URBAN STUDIES & PLANNING

USP

USP-E0361

Complex Adaptive Systems

Lecture 3

8.5.2023 Anssi Joutsiniemi

Complexity economics @ SFI 1990's

- Rationality is bounded
- Information is incomplete
- Equilibrium is not achieved
- Reasoning is inductive
- Environment is changing

Related:
**Mitchell Waldrop** (1993). *Complexity - The Emerging Science at the Edge of Order and Chaos*
Murray Gell-Mann (1994). *The Quark and the Jaguar: Adventures in the Simple and the Complex*
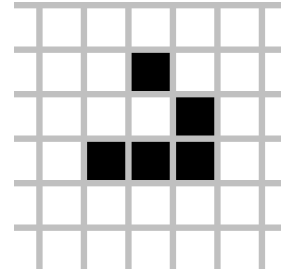**John Holland** (1995). *Hidden Order: How Adaptation Builds Complexity*
John Holland (1998). *Emergence: From Chaos to Order*
Kauffman, Stuart (1993). *The Origins of Order*
**Casti, John** (1994). *Complexification*
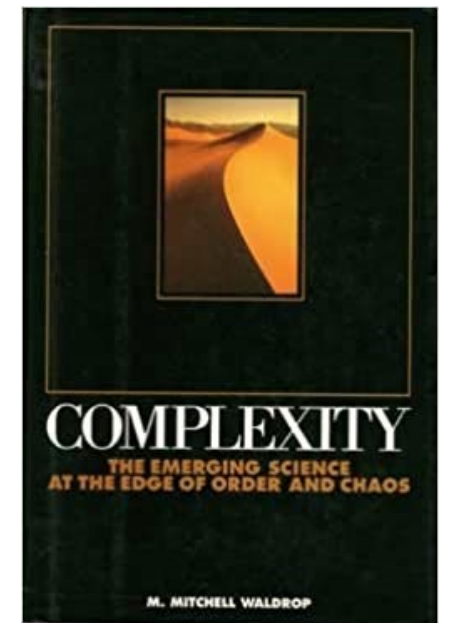
Conway: Game of Life (1970)

Transition rules of automaton:
- Any live cell with fewer than two neighbours dies, as if by loneliness.
- Any live cell with two or three neighbours lives, unchanged, to the next generation.
- Any live cell with more than three neighbours dies, as if by overcrowding.
- Any dead cell with exactly three neighbours comes to life.
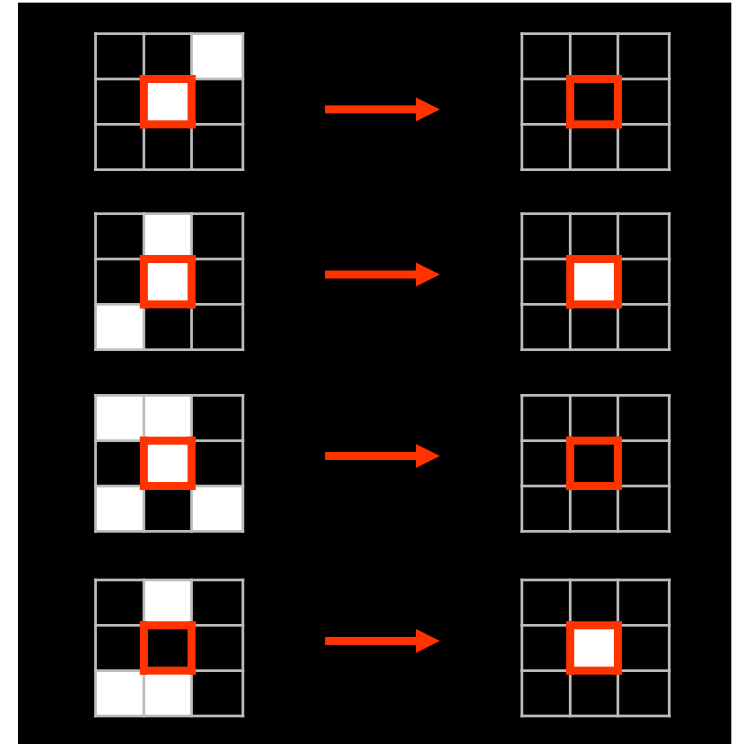
Cellular Automaton (CA)

