Swarm Intelligence: PSO algo.

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Swarm Intelligence

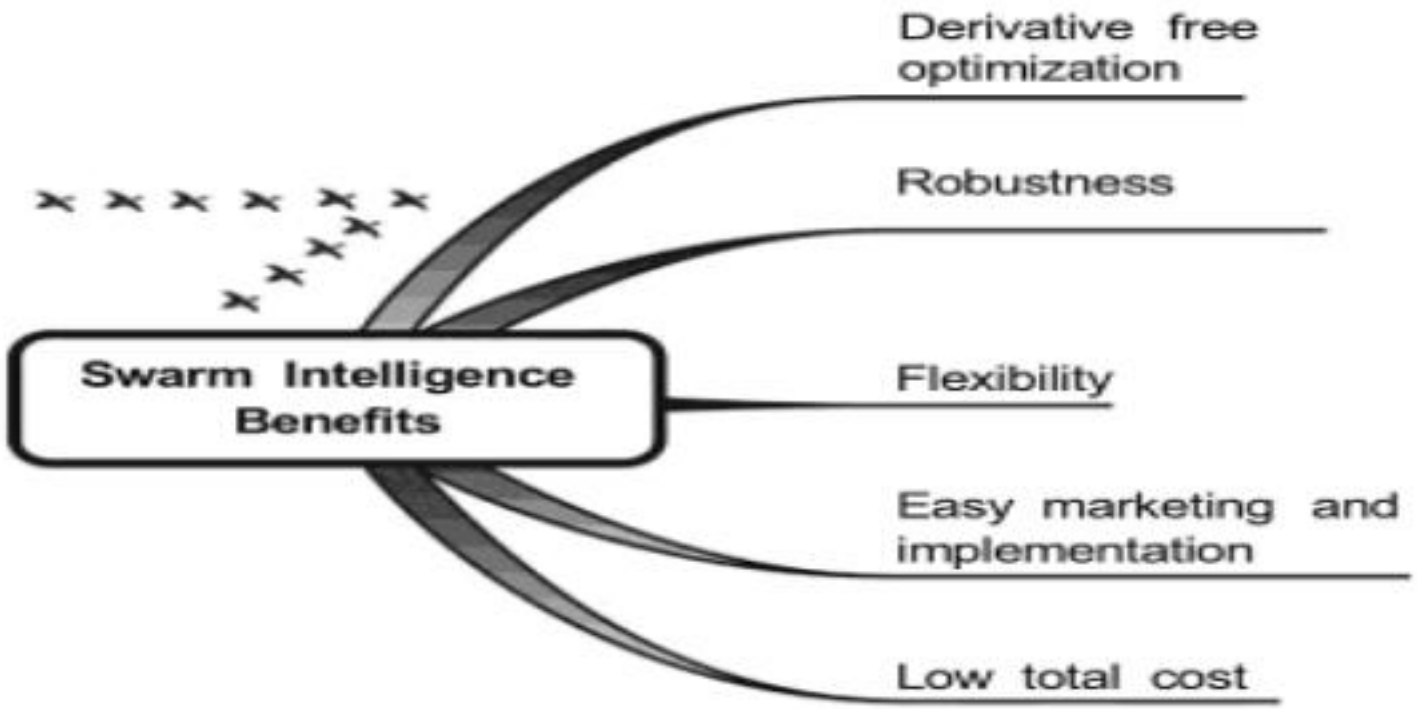
- ✓ **Swarm Intelligence is a branch of Artificial Intelligence where we observe nature and try to learn how different biological phenomena can be imitated in a computer system to optimize the scheduling algorithms**

- ✓ **In swarm intelligence, we focus on the collective behavior of simple organisms and their interaction with the environment.**

- ✓ **SI systems consist typically of a population of simple agents or boids interacting locally with one another and with their environment. The inspiration often comes from nature, especially biological systems.**
  - ➢ **Boids is an artificial life program, which simulates the flocking behaviour of birds.The name "boid" corresponds to a shortened version of "bird-oid object".**

- ✓ **The agents follow very simple rules, and although there is no centralized control structure dictating how individual agents should behave.**

Swarm Intelligence



- **It can offer possible optimized solutions ensuring high robustness, flexibility and low cost. Moreover, they can solve large-scale sophisticated problems without a centralized control entity.**

Two Types of Optimization Algorithms In Swarm Intelligence

- ✓ The first one is Ant Colony Optimization(ACO). Here the algorithm is based on the collective behavior of ants in their colony.

