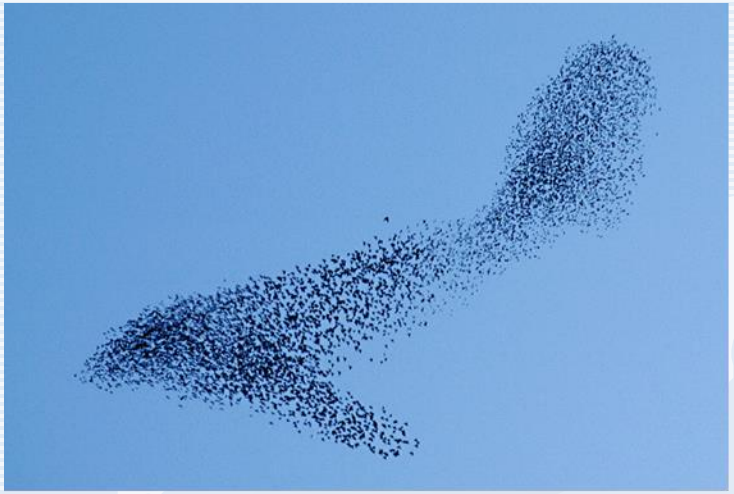
# CHAPITRE V
# Particle Swarm Optimization



# Particle Swarm Optimization (PSO)

- PSO is stochastic optimization technique proposed by Kennedy and Eberhart ( 1995) [2].

- A population based search method with position of particle is representing solution and Swarm of particles as searching agent.

- PSO is a robust evolutionary optimization technique based on the movement and intelligence of swarms.

- PSO find the minimum value for the function.

# Particle Swarm Optimization (PSO)

- The idea is similar to bird flocks searching for food.
  - Bird = a particle, Food = a solution
  - *pbest* = the best solution (fitness) a particle has achieved so far.
  - *gbest* = the global best solution of all particles within the swarm

# PSO Search Scheme

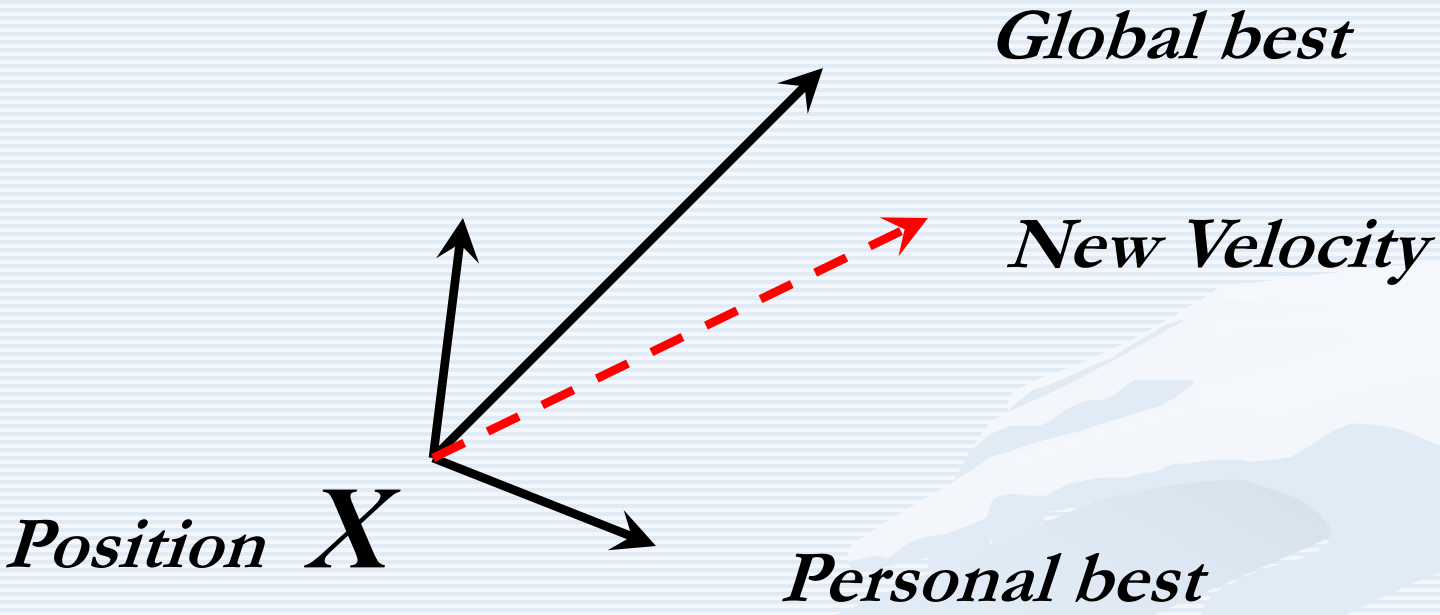
- **pbest** : the best solution achieved so far by that particle.
- **gbest** : the best value obtained so far by any particle in the neighborhood of that particle.

