Complex Systems: Agent-based modelling

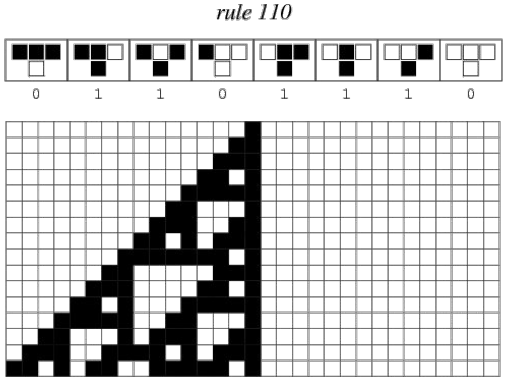
By: Luke Barbano

What is a complex system?

- Broad category for system of many mutually interacting components
- Usually represented as graph
  - network of nodes
  - Links represent interactions
- Features of complex systems:
  - Self-organization
  - Emergence
  - Open
  - Spontaneous disorder (cascading failure)
  - Adaptation (memory)
  - Feedback loops
  - Nonlinearities

Examples of complex systems

- Cellular automata
- Biological cell dynamics
- The economy
- Climate
- Crowds
- Ecosystems



What is agent-based modelling?

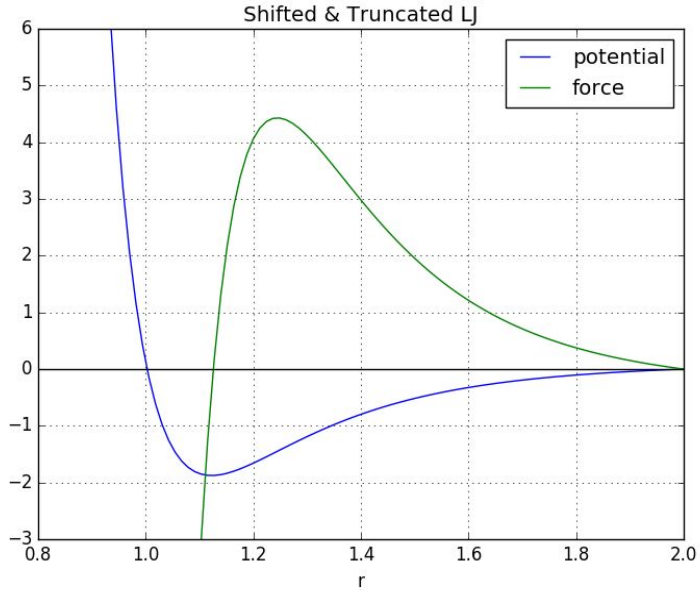
- Approach to recreate complex, collective behavior
- Imbue individual objects with agency
  - objects follow rules
  - rules can come from theory or observations of real physical systems
  - Introduce randomness via monte carlo
- Evolve system in time
- Compare macroscopic behavior to that of real physical system
- Vary the rules to determine which properties are important to the system’s macroscopic behavior

Fire Ants

https://youtu.be/NpiDADw5Omw?t=115

Fire Ants Model

- Ant body is one node
- Ants interact via truncated and shifted Lennard Jones force
- Optional dissipative drag force
- Bugs start on a lattice spaced s.t. they are out of interaction range
- Bugs perturbed slightly off lattice points
- Integrate system of equations OR minimize energy



Fire Ants 2-D simulation!

See Python code

Fin