- ✓ The second technique is Particle Swarm Optimization(PSO).

Particle Swarm Optimization (PSO).History

- ✓ **PSO is originally attributed to Dr:Eberhart, Kennedy and Shi and was first intended for simulating social behaviour, as a stylized representation of the movement of organisms in a bird flock or fish school.**

- ✓ **The algorithm was simplified and it was observed to be performing optimization.**

bird flock

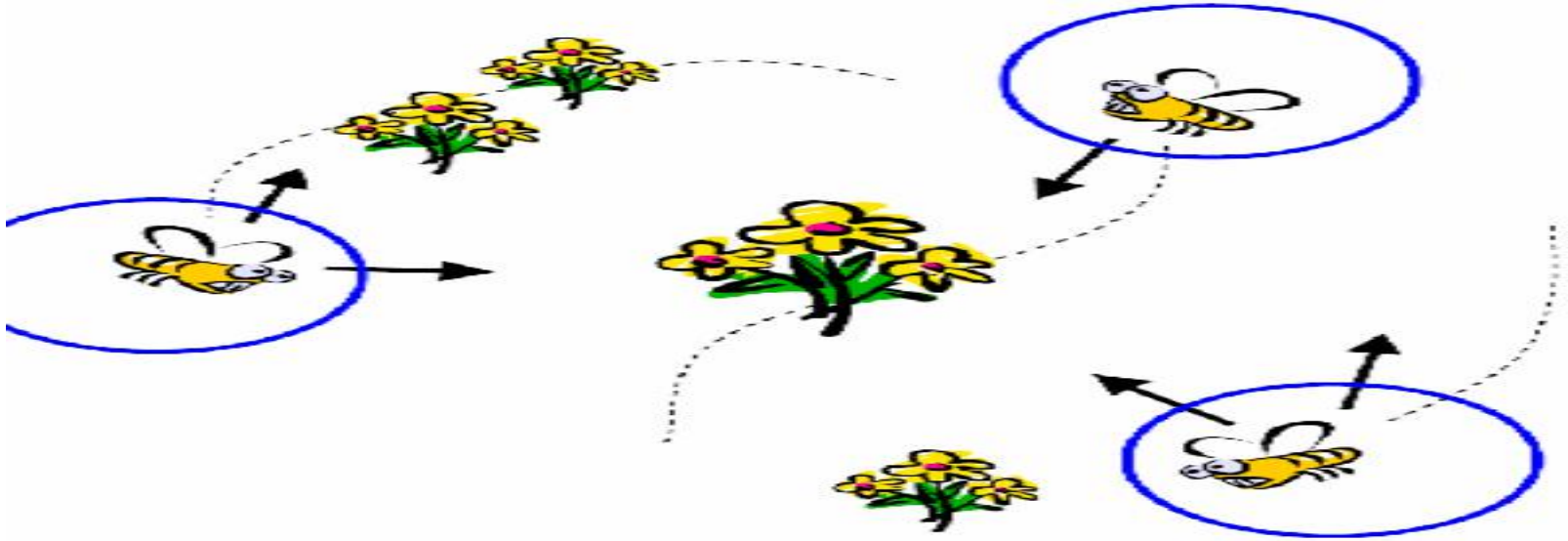
fish school

Particle Swarm Optimization (PSO).concepts

- ✓ **PSO is a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality.**
- ✓ **It solves a problem by having a population of candidate solutions, here dubbed particles.**
- ✓ **moving these particles around in the search-space according to simple mathematical formulae over the particle's position and velocity.**
- ✓ **Each particle's movement is influenced by its local best known position.**
- ✓ **is also guided toward the best known positions in the search-space, which are updated as better positions are found by other particles. This is expected to move the swarm toward the best solutions.**