- John von Neumann:
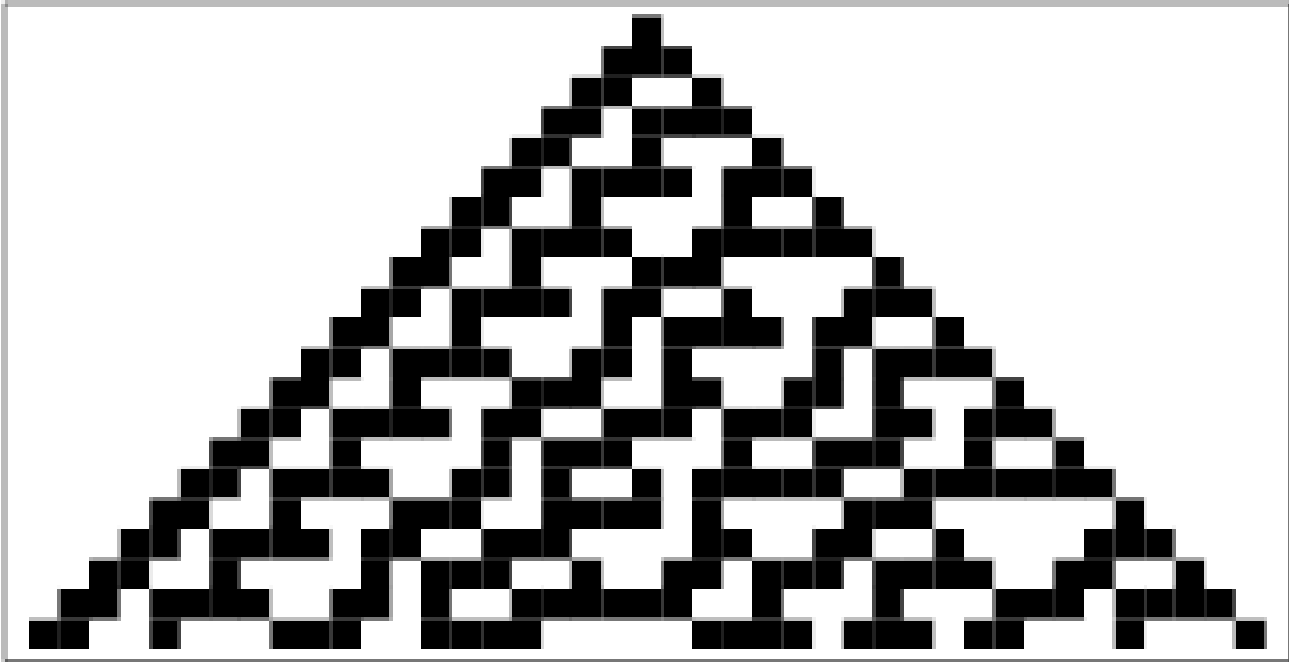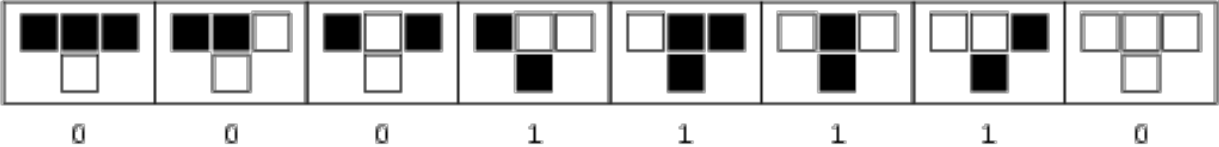 "Problem of self-reproduction" (1948 =>1957)