- The basic concept of PSO lies in accelerating each particle toward its pbest and the gbest locations, with a random weighted acceleration at each time.

# PSO Search Scheme

- PSO uses a number of agents, i.e., particles, that constitute a swarm flying in the search space looking for the best solution.

- Each particle is treated as a point (candidate solution) in a N-dimensional space which adjusts its "flying" according to its own flying experience as well as the flying experience of other particles.


Global best
New Velocity
Position X
Personal best

# Particle Swarm Optimization (PSO)

Each particle tries to modify its position $X$ using the following formula:

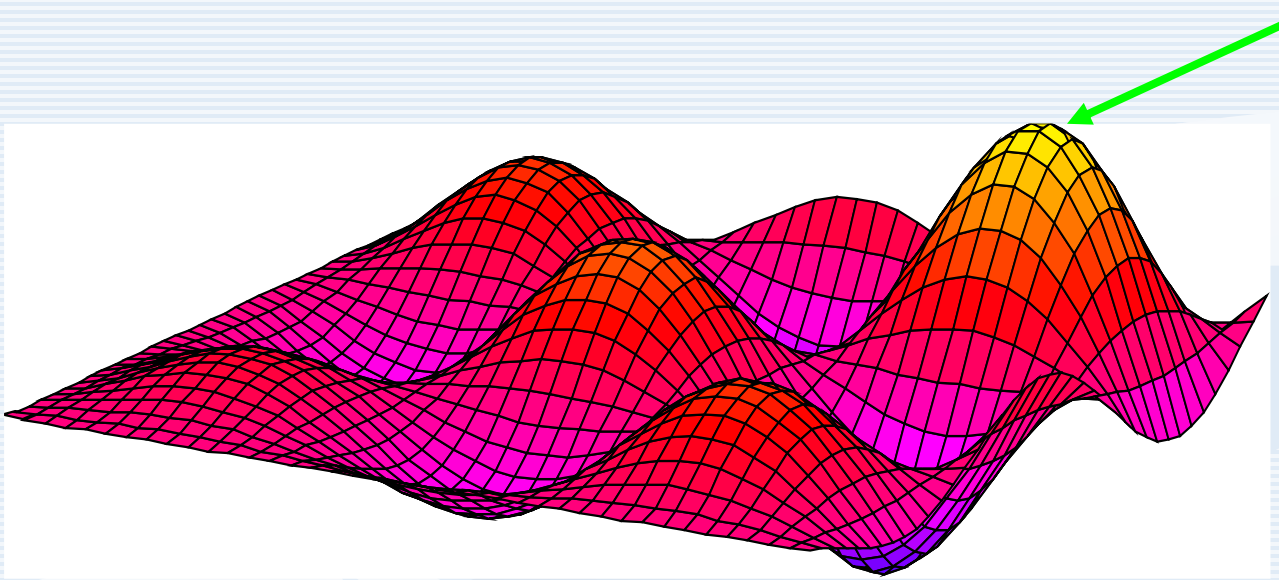
$$X(t+1) = X(t) + V(t+1) \quad (1)$$

$$V(t+1) = wV(t) + c_1 \times rand(\,) \times (X_{pbest} - X(t)) + c_2 \times rand(\,) \times (X_{gbest} - X(t)) \quad (2)$$

| | |
|---|---|
| $V(t)$ | velocity of the particle at time t |
| $X(t)$ | Particle position at time t |
| $w$ | Inertia weight |
| $c_1$ , $c_2$ | learning factor or accelerating factor |
| rand | uniformly distributed random number between 0 and 1 |
| $X_{pbest}$ | particle's best position |
| $X_{gbest}$ | global best position |