Particle Swarm Optimization (PSO).Example

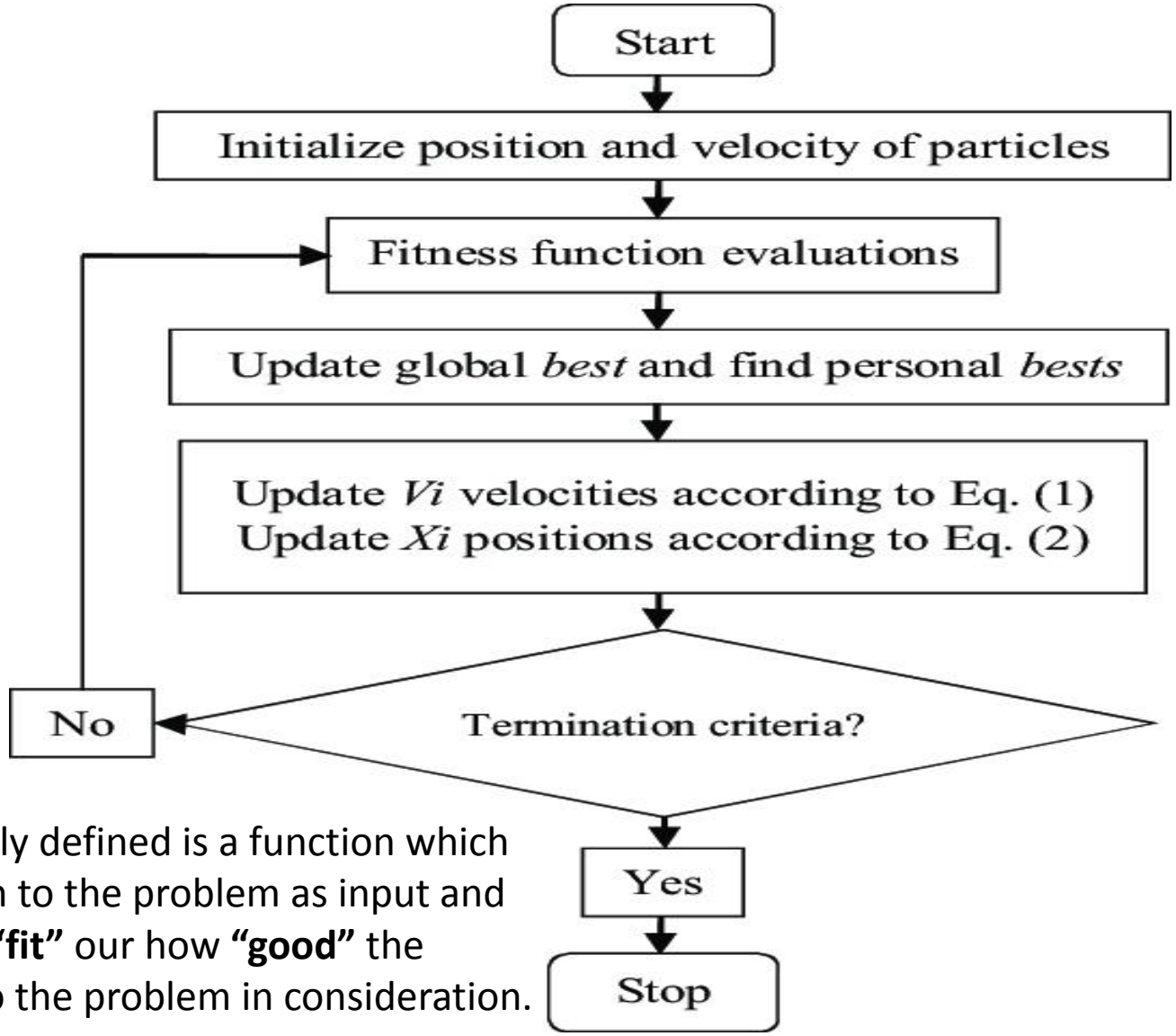
- **When a swarm of bees spreads in a field of flowers, they are often concentrated in the densest area of flowers. Bees arrive at this area by applying the algorithm to optimize the swarm elements. That is, they are initially spread in the field so that each bee records the heavier area with flowers. Then each bee moves randomly, if it finds a denser area that has updated its information, and so on. Upon completion of the random search. Each bee announces what if any. Then the bees swarm to the best of the existing and during the direction of each bee scans the road leading to the optimal area. If you find better, tell the**