  - Cell division
  - Finite
  - Determinism
  - Homogenity
  - Local rules

- Lisää esim: http://atlas.wolfram.com/
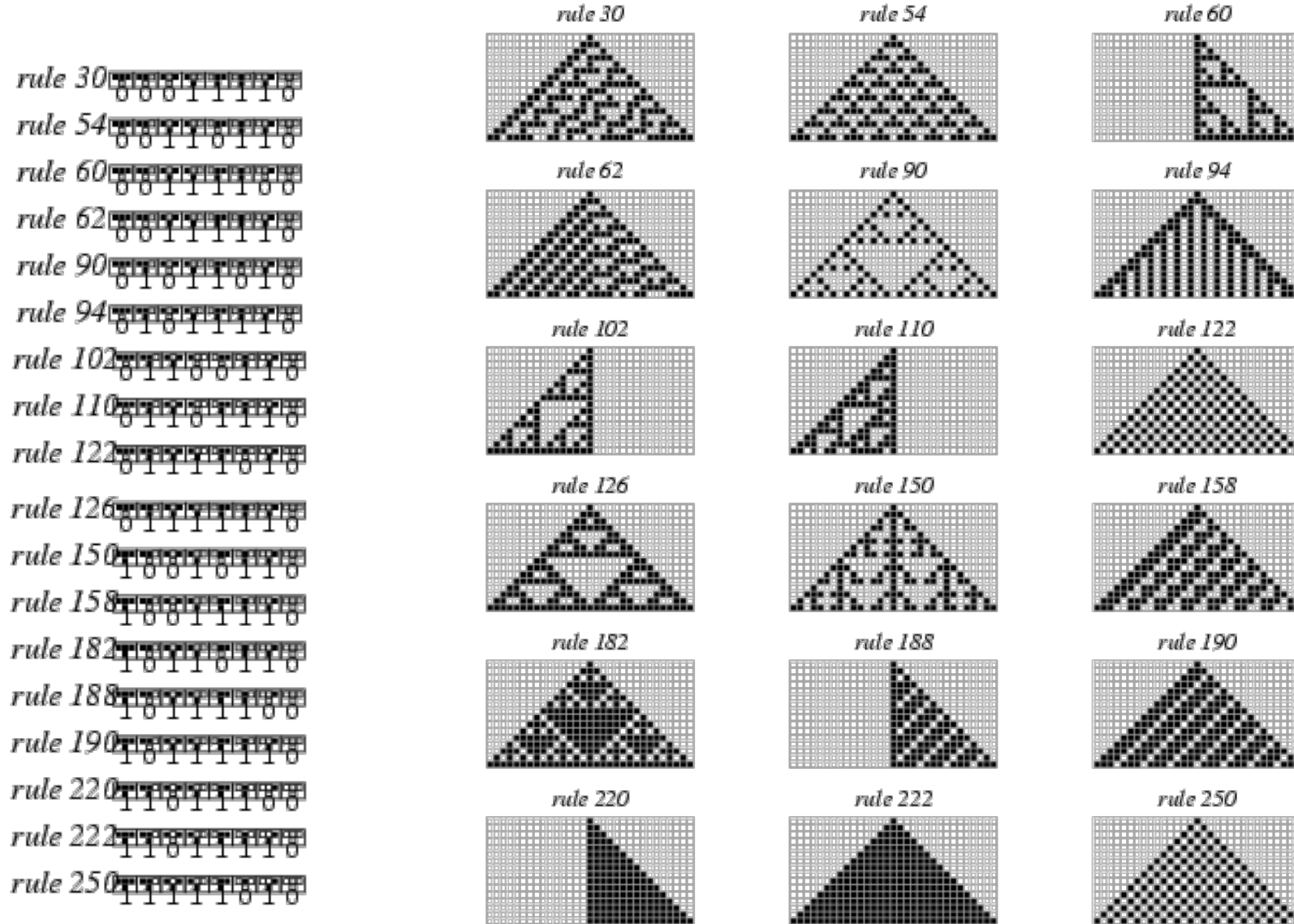
Neighbourhood rules

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1-dimensional cellular automata

