Swarm Intelligence

From Natural to Artificial Systems

Asfandyar ali shah
Swarming – The Definition

- aggregation of similar animals, generally cruising in the same direction

- Termites swarm to build colonies
- Birds swarm to find food
- Bees swarm to reproduce
Why do animals swarm?

- To forage better
- To migrate
- As a defense against predators

- Social Insects have survived for millions of years.
Swarming is Powerful

- Swarms can achieve things that an individual cannot
Swarming – Example

- **Bird Flocking**

- “Boids” model was proposed by Reynolds
  - Boids = Bird-oids (bird like)

- Only three simple rules
Collision Avoidance

- Rule 1: Avoid Collision with neighboring birds
Velocity Matching

- Rule 2: Match the velocity of neighboring birds
Flock Centering

Rule 3: Stay near neighboring birds
Swarming - Characteristics

- Simple rules for each individual
- No central control
  - Decentralized and hence robust
- Emergent
  - Performs complex functions
Learn from insects

- Computer Systems are getting complicated

- Swarm intelligence systems are:
  - Robust
  - Relatively simple
Swarm Intelligence - Definition

- “Any attempt to design algorithms or distributed problem-solving devices inspired by the collective behavior of social insect colonies and other animal societies”
- Swarm Solves optimization problems
Applications

- Movie effects
  - Lord of the Rings

- Network Routing
  - ACO Routing

- Swarm Robotics
  - Swarm bots
Particle Swarm Optimization
Particle Swarm Optimization

- Particle swarm optimization imitates human or insects social behavior.
- Individuals interact with one another while learning from their own experience, and gradually move towards the goal.
- It is easily implemented and has proven both very effective and quick when applied to a diverse set of optimization problems.
Ant Colony Optimization - Biological Inspiration

- Inspired by foraging behavior of ants.
- Ants find shortest path to food source from nest.
- Ants deposit pheromone along traveled path which is used by other ants to follow the trail.
- This kind of indirect communication via the local environment is called stigmergy.
- Has adaptability, robustness and redundancy.
Foraging behavior of Ants

- 2 ants start with equal probability of going on either path.
Foraging behavior of Ants

- The ant on shorter path has a shorter to-and-fro time from its nest to the food.
The density of pheromone on the shorter path is higher because of 2 passes by the ant (as compared to 1 by the other).
Foraging behavior of Ants

- The next ant takes the shorter route.
Foraging behavior of Ants

- Over many iterations, more ants begin using the path with higher pheromone, thereby further reinforcing it.
After some time, the shorter path is almost exclusively used.
Conclusion

- Provide heuristic to solve difficult problems
- Has been applied to wide variety of applications
- Can be used in dynamic applications
References


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