Particle Swarm Optimization (PSO).Algorithm

- ✓ **A basic variant of the PSO algorithm works by having a population (called a swarm) of candidate solutions (called particles).**
- ✓ **These particles are moved around in the search-space according to a few simple formulae.**
- ✓ **The movements of the particles are guided by their own best known position in the search-space as well as the entire swarm's best known position.**
- ✓ **When improved positions are being discovered these will then come to guide the movements of the swarm.**
- ✓ **The process is repeated and by doing so it is hoped, but not guaranteed, that a satisfactory solution will eventually be discovered.**

Particle Swarm Optimization (PSO).Algorithm



- The **fitness function** simply defined is a function which takes a candidate solution to the problem as input and produces as output how **"fit"** our how **"good"** the solution is with respect to the problem in consideration.

Key Assumptions

1. let $f: R^n \rightarrow R$ be the cost function which must be minimized
2. The goal is to find a solution $\underline{x}$ for which $f(X) \leq f(y)$ for all $\underline{y}$ in the search-space, which would mean $\underline{X}$ is the global minimum.
3. Let S be the number of particles in the swarm.
4. Each Particles having a position $\underline{x_i} \in R^n$ in the search-space (at any moment).
5. Each Particles having a velocity $\underline{v_i} \in R^n$.
6. Let $\underline{p_i}$ be the best known position of particle i
7. Let $\underline{g}$ be the best known position of the entire swarm.
8. The values b_{lo} and b_{up} represents the lower and upper boundaries of the search-space
9. The termination criterion can be the number of iterations performed, or a solution where the adequate objective function value is found.
10. The parameters ω, ϕ_p, and ϕ_g are selected by the practitioner and control the behaviour and efficacy of the PSO method.
11. ω :The Inertia Weight determines the contribution rate of a particle's previous velocity to its velocity at the current time step (In order to balance global and local search).
12. This velocity regulation aims to achieve a balance between exploration and exploitation. The most common methods to regulate the velocity are the inertia weight and constriction factor.

A basic PSO algorithm

for each particle i = 1, ..., S **do**
  Initialize the particle's position with a uniformly distributed random vector: $\mathbf{x_i} \sim \mathbf{U(b_{lo}, b_{up})}$
  Initialize the particle's best known position to its initial position: $\mathbf{p_i} \leftarrow \mathbf{x_i}$
 if $f(p_i) < f(g)$ **then**
    update the swarm's best known position: $\mathbf{g} \leftarrow \mathbf{p_i}$
  Initialize the particle's velocity: $\mathbf{v_i} \sim \mathbf{U(-|b_{up}-b_{lo}|, |b_{up}-b_{lo}|)}$
while a termination criterion is not met **do**:
 for each particle i = 1, ..., S **do**
  for each dimension d = 1, ..., n **do**
    Pick random numbers: $\mathbf{r_p, r_g} \sim \mathbf{U(0,1)}$
    Update the particle's velocity: $\mathbf{v_{i+1,d+1}} \leftarrow \omega\, \mathbf{v_{i,d}} + \phi_p\, \mathbf{r_p}\, (\mathbf{p_{i,d}} - \mathbf{x_{i,d}}) + \phi_g\, \mathbf{r_g}\, (\mathbf{g_d} - \mathbf{x_{i,d}})$
  Update the particle's position: $\mathbf{x_{i+1}} \leftarrow \mathbf{x_i} + \mathbf{v_{i+1}}$
  if $f(x_i) < f(p_i)$ **then**
    Update the particle's best known position: $\mathbf{p_i} \leftarrow \mathbf{x_i}$
   if $f(p_i) < f(g)$ **then**
    Update the swarm's best known position: $\mathbf{g} \leftarrow \mathbf{p_i}$

