Agent-based Modelling and Simulation 1

some material adapted from slides of
Macal & North 2006

Contents

1. Review linear algebra
2. Intro to agent-based modelling and simulation

Review Linear Algebra

- Magnitudes
- Manipulating vectors (add, multiply, divide, subtract)
- Calculating distances between two points**

Agent-based Modelling and Simulation

What is Agent-based Simulation?

- A simulation with many individual agents
- Each agent follows a simple set of rules
- No central authority or controller
- Time passes by in turns or “time steps”
- Complex “macro-behaviour” emerges from interactions among agents at local level
- Example: Model the mall - Sylvia Park

ABM is not computer graphics

- ABM is visualised using computer graphics

The focus is behaviour

Any given orc could work out… whether it should flee or attack. This produced far more realistic results than orchestrating the motions of digital extras in a scripted, choreographed way.

Economist, 5 March, 2009

The name game

- ABMS has been referred to by many names
  - ABM = Agent-based modelling
  - ABS = Agent-based simulation
  - IBM = Individual-based modelling
- **ABMS** = Agent-based Modelling and Simulation
- Not much in common with software agents
- The word “agent” itself is poorly defined

Why do we need ABMS?

- We need tools to study complexity
- Things are getting more and more complex, like the internet, transportation, networks
- Systems approaching design limits (transportation networks)
- Increasing dependencies in infrastructure such as power, electricity, telephony, social media

Why do we need ABMS?

- Maths is usually a top-down approach
- Because we can now use it!
- Due to increased computational power:
  - We can have larger simulations,
  - longer running times
  - see system states that are temporally (time) distant

Important terminology

- Simple **micro-behaviour** combines to produce complex **macro-behaviour**
- Micro-behaviour of one agent (e.g. a boid) (micro-behaviour **is controlled by rules**)
- Macro-behaviour of the whole group of agents (e.g. a flock of birds or a swarm of bees) (macro-behaviour **emerges**)

Components of an agent-based model simulation

- Consists of:
  - Agents
  - Some kind of environment
  - Interaction rules/topologies
  - Behaviours

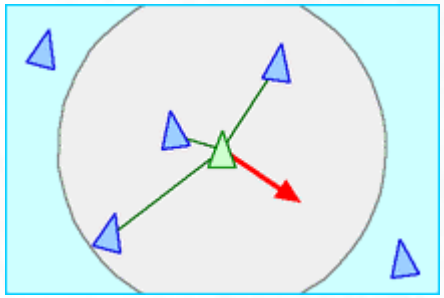
Need to define “agent” somehow

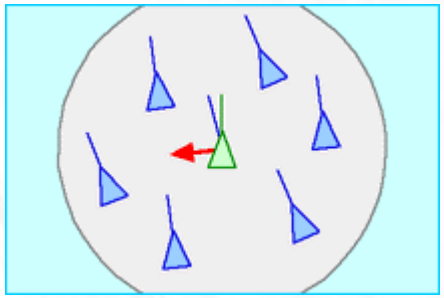
- An agent is some kind of discrete component
- It is autonomous in decision making
  - Examples:
  - People
  - Cars
  - Social insects
  - Systems of collaborating robots
  - Even businesses
- Agents can be diverse and heterogeneous

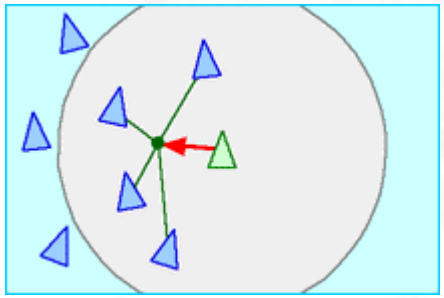
Can't simulate the universe in its entirety

- Assumptions must be made:
  - Key aspects of behaviours defined
  - Interaction mechanisms can be described
  - System is able to be built from the bottom up

Example: Boids and flocking







- **Separation**: steer to avoid crowding local flockmates
- **Alignment:** steer towards the average heading of local flockmates
- **Cohesion**: Steer to move toward the average position of local flockmates

http://www.red3d.com/cwr/boids/

Example: Boids and flocking

- https://www.youtube.com/watch?v=1VtSrOfzifA
- https://www.youtube.com/watch?v=GUkjC-69vaw
- https://www.youtube.com/watch?v=nOxp4E2769w

More on “agent”

- Decision rules can vary by agent
  - Sophistication of rules may be different
  - Memory attributes may differ
  - “thinking” ability may differ
- Good questions to ask in a simulation:
  - Do certain types of agents dominate?
  - Does the system evolve towards some kind of equilibrium?

More on “agent”

- No central authority or controller - very important
- agents operate independently

Other examples

- **Movies** – crowds, battles, orcs, etc
- **Crowd Simulation** – fire-fighter training
- **Military history** – simulations of battles
- **Game Theory** – prisoner's dilemma networks, etc
- **Artificial Life** – "animats" (artificial animals) boids, flocking, predator-prey, etc…