# Alpine function

$$f(x_1,\ldots,x_D) = \sin(x_1)\ldots\sin(x_D)\sqrt{x_1\ldots x_D}$$



**Particle fly and search for the highest peak in the search space**

# PSO Algorithm

**The PSO algorithm pseudocode [2] as following:**

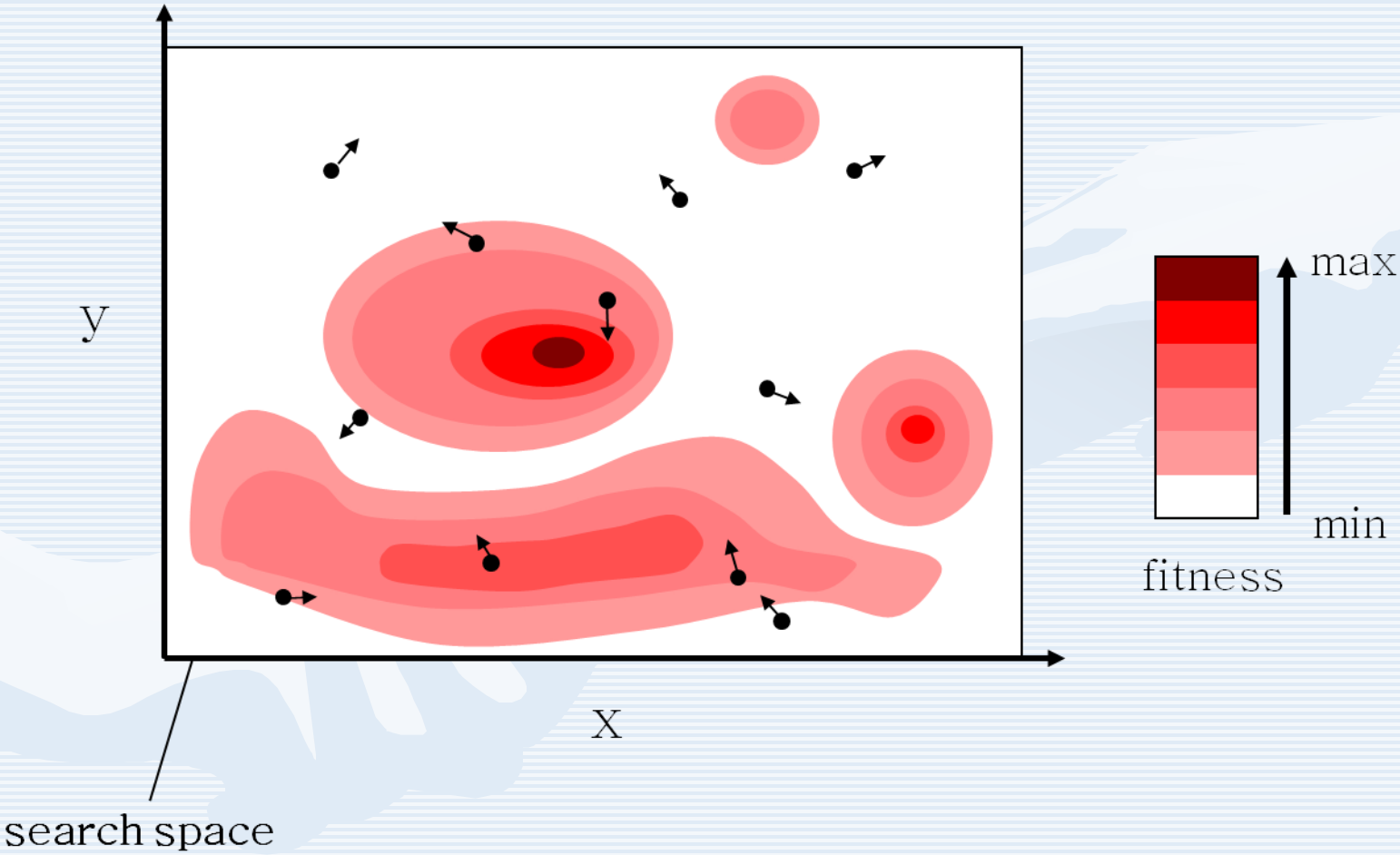
**initialization**: Randomly initialized position and velocity of Particles:

$Xi_{(0)}$ and $Vi_{(0)}$

**Output**: Position of the approximate global optimum $X^*$

1: **while** terminating condition is not reached do
2: **for** $i$ = 1 to *number of particles* **do**
3: Calculate the fitness function $f$
4: Update personal best and global best of each particle
5: Update velocity of the particle using Equation 2
6: Update the position of the particle using equation 1
7: **end for**
8: **end while**

