CSE/ECE 848
Introduction to
Evolutionary Computation

Module 3 - Lecture 12 - Part 3
Swarm Intelligence and
Particle Swarms

Wolfgang Banzhaf, CSE
John R. Koza Chair in Genetic Programming

CSE/ECE 848 Introduction to
Evolutionary Computation

Swarm Intelligence

- Collective behavior of decentralized, self-organized systems, natural or artificial (Beni and Wang 1989)

- A metaphor for solving distributed problems

- Inspired from the social behavior of insects and animals such as:

  - Swarming

  - Flocking

  - Herding

CSE/ECE 848 Introduction to Evolutionary Computation

Examples in Nature

Fish Schools

Bird Flocks

Herds

CSE/ECE 848 Introduction to
Evolutionary Computation

Swarm Intelligence II

- This behaviour demonstrates

    - Exchange of information

    - Cooperation

    - Self-organization

- What does intelligence have to do with it?

CSE/ECE 848 Introduction to
Evolutionary Computation

Socio-Cognition

The mind is social!

- Human intelligence results from social interaction. By

  - Evaluating one another

  - Comparing one another

  - Imitating one another

  - Learning from experience of another

  - Emulating successful behaviours of one another …

CSE/ECE 848 Introduction to
Evolutionary Computation

Socio-Cognition II

- … people are able to adapt to complex environments through the discovery of relatively optimal patterns of attitudes, beliefs, and behaviours." (Kennedy & Eberhart, 2001)

- Culture and cognition are inseparable consequences of human sociality.

  - Culture emerges as individuals become more similar through mutual social learning.

CSE/ECE 848 Introduction to Evolutionary Computation

Swarms in Fiction
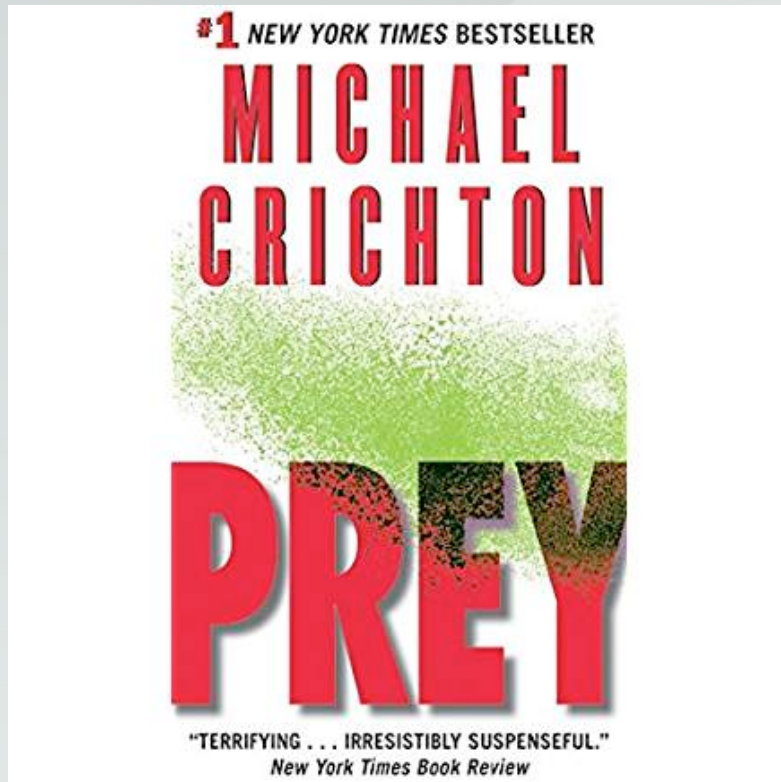
"… Within hours of his arrival at the remote testing center, Jack discovers his wife's firm has created self-replicating nanotechnology — a literal swarm of microscopic machines. Originally meant to serve as a military eye in the sky, the swarm has now escaped into the environment and is seemingly intent on killing the scientists trapped in the facility." (Michael Crichton, 2002)

CSE/ECE 848 Introduction to Evolutionary Computation

Swarm Algorithms

Flocking Behavior (Craig Reynolds, 1987)

- Steer toward center

- Match neighbours' velocity

- Avoid collision

CSE/ECE 848 Introduction to
Evolutionary Computation
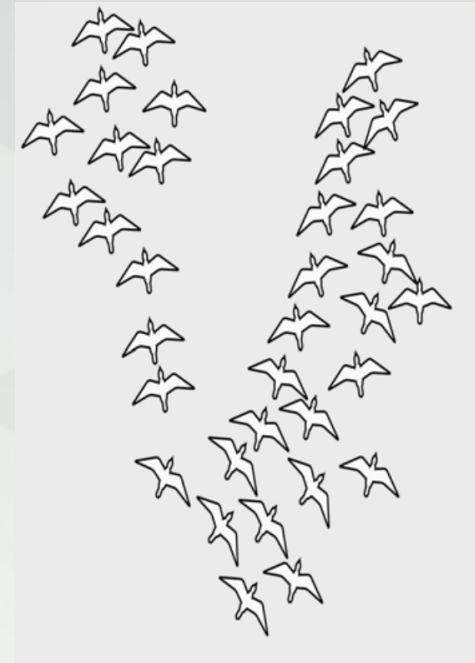
Particle Swarms

"Particle swarm algorithms imitate human (or insect) social behaviour. Individuals interact with one another while learning from their own experience, and gradually the population members move into better regions of the problem space".
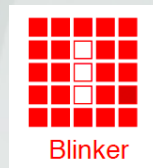

James Kennedy

Russell Eberhart

CSE/ECE 848 Introduction to
Evolutionary Computation

Particle Swarms II

- Particle swarms are closely related to cellular automata (CA)

Blinker

Glider

Game of Life Structures

- Individual cell updates are done in parallel

- Each new cell value depends only on the old value of the cell and its neighbourhood

- All cells are updated using the same rules (Rucker 1999)

- Individuals in a swarm can be conceptualized as cells of a CA whose states change in many dimensions simultaneously.

CSE/ECE 848 Introduction to Evolutionary Computation