Wolfram classes

Class I. CA evolving to a homogeneous state

Class II. CA evolving periodically

-Periodic repeats the same pattern like a loop
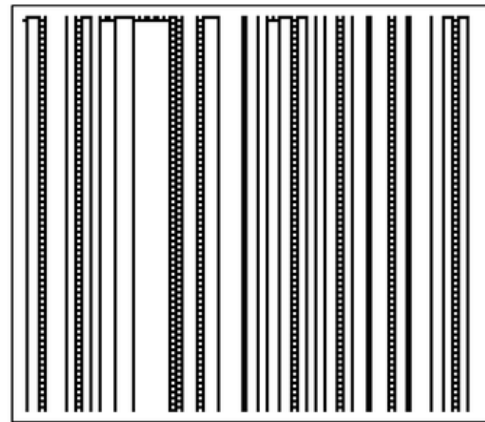
Class III. CA evolving chaotically

-Pseudorandom, fractal pattern

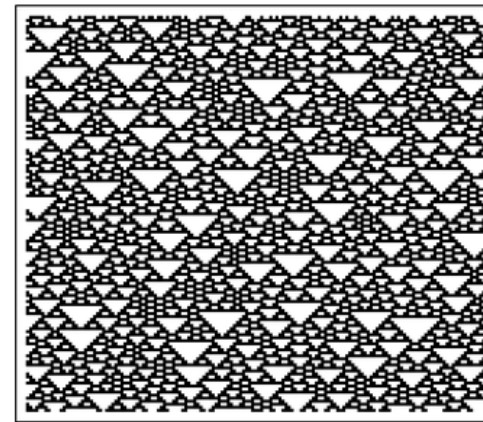**Class IV.** CA evolving according to complex rules

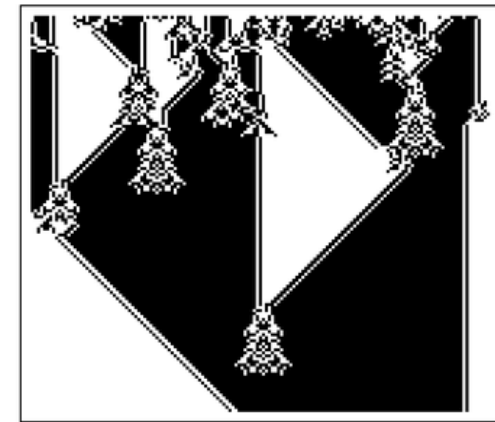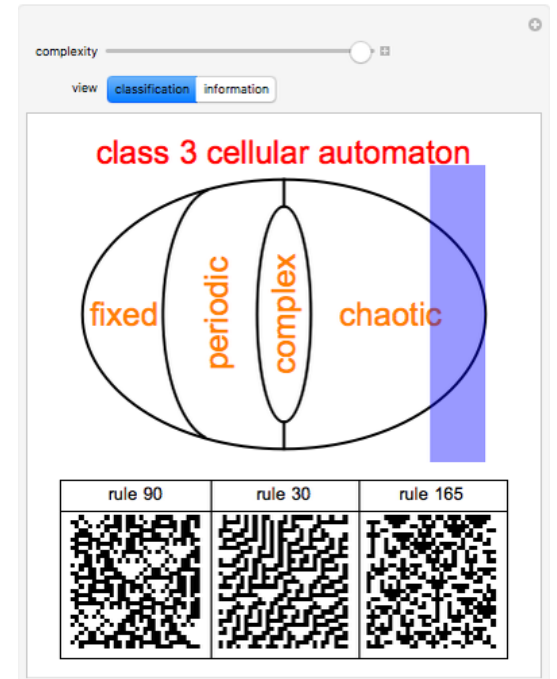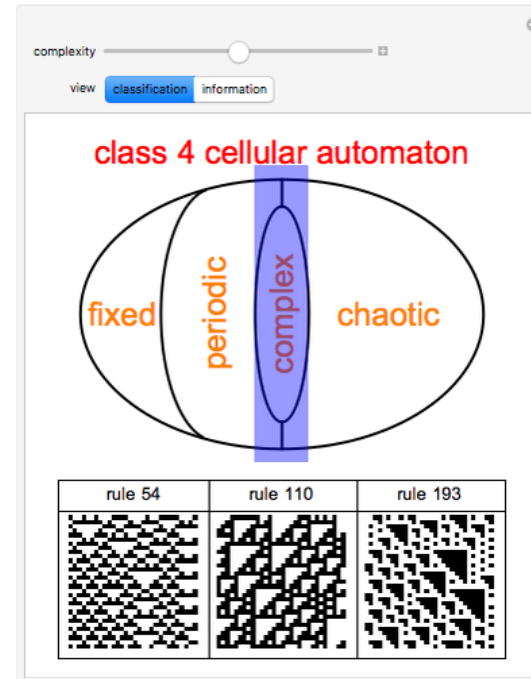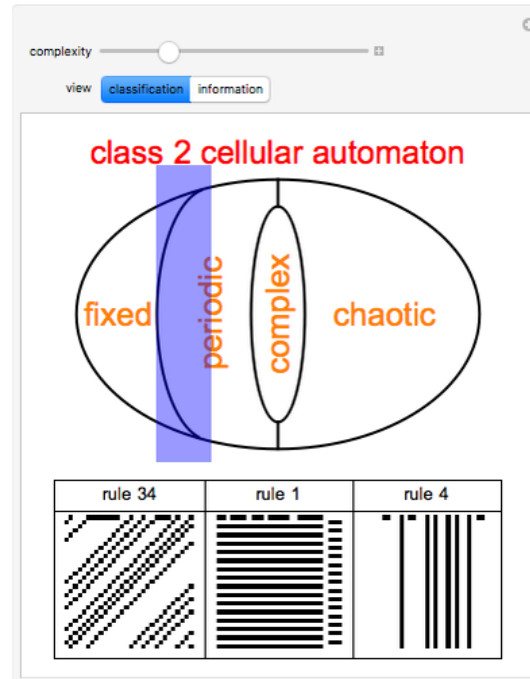-Local structures exhibits behaviors of both II and III