# PSO Algorithm - Example



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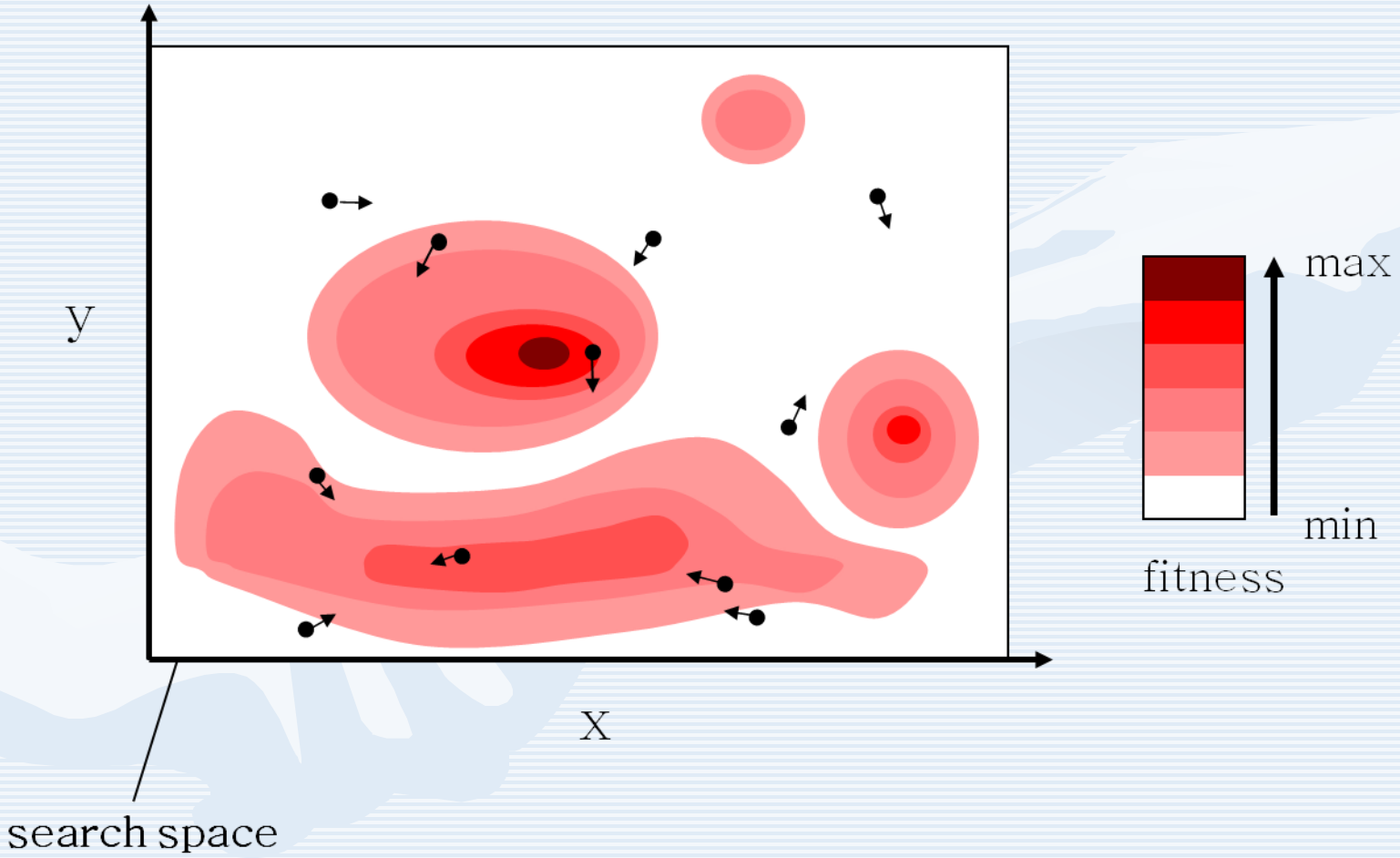