Inertia effect

Global search, Social influence

Local search, personal influence

$\phi_p = \phi_g = 2$ are the learning factor. ω is the inertia weight

Parameter selection

- **The choice of PSO parameters can have a large impact on optimization performance. Selecting PSO parameters that yield good performance has therefore been the subject of much research.**

- **The PSO parameters can also be tuned by using another overlaying optimizer, a concept known as meta-optimization, or even fine-tuned during the optimization, e.g., by means of fuzzy logic.**

- **Parameters have also been tuned for various optimization scenarios.**

Neighbourhoods and topologies

- **The topology of the swarm defines the subset of particles with which each particle can exchange information.The basic version of the algorithm uses the global topology as the swarm communication structure.**

- **This topology allows all particles to communicate with all the other particles, thus the whole swarm share the same best position g from a single particle.**

- **this approach might lead the swarm to be trapped into a local minimum, thus different topologies have been used to control the flow of information among particles.**

- **A commonly used swarm topology is the ring, in which each particle has just two neighbours, but there are many others.The topology is not necessarily static. In fact, since the topology is related to the diversity of communication of the particles, some efforts have been done to create adaptive topologies (SPSO, APSO, stochastic star TRIBES, Cyber Swarm, and C-PSO)**

The Advantages and Disadvantages of PSO

Advantages	Disadvantages
1. It can be applied into both scientific research and engineering use. 2. PSO have no overlapping and mutation calculation. 3. The calculation in PSO is very simple. 4. PSO adopts the real number code, and it is decided directly by the solution. The number of the dimension is equal to the constant of the solution.	1. The method easily suffers from the partial optimism, which causes the less exact at the regulation of its speed and the direction. 2. The method can not work out the problems of scattering and optimization(Chen Yonggang,Yang Fengjie,Sun Jigui ,2006,(In Chinese)). 3. The method can not work out the problems of non-coordinate system, such as the solution to the energy field and the moving rules of the particles in the energy field

COMPARISON OF GENETIC ALGORITHM AND PARTICLE SWARM OPTIMISATION

- Both GAs and PSO can be used in the optimisation of parameters during model identification. In terms of computational effort, the GA approach is faster, although it should be noted that neither algorithm takes what can be considered an unacceptably long time to determine their results. With respect to accuracy of model parameters, the GA determines values which are closer to the known values than does the PSO.

  Finally, the GA seems to arrive at its final parameter values in fewer generations than the PSO.

  Thus it must be concluded that for the process of process modelling, the GA approach is superior to the PSO approach.

- Techniques such as PSO and Genetic Algorithms are inspired by nature, and have proved themselves to be effective solutions to optimization problems. However, these techniques are not a panacea, despite their apparent robustness. There are control parameters involved in these meta-heuristics.

COMPARISON OF GENETIC ALGORITHM AND PARTICLE SWARM OPTIMISATION.Con

GENETIC ALGORITHM	PARTICLE SWARM OPTIMIZATION
1.Weak solutions also give contribution to find the actual solution.	1.Generally Knowledge of the best Particles contribute to find the solution.
2.Coding for Chromosome Required.	2.No Coding as such.
3.Crossover,Mutation happen.	3.Change of Velocity and Direction.
4.Hard To Implement.	4.very easy to Implement.
5.Faster.	5.Slower.
6.Gives better results.	6.Give Good Results but not Like GA

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THANKS !