class 1

class 2

class 3

class 4

Wolfram classes
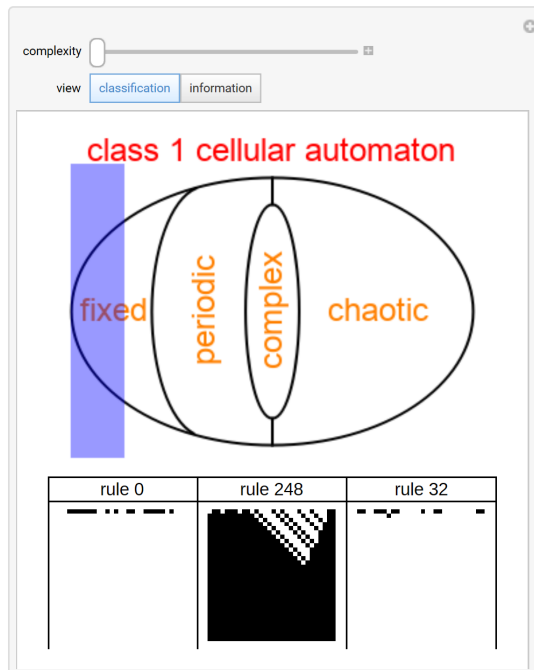
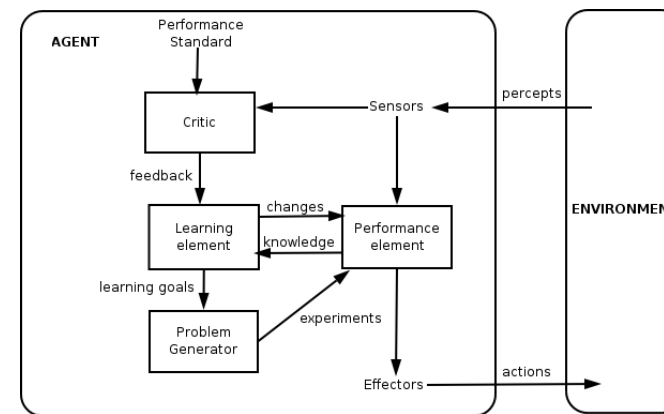# Multi-Agent System   (MAS)
Agent-base Modelling (ABM)