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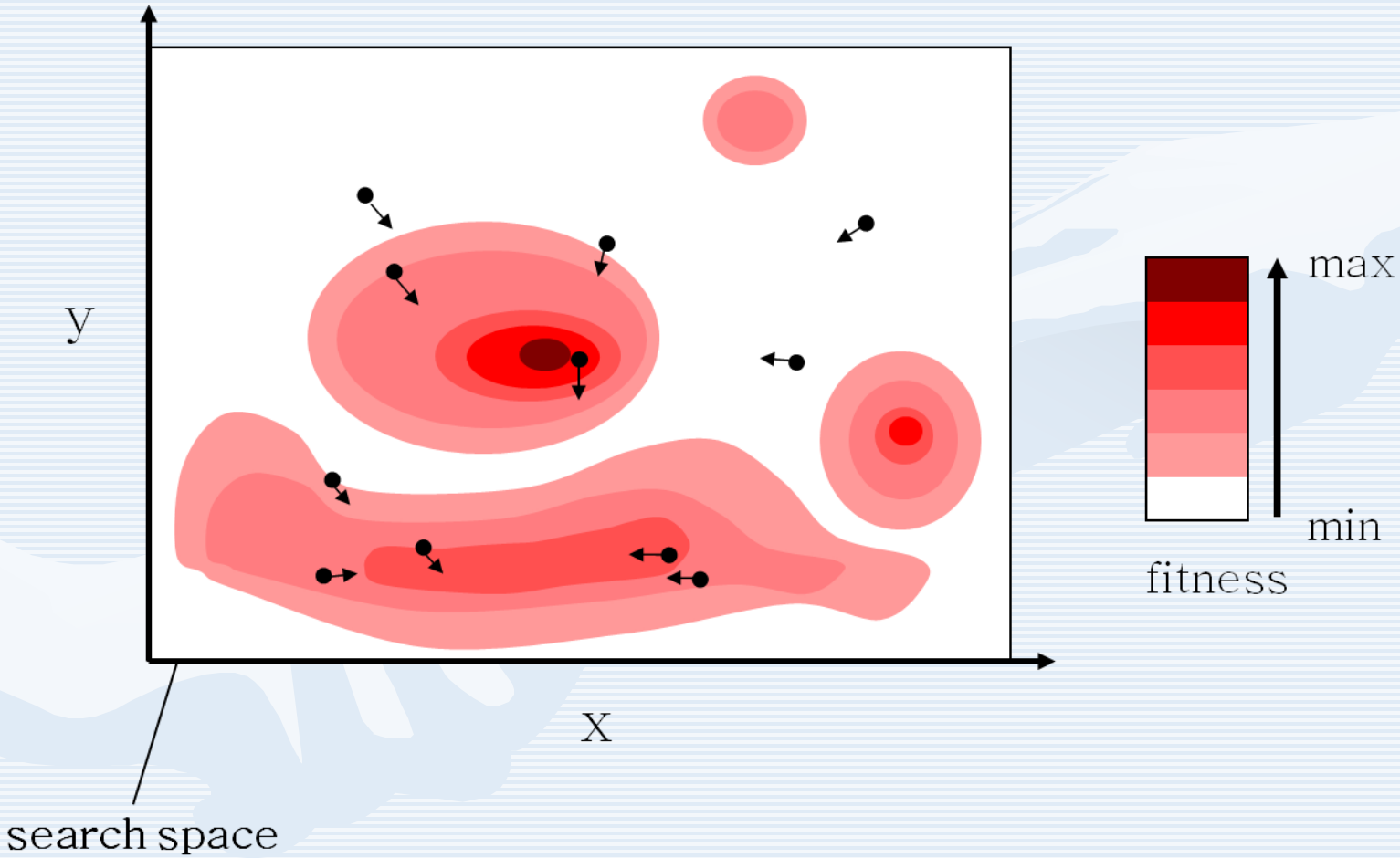

