SWARM INTELLIGENCE

“The ARTIFICIAL INTELLIGENCE TECHNIQUE ”

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WHAT IS ARTIFICIAL INTELLIGENCE?

- John McCarthy, who coined the term defines it as "the science and engineering of making intelligent machines."

- **Artificial Intelligence (AI)** is the intelligence of machines and the branch of computer science which aims to create it.

- the study and design of **intelligent agents**, which is a system that perceives its environment and takes actions which maximize its chances of success.
Ever changing World

- Environment dynamically changes and can not be framed by calculation or algorithms.
- Till today many Scientists have proposes solutions to cope up with limitations and Exceptions of environment.
- Social insects and birds are successful in surviving for several years and are efficient, flexible and robust.
- Solve many Problems like find food, build the nest, self organize, optimise their path.
Powerful ... but simple

- Swarms build colonies and work in a coordinated manner — yet no single member of the swarm is in control.
- Termites build giant structures.
- Ants manage to find food sources quickly and efficiently.
- Flocks of birds coordinate to move without collision.
- Schools of fish fend off predators and move as one body
Technical systems are getting larger and more complex.  
- Global control hard to define and program  
- Larger systems lead to more errors

Swarm intelligence systems are:  
- Robust  
- Relatively simple (How to program a swarm?)
Swarm Intelligence

- **Swarm intelligence** (SI) as defined by Bonabeau, Dorigo and Theraulaz is "any attempt to design algorithms or distributed problem-solving devices inspired by the collective behavior of social insect colonies and other animal societies“

How To –Think Swarm Intelligence
Modeling

- Reynolds created a "boid" model in 1987 - A distributed behavioral model, to simulates the motion of a flock of birds.
- Each boid is an independent actor that navigates on its own perception of the dynamic environment.

Four Rules of Boid Model

- Avoidance rule
- Copy rule
- Center rule
- View rule
**SEPARATION**

- **Avoidance Rule**
  Indicates repulsion relationship which results in the avoidance of collisions
  (acquire the unfilled space)

**ALIGNMENT**

- **Copy Rule**
  Copying movements of neighbors can be seen as a kind of attraction and needs velocity matching
  (move with the direction of boids)
COHESION

▶ Center rule
   Center rule plays a role in both attraction and repulsion.
   (move to a position which is an average of the neighboring boids)

▶ View rule
   View indicates that a boid should move laterally away from any boid the blocks its view
Principles of Collective Behavior
Homogeneity: every bird in flock has the same behavior model. The flock moves without a leader, even though temporary leaders seem to appear.

- Locality: the motion of each bird is only influenced by its nearest flock mates.

Vision is considered to be the most important senses for flock organization.

- Collision Avoidance: avoid with nearby flock mates.
- Velocity Matching: attempt to match velocity with nearby flock mates.
- Flock Centering: attempt to stay close to nearby flock mates.
Metaheuristic

Most popular Algorithms:

- Particle Swarm Optimization (PSO)
- Ant colony optimization (ACO)
Particle Swarm Optimization (PSO)

- Idea: Used to optimize continuous functions

- PSO is a population-based search algorithm and is initialized with a population of random solutions, called particles.

- The particles have the tendency to fly towards the better and better search area over the course of search process.

- Function is evaluated at each time step for the agent’s current position.
- Each agent “remembers” personal/local best value of the function \((pbest)\).
- Globally best value is known \((gbest)\).
- Both points are attracting the agent and thus an optimized value of the function is calculated.

(a) 

(b) 

a. gbest swarm
b. pbest swarm
Ant Colony Optimization (ACO)

- Is inspired by the behavior of ant colonies.
- Ability of Optimization in finding shortest path.
- Ants leave a chemical pheromone trail.
- Pheromone trails enables them to find shortest paths between their nest and food sources.
- Ants find the shorter path in an experimental setup.
- A bridge leads from a nest to a foraging area, (a) 4 minutes after bridge placement, (b) 8 minutes after bridge placement.
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Main steps of the ACO algorithm are given below:

1. **pheromone trail initialization**
2. **solution construction using pheromone trail**
   
   Each ant constructs a complete solution to the problem according to a probabilistic state transition rule. The state transition rule depends mainly on the state of the pheromone.

3. **pheromone trail update:**
   
   (a) Evaporation phase
   
   (b) Reinforcement phase

4. **process is iterated** until a termination condition is reached.
Applications of SI

- Swarm simulation programming
- Computer Networks
- Data Mining
- Robotics
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