Part IV: Computational Swarm Intelligence

Computational Intelligence: Second Edition

Treasure Hunting

- **Who?** You and a group of friends
- **What do you know?** Knowledge of the approximate area of the treasure, but not exactly where it is located
- **What do you have?**
  - Metal detector
  - Strength and position of signal of your neighbors' metal detectors
  - Your friends!
- **What is your goal?** To find that treasure, or at least part of it

Treasure Hunting (cont)

- **The agreement:** You have agreed on some sharing mechanism
  - so that all who have taken part in the search will be rewarded,
  - but with the person who found the treasure getting a higher reward than all others, and
  - the rest being rewarded based on distance from the treasure at the time when the first one finds the treasure
- **What will be your actions?**
  - Ignore your friends?
  - Use the information from your neighboring friends?

Group Dynamics / Collective Intelligence

- Some kind of cooperation through the sharing of local information
- Individuals act on the local information, and their actions change the local information
- Information propagates through the entire group
- The group is referred to as a *swarm*

Swarms and Swarm Intelligence

- Definition:
  A swarm can be defined as a group of (generally mobile) agents that communicate with each other (either directly or indirectly), by acting on their local environment
- The interactions between agents result in distributive collective problem-solving strategies
- Swarm intelligence (SI) refers to the problem-solving behavior that emerges from the interaction of such agents
- More formally, swarm intelligence is the property of a system whereby the collective behaviors of unsophisticated agents interacting locally with their environment cause coherent functional global patterns to emerge
- Computational swarm intelligence (CSI) refers to algorithmic models of such behavior

Emergent Bahavior

- Within swarms, individuals are relatively simple in structure, but their collective behavior is usually very complex
- The complex behavior of a swarm is a result of the pattern of interactions between the individuals of the swarm over time
- This complex behavior is not a property of any single individual, and is usually not easily predicted or deduced from the simple behaviors of the individuals
- The complex behavior is referred to as *emergent behavior*

Emergent Bahavior Examples

- Termites build large nest structures with a complexity far beyond the comprehension and ability of a single termite.
- Tasks are dynamically allocated within an ant colony, without any central manager or task coordinator.
- Recruitment via waggle dances in bee species, which results in optimal foraging behavior.
- Foraging behavior in ant colonies as a result of simple trail-following behaviors.
- Birds in a flock and fish in a school self-organize in optimal spatial patterns.

Emergent Bahavior Examples (cont)

- Predators, for example a group of lionesses, exhibit hunting strategies to outsmart their prey.
- Bacteria communicate using molecules (comparable to pheromones) to collectively keep track of changes in their environment.
- Slime moulds consist of very simple cellular organisms with limited abilities. However, in times of food shortage they aggregate to form a mobile slug with the ability to transport the assembled individuals to new feeding areas.

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