A brief introduction to swarm intelligence

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INTELLECTUS (NOUS)

Capacity for
- logic
- abstract thought
- understanding
- self-awareness
- communication
- learning
- emotional knowledge
- memory
- planning
- creativity and problem solving

Source:
INTELLIGENCE IN NATURE

Animals
- Human
- Non-human - g Factor
  - Vertabrates: Mammals, birds, reptiles, fish
  - Cephalopods
  - Arthropods

Plants - Perception?

Neuroscience and intelligence

Human
- Brain volume
- Grey matter
- White matter
- Cortical thickness
- Neural efficiency

Primate
- Brain size

Brain-to-body mass ratio

Source:
https://commons.wikimedia.org/wiki/User:Nhobgood
ARTIFICIAL INTELLIGENCE

Practopoiesis
Conceptual bridge between biological and artificial intelligence.

- Weak AI
- Strong AI

Artificial agent
AI-hard or AI-complete
A LI’L HISTORY

-360
Aristotle described the syllogism, a method of formal, mechanical thought.

1206
Al-Jazari created a programmable orchestra of mechanical human beings

1600
René Descartes proposed that bodies of animals are nothing more than complex machines

1642
Blaise Pascal invented the mechanical calculator, the first digital calculating machine

1769
Wolfgang von Kempelen built and toured with his chess-playing automaton, The Turk

1913
Bertrand Russell and Alfred North Whitehead published Principia Mathematica, which revolutionized formal logic

1931
Kurt Gödel, father of theoretical computer science

1950
Alan Turing proposes the Turing Test as a measure of machine intelligence

1997
The Deep Blue chess machine (IBM) defeats the (then) world chess champion, Garry Kasparov

2005
Blue Brain is born, a project to simulate the brain at molecular detail

2011
IBM’s Watson computer defeated television game show Jeopardy! champions Rutter and Jennings

2011
Apple’s Siri, Google’s Google Now and Microsoft’s Cortana are smartphone apps that use natural language to answer questions, make recommendations and perform actions
AI TOOLS

Search and optimization
Search algorithm, Mathematical optimization and Evolutionary computation

Logic
Logic programming and Automated reasoning

Probabilistic methods for uncertain reasoning
Bayesian network, Hidden Markov model, Kalman filter, Decision theory and Utility theory

Classifiers and statistical learning methods
Classifier (mathematics), Statistical classification and Machine learning

Neural networks
Artificial neural network and Connectionism

Control theory

Languages

Three Laws of Robotics
1) A robot may not injure a human being, or, through inaction, allow a human being to come to harm.

2) A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.

3) A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.
In the radio series and the first novel, a group of hyper-intelligent pan-dimensional beings demand to learn the 

*Answer to the Ultimate Question of Life, The Universe, and Everything*

from the supercomputer, Deep Thought, specially built for this purpose. It takes Deep Thought 7½ million years to compute and check the answer, which turns out to be 42. Deep Thought points out that the answer seems meaningless because the beings who instructed it never actually knew what the Question was.

The Ultimate Question:
What do you get if you multiply six by nine?

The Answer:
6_{13} \times 9_{13} = 42_{13}
Swarm intelligence (SI) is the collective behavior of decentralized, self-organized systems, natural or artificial. Introduced by Gerardo Beni and Jing Wang in 1989, in the context of cellular robotic systems.

Examples in natural systems of SI:
- Ant colonies
- Bird flocking
- Animal herding
- Bacterial growth
- Fish schooling
- Microbial intelligence

Inspiration from Nature
1. Social Insects
   - Natural Navigation
   - Natural Clustering
   - Natural construction
2. Foraging
3. Flocking
**Particle swarm optimization**

Simulating social behaviour.


Ant colony optimization

A probabilistic technique in metaheuristic optimizations.


Source:
https://commons.wikimedia.org/wiki/File:Aco_shortpath.svg
Artificial bee colony algorithm

Intelligent foraging behaviour.


Multi-level thresholding
MR brain image classification
Face pose estimation

Differential evolution

A method that optimizes a problem by iteratively trying to improve a candidate solution.


Parallel computing
Multiobjective optimization
Constrained optimization
**The bees algorithm**

A population-based search algorithm


**Artificial immune systems**

A class of computationally intelligent systems. Adaptive systems.


**Bioinformatics**

Optimisation of classifiers/Clustering systems
Manufacturing
Bioengineering
Multi-objective optimization
Bat algorithm

A metaheuristic optimization algorithm.


Glowworm swarm optimization

The algorithm makes the agents glow at intensities approximately proportional to the function value being optimized.

**Gravitational search algorithm**

Based on the law of gravity and the notion of mass interactions.


**Self-propelled particles**

Predict robust emergent behaviours occur in swarms independent of the type of animal that is in the swarm.


**Stochastic diffusion search**

An agent-based probabilistic global search and optimization technique best suited to problems where the objective function can be decomposed into multiple independent partial-functions.

A comprehensive mathematical framework.


**Multi-swarm optimization**

Use of multiple sub-swarms instead of one (standard) swarm.

Multi-swarm system effectively combines components from Particle swarm optimization, Estimation of distribution algorithm, and Differential evolution into a multi-swarm hybrid.