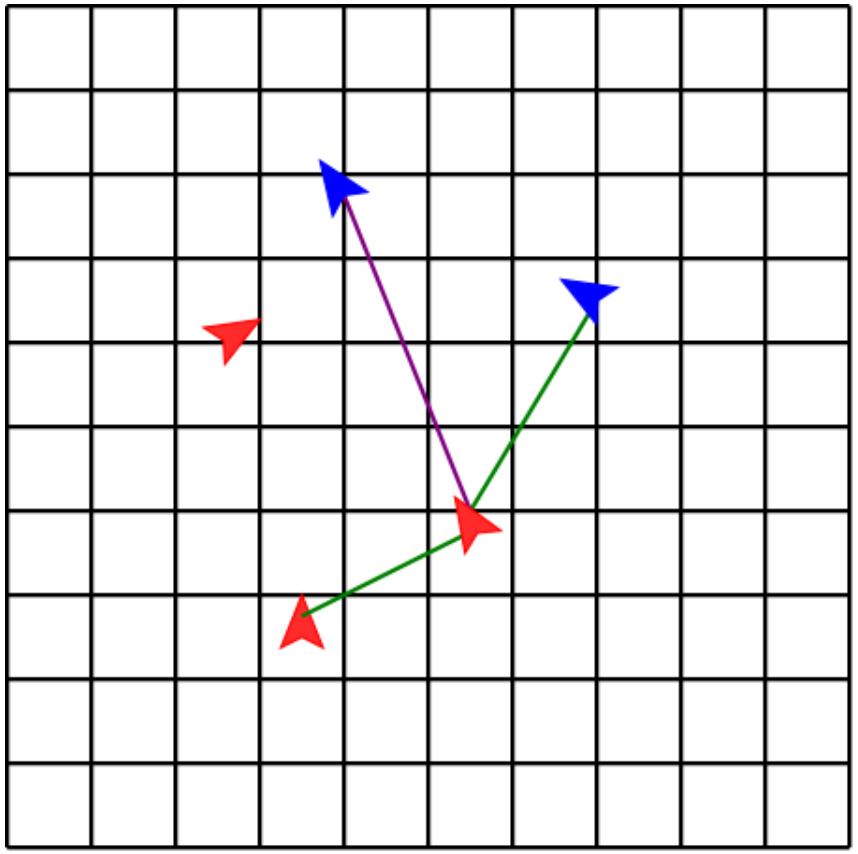
NetLogo components

Patches

Turtles

Links

Observer



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Examine NetLogo Interface

1. Launch NetLogo
2. Examine the Interface Tab
    1. The world and changing its settings
    2. Adding widgets: buttons, sliders, switches, choosers, monitor, plot etc
    3. The tick counter
3. The Info tab
4. The Code tab

Game of Life – Tutorial 1

Aim: Program Conway's Game of Life from scratch in NetLogo

Aspects of the model	
Agent types	
Environment	
Agent behaviour	
Parameters	
Time step	
Measures Visualization	

Implement the model – tutorial 1

Heroes and Cowards – Tutorial 2

Aim: create an ABM simulation of the game "Heroes and Cowards"

Rules of the game: Each player chooses two people at random. One of chosen people is denote as the "friend" and the other as "enemy". The game is played in two ways: cowards and heroes modes.

Cowards mode: you're told to move so as to make sure your friend is always between you and your enemy (i.e. hide from you enemy)

Heroes mode: you're told to move in between their friend and enemy (i.e. protect your friend).

Try out the game in class.

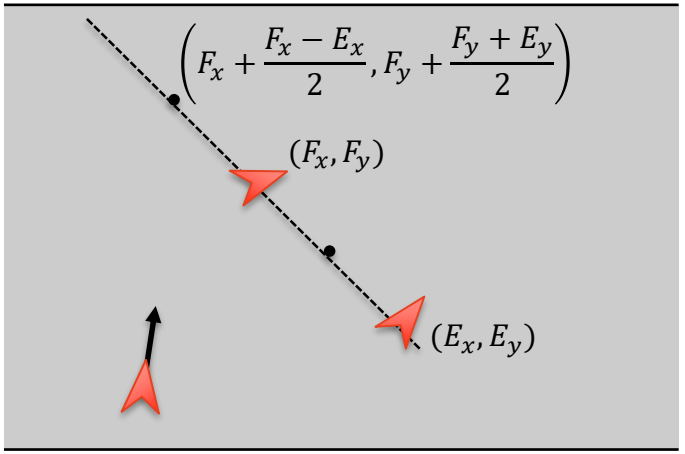
Heroes and Cowards – Tutorial 2

Constructing the ABM

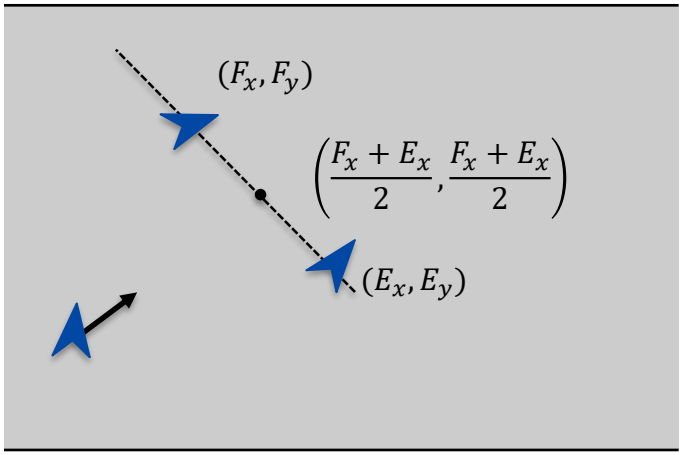
Aspects of the model	
Agent types	
Environment	
Agent behaviour	
Parameters	
Time step	
Measures Visualization	

Implement the model – tutorial 2

Coward heading calculation



Hero heading calculation



Simple Economy – Tutorial 3

Question: What kind of wealth distribution would emerge if agents follow the following simple rules?

Rules: Each person starts with a fixed amount of dollars. At every time step, each person selects another person at random and gives one dollar.

Aspects of the model	
Agent types	
Environment	
Agent behaviour	
Parameters	
Time step	
Measures Visualization	

Implement the model – tutorial 3

Summary

- We've looked at what is agent based modelling and why it is useful.
- We've created three simple agent based models in NetLogo.
  - Interface tab: creating widgets and changing world settings
  - The **setup** procedure
  - The **go** procedure
  - Controlling patches and turtles
  - Using random numbers
  - ….

- *Next week*: let's learn how to modify existing NetLogo models from the model library.

Questions

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