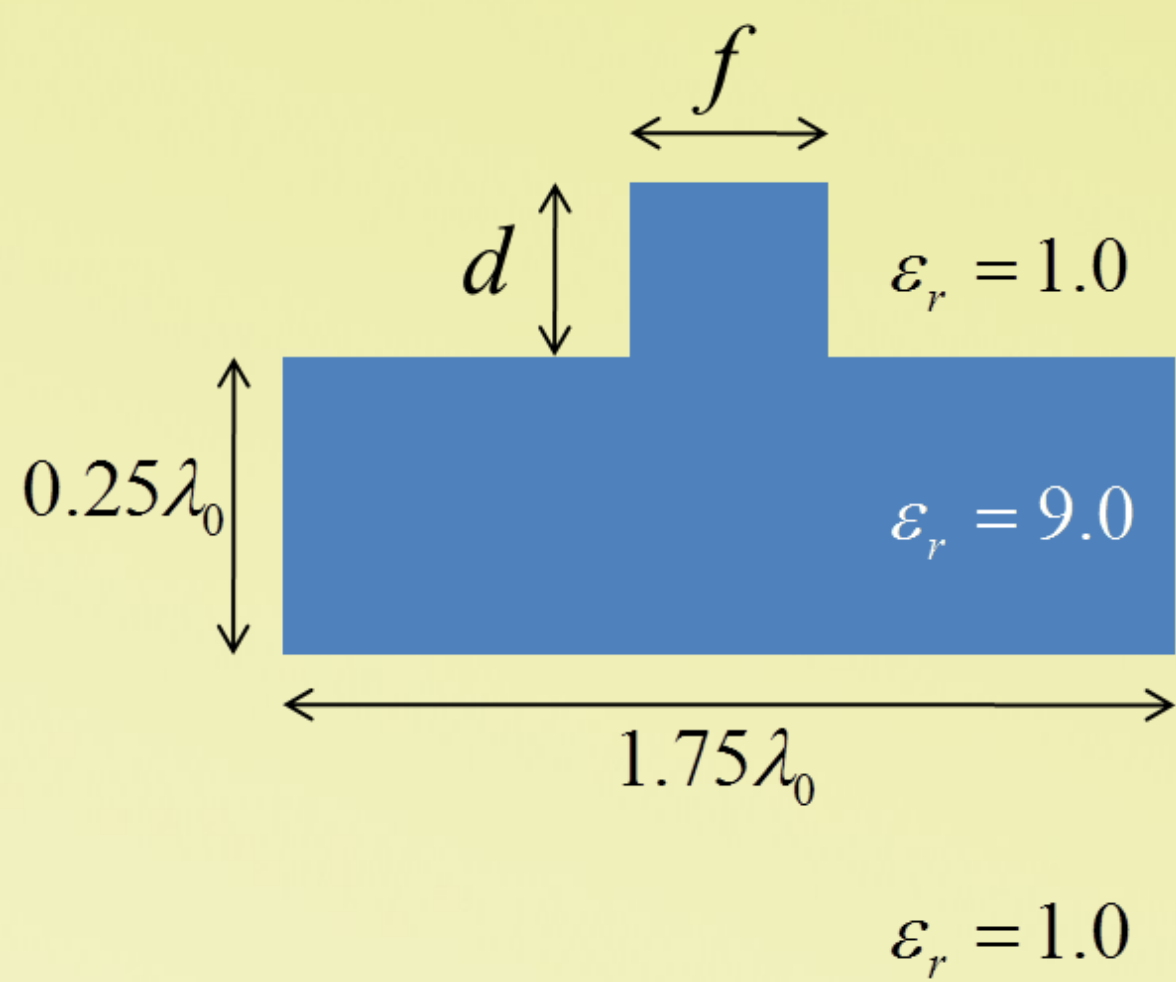


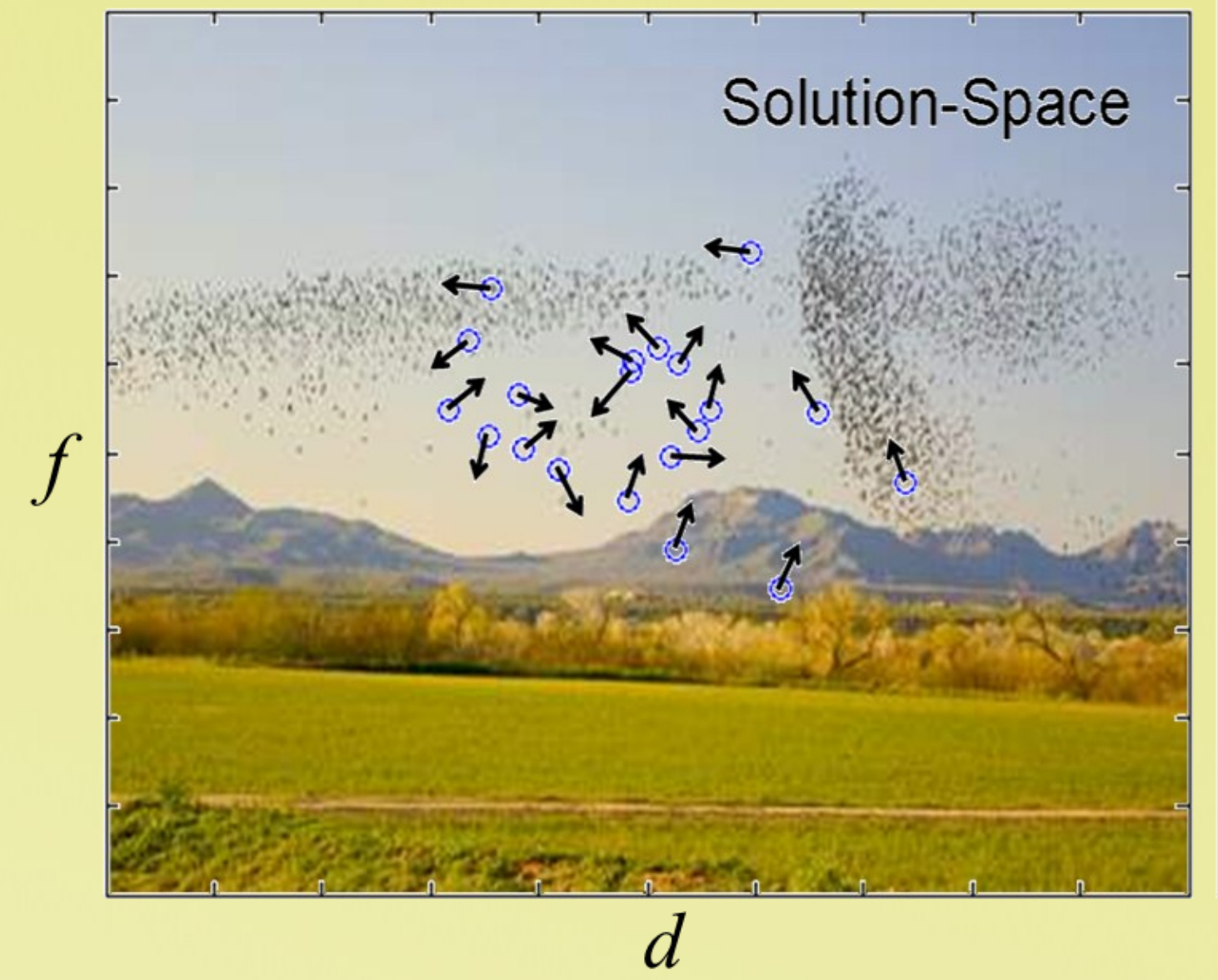
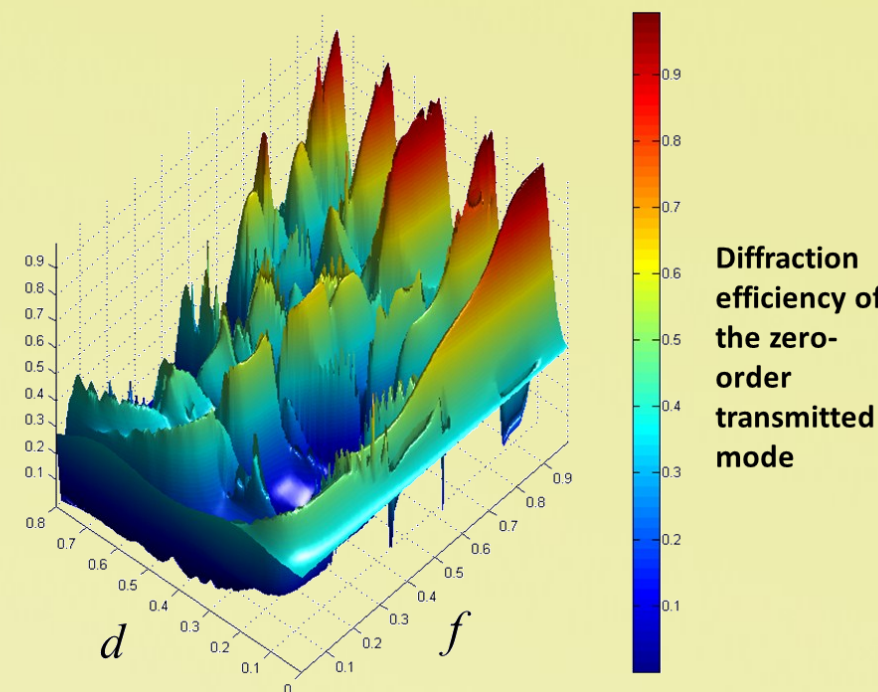
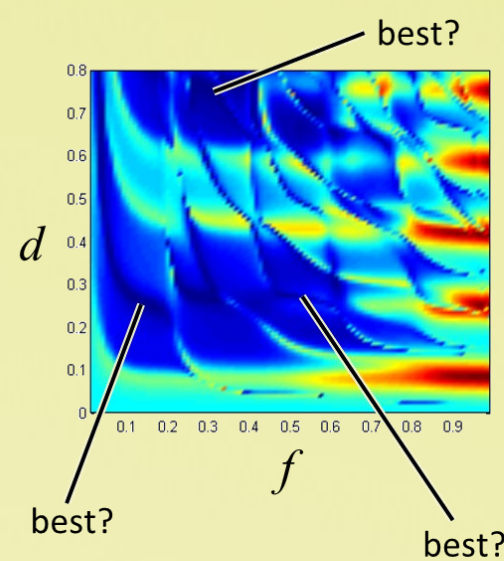
Particle Swarm Optimization

Particle swarm optimization (PSO) was inspired by the cooperation of living animals. It is an extremely simple method to implement and is very well suited for devices described by variables that continuously vary within some range. PSO is claimed in the literature to converge faster than genetic algorithms.

OPTIMIZATION PROBLEM



How do we choose d and f to minimize the zero-order transmitted mode without doing an exhaustive search?



PSO ALGORITHM

Update equation for particle velocity:

$$v_{i+1}^k = \underbrace{wv_i^k}_{\text{inertia term}} + \underbrace{cr_1^k(p_i^k - x_i^k)}_{\text{cognitive term}} + \underbrace{sr_2^k(p_g^k - x_i^k)}_{\text{social term}}$$

Update equation for particle position:

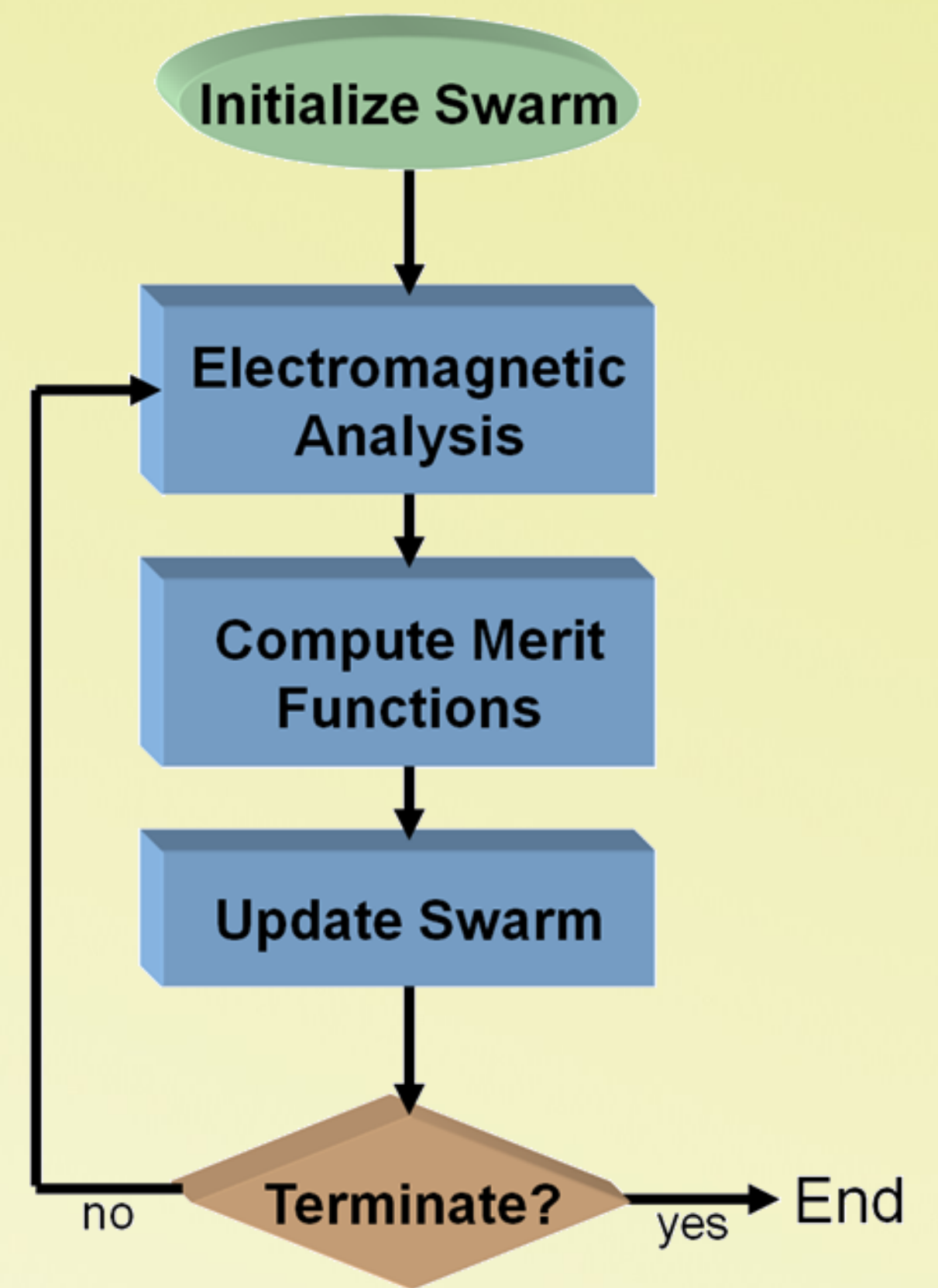
