Particle Swarm Optimization

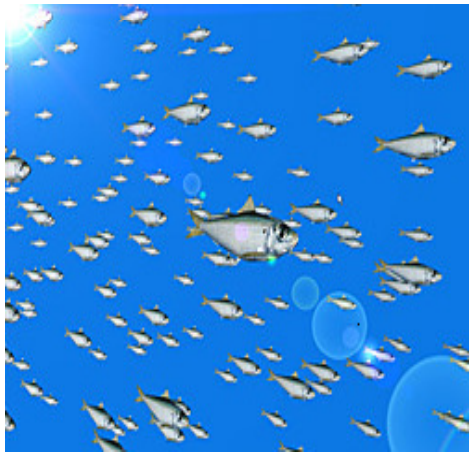
Particle Swarm Optimization Inspiration

Based on bird flocking or fish schooling and swarming theory of A-Life.

About fish schooling: "***In theory at least, individual members of the school can profit from the discoveries and previous experience of all other members of the school during the search for food*** ".

(a sociobiologist E. O. Wilson)

This is the basic concept behind PSO.



The idea behind PSO is the idea to simulate the birds' behavior in finding food through social learning, by observing the behavior of nearby birds who appeared to be near the food source.
Following rules are given to describe behavior of flock (or schools):

Safe-Wandering: The ability of a group of agents to move about while avoiding collisions with obstacles and each other.
Dispersion: The ability of a group of agents to spread out in order to establish and maintain some minimum inter-agent distance.
Aggregation: The ability of a group of agents to gather in order to establish and maintain some maximum inter-agent distance.
Homing: The ability to find a particular place or region.

Kennedy and Eberhart simplified this model to the extent that it would only encompass homing and aggregation without dispersion and Safe-Wandering. The concepts of safe-wandering and dispersion are designed to force each member to move without collision.

1. *The proximity principle*

   The population should be able to carried out simple space and time computations.

2. *The quality principle*

   The population should be able to respond quality factors in the environment.

3. *Principle* of diverse response

The population should not commit its activities along excessively narrow channels.

4. *Principle of stability*

The population should not change its mode of behavior every time the environment changes.

5. *Principle of adaptability*

The population must be able to change behavior mode when its worth the computational price.

- PSO is a dynamic population of active, interactive agents with very little in the way of inherent intelligence
- *PSO does not regard for particular characteristics of any problem*
- Potential solutions make better than random guesses using **Collaborative Trial and Error**

Why Guesses are better than random

- Guesses are better than random because they are informed by social learning.

- Each individual teaches its neighbor, each individual learns from its neighbors.

- PSO uses a population of individuals, to search feasible region of the function space. In this context, the population is called ***swarm*** and the individuals are called ***particles.***

- Though the PSO algorithm has been shown to perform well, researchers have not been able to explain fully how it works yet.

Swarm Movement

New Position = Current Position +
Persistence +
Social Influence

Updated Velocity

rand (0,1), to stop the swarm converging too quickly

Current Velocity

Acceleration factors, can be used to change the weighting between personal and population experience

$$v = v + c_1 r_1 (pbest - current) + c_2 r_2 (gbest - current)$$

This is the cognitive component which draws individuals back to their previous best situations.

This is the social component where individuals compare themselves to others in their group.

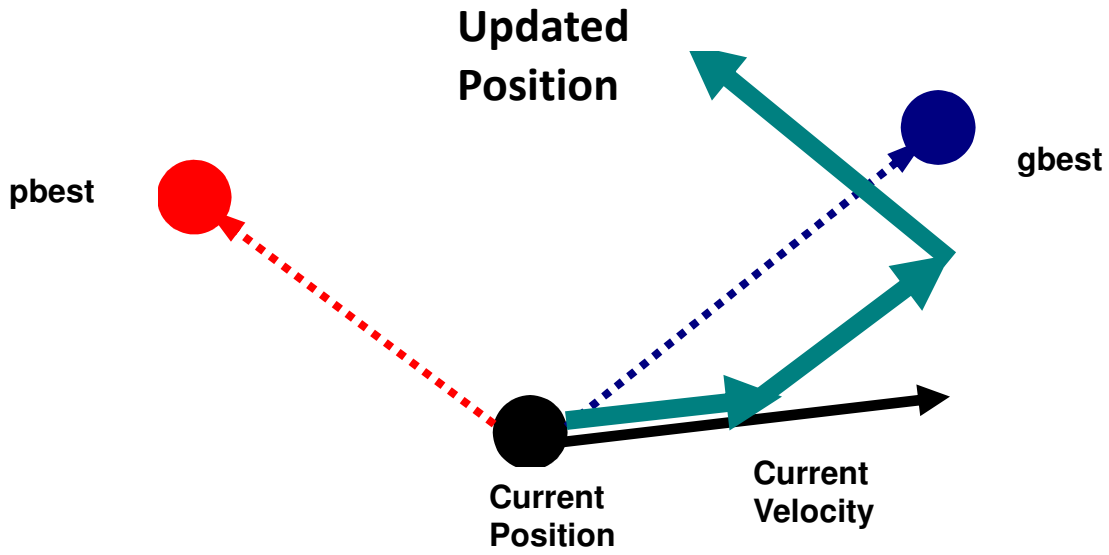
Velocity Update Equation
(Rate of Change in Particle's Position)

$$current = current + v$$ ⟶ Position Update Equation

Basic Flow of PSO

1. Initialize the ***swarm*** from the solution space
2. Evaluate ***fitness*** of individual ***particles***
3. Modify ***gbest***, ***pbest*** and ***velocity***
4. Move each ***particle*** to a new ***position***.
5. **Go to step 2**, and repeat until convergence or a stopping condition is satisfied.

Movement of a particle in the PSO process



Stagnation

If the current position of a particle is identical with the global best position and if the current velocity is a small value, the velocity in next iteration will be smaller. Then the particle will be trapped in this area which leads to premature convergence.

This phenomenon is known as ***stagnation***

Diversity is the Engine that Drives the Algorithm

The system will only run out of energy when all particles have converged to a point

Particle Swarm and Evolutionary Algorithm

- In PSO, the particle has an identity which it retains over time, in form of temporarily linked movement.
- But in Evolutionary algorithm, population members die to be replaced by offspring.

Everyone survive in PSO