A multi-agent system (MAS) is a computerized system composed of multiple interacting intelligent agents. Despite considerable overlap, a multi-agent system is not always the same as an agent-based model (ABM). The goal of an ABM is to search for explanatory insight into the collective behavior of agents (which don't necessarily need to be "intelligent") obeying simple rules, typically in natural systems, rather than in solving specific practical or engineering problems. The terminology of ABM tends to be used more often in the science, and MAS in engineering and technology.
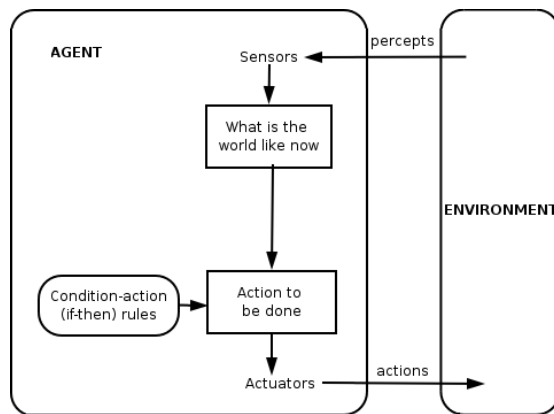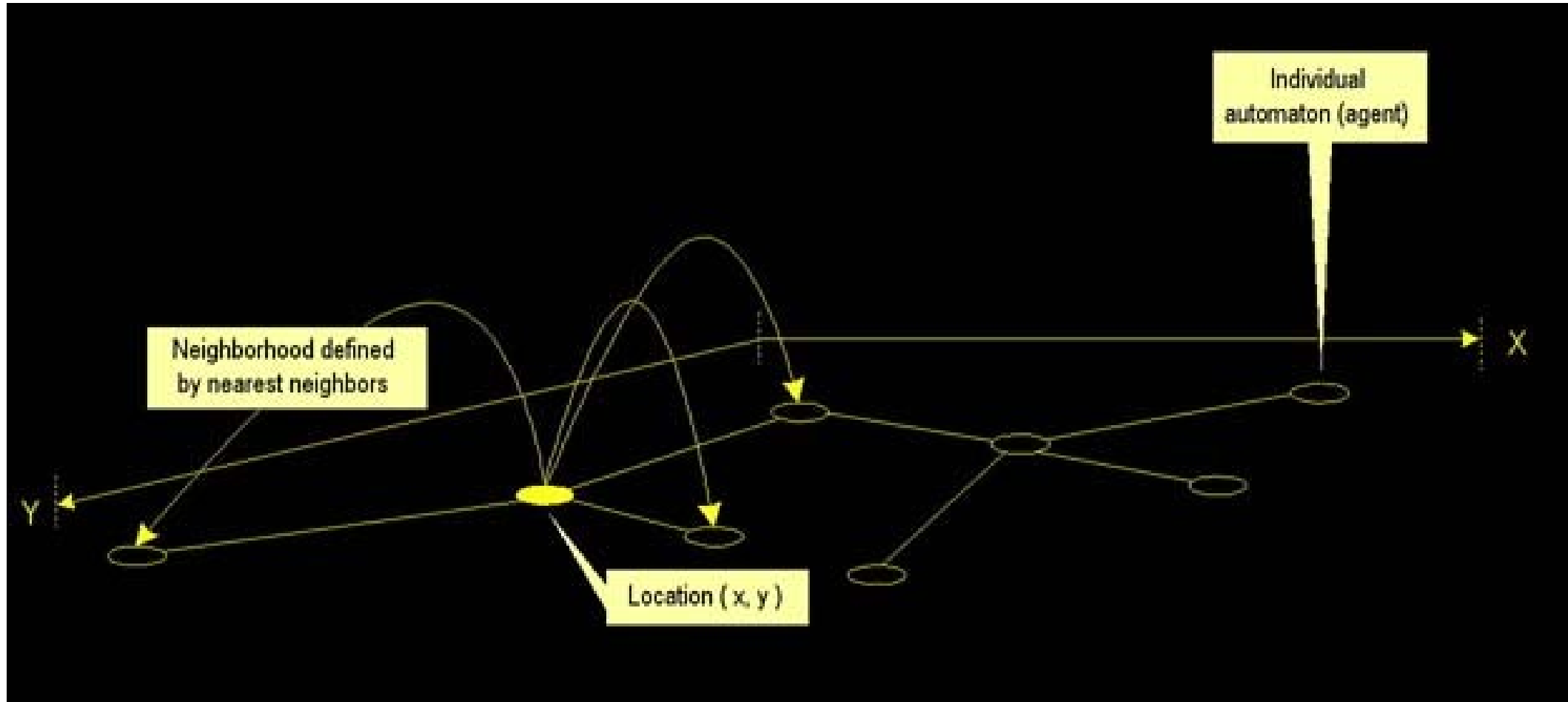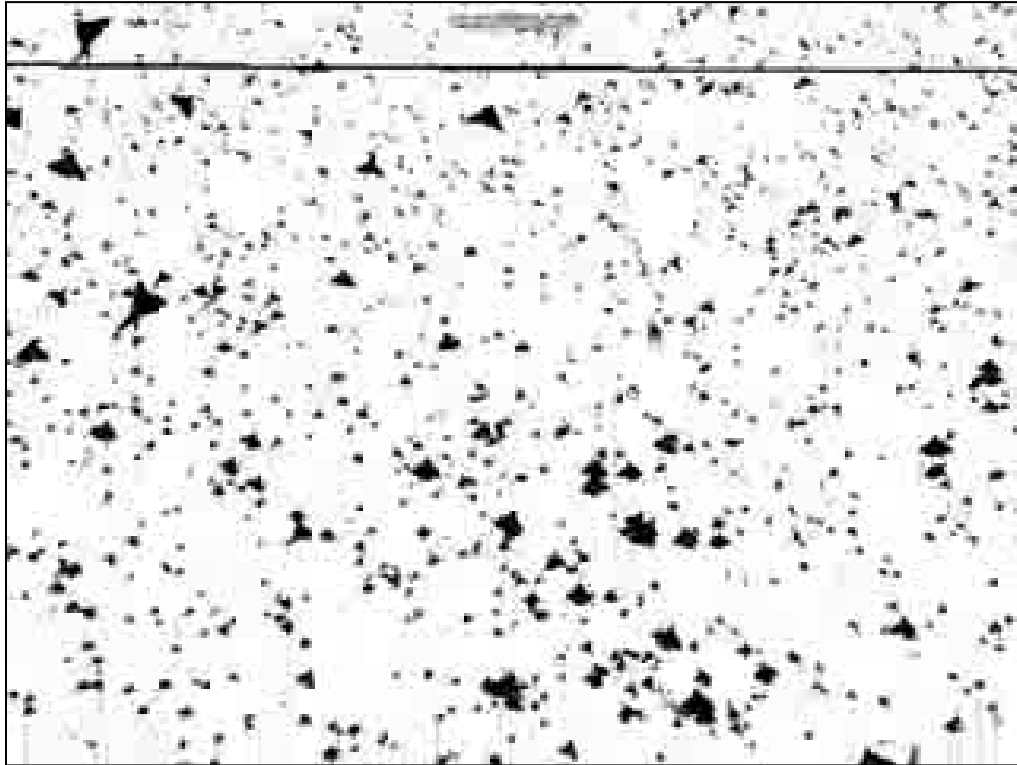

Reflecting agent
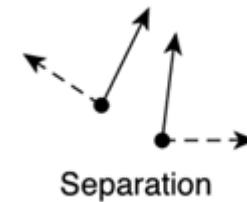
Learning agent

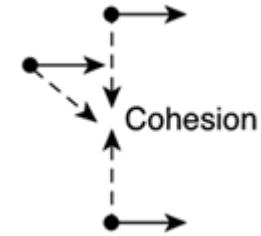# Multi-Agent System (MAS)

MAS rule set...

...is also the base for Craig Raynolds Boids "game"

Boids Rules

- **Cohesion** *(Centrality)*
  ("head toward the centre")

- **Separation** *(Distance)*
  ("keep personal distance")

- **Alignment** *(Direction)*
  ("delineate with others")

Cohesion

Separation

Alignment

Boids links

- https://www.youtube.com/watch?v=bqtqltqcQhw
- https://www.youtube.com/watch?v=QbUPfMXXQIY