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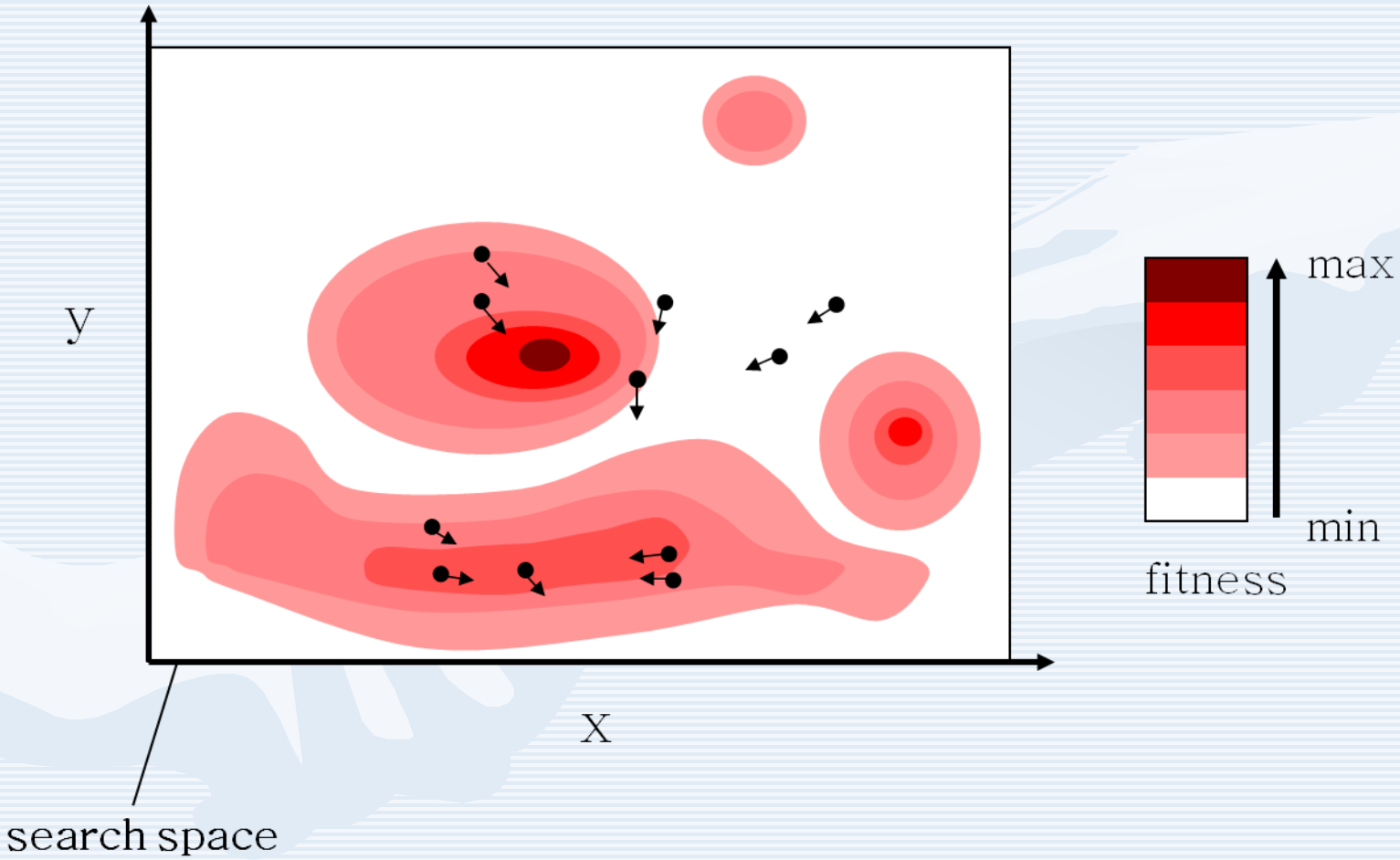

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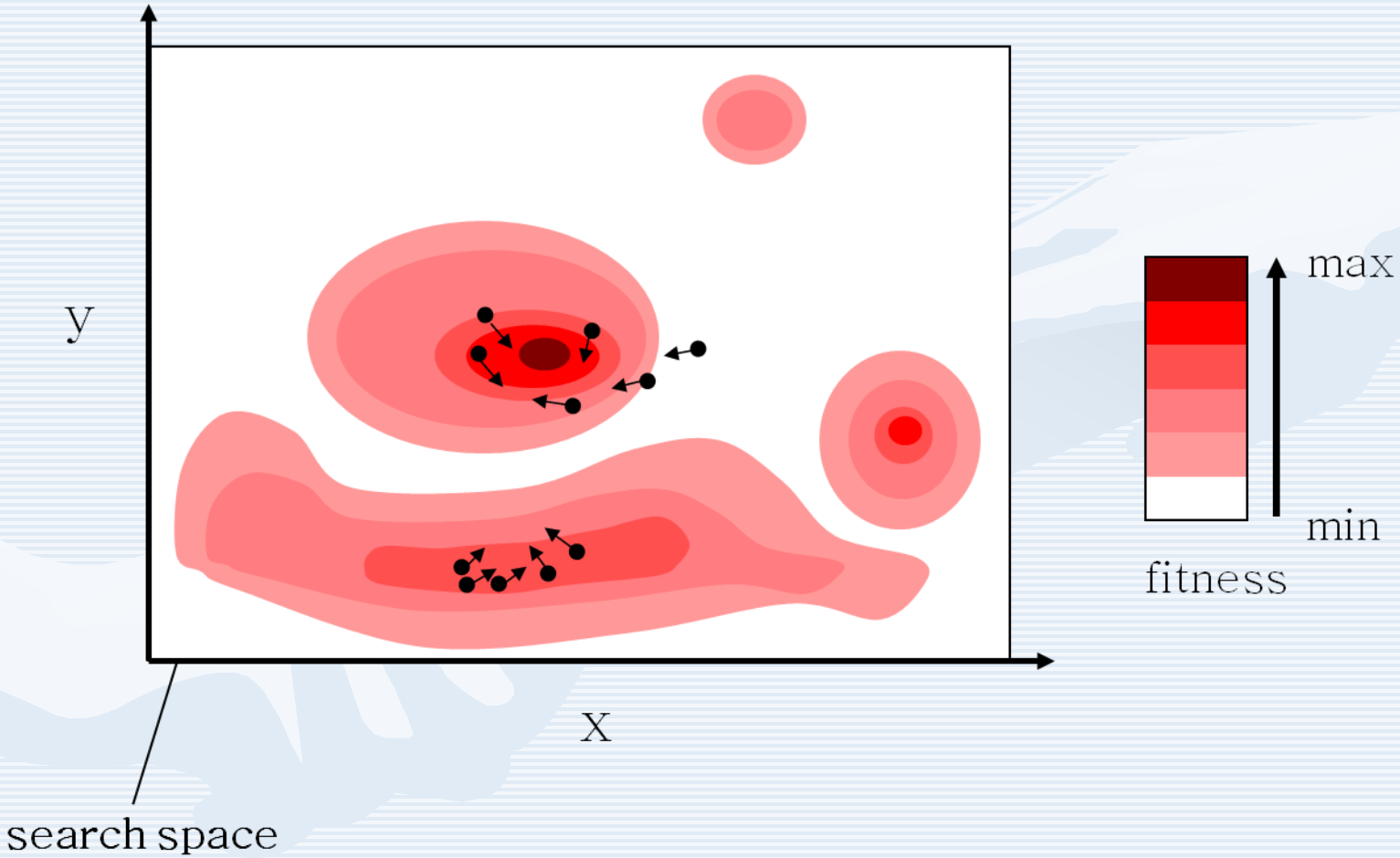

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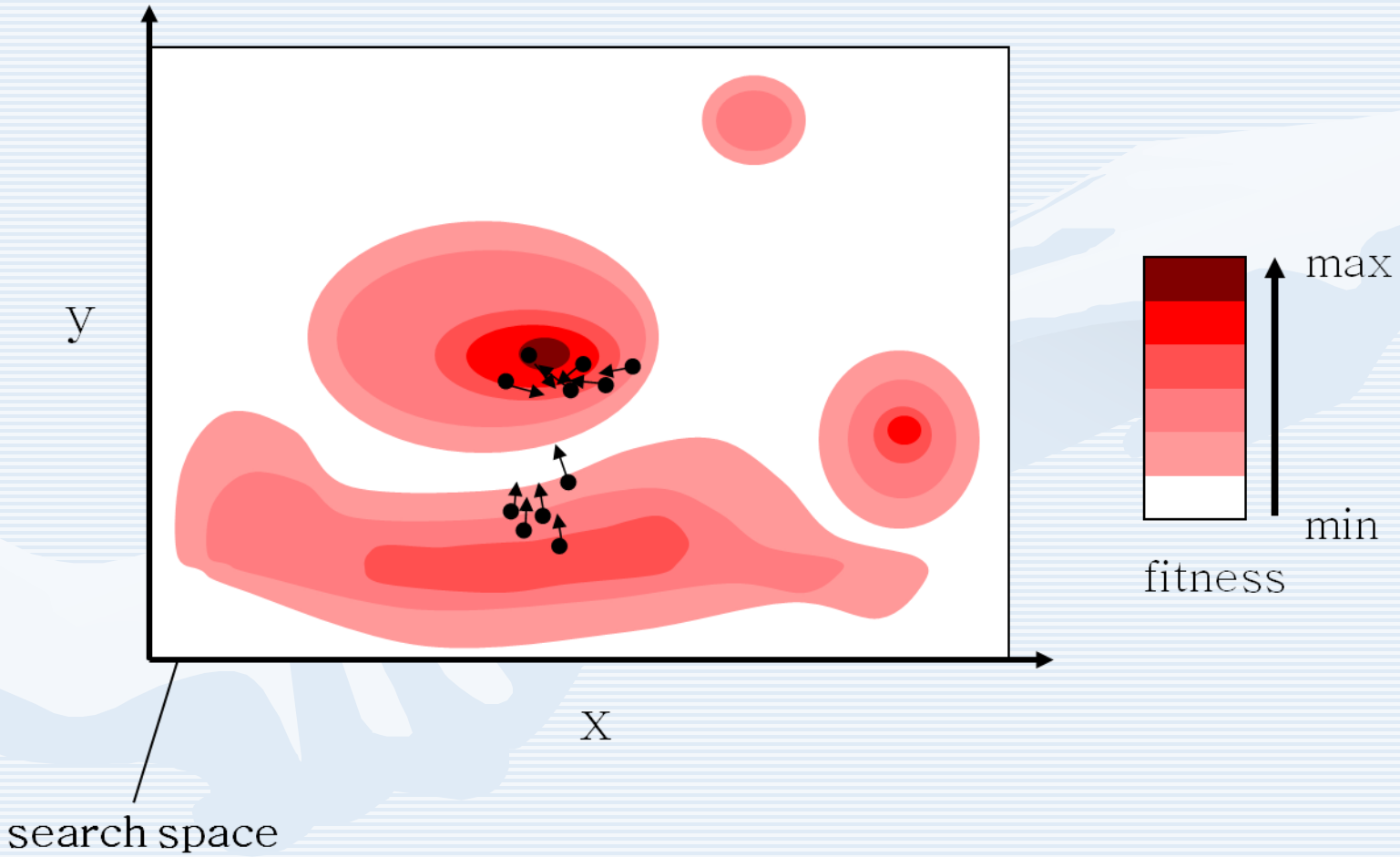

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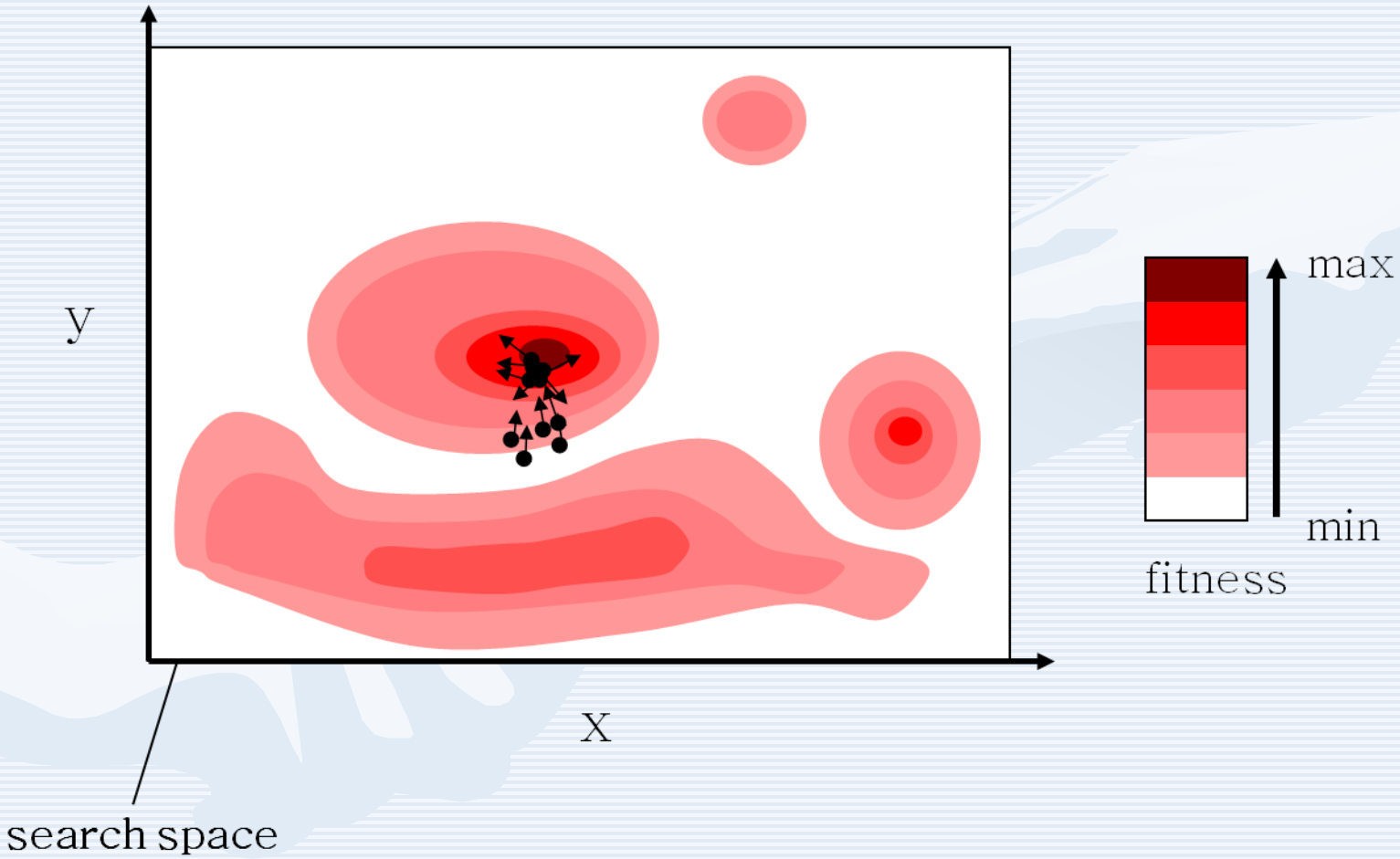

# PSO Algorithm - Example