

## Nature-Inspired Computing

### Swarm Intelligence

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## What is a Swarm?

Definition: swarm is a general sense to refer to any loosely structured collection of interacting agents. (*Santa Fe Institute*)

- has collective motion as well as collective behavior of all kinds

## What is SI ?

Definition 1:

a property of systems of non-intelligent agents exhibiting collectively intelligent behavior (*Beni*)

Definition 2:

algorithms or distributed problem solving devices inspired by the collective behavior of social insect colonies and other animal societies (*Bonabeau, Dorigo, Theraulaz*)

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## Biological Inspiration

- social insects (bees, ants, termites)
- flocks of birds
- herds of mammals
- schools of fish
- packs of wolves
- crowd: swarm of people
- traffic
- economy (swarm of economic agents)
- immune system: swarm of cells
- ...

## Characteristics of a Swarm

- distributed: no central control or data source
- no explicit model of environment
- perception of environment (sensing)
- ability to change environment

## Emergent Behavior

colonies of insects achieve a

- flexible,
- reliable,
- intelligent,
- complex level performance

from insect elements which are

- stereotyped,
- unreliable,
- unintelligent,
- simple.

## Emergent Behavior

- insects
  - follow simple rules,
  - use simple local communication
- global structure (nest) emerges from unreliable actions of many

## Insects

- achieve collective performance not possible by each individual alone
- suitable model for distributed computing
- limited behavioral repertoire for each individual insect
- no individual has access to whole state of colony
  - cannot do effective division of labor
  - cannot guarantee progress of colony

## Insect Societies

- collective decision making systems
  - have direct communication
  - have indirect communication
- ⇒ society self-organizes

## Some Terminology

stigmergy: communication by altering the state of the environment in a way that will affect the behavior of others for whom the environment is a stimulus ⇒ indirect communication

autocatalytic = positive feedback cycle

self-organizing system: no central control, intention of population is distributed throughout its membership; and the members themselves are unaware of the "plan" they are carrying out

## Intelligence

Definition:  
ability to solve problems in some abstract or real domain

Definition:  
ability to produce behavior appropriate for a situation

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## Swarm-Inspired Methods

- ant colony optimization - ACO
- particle swarm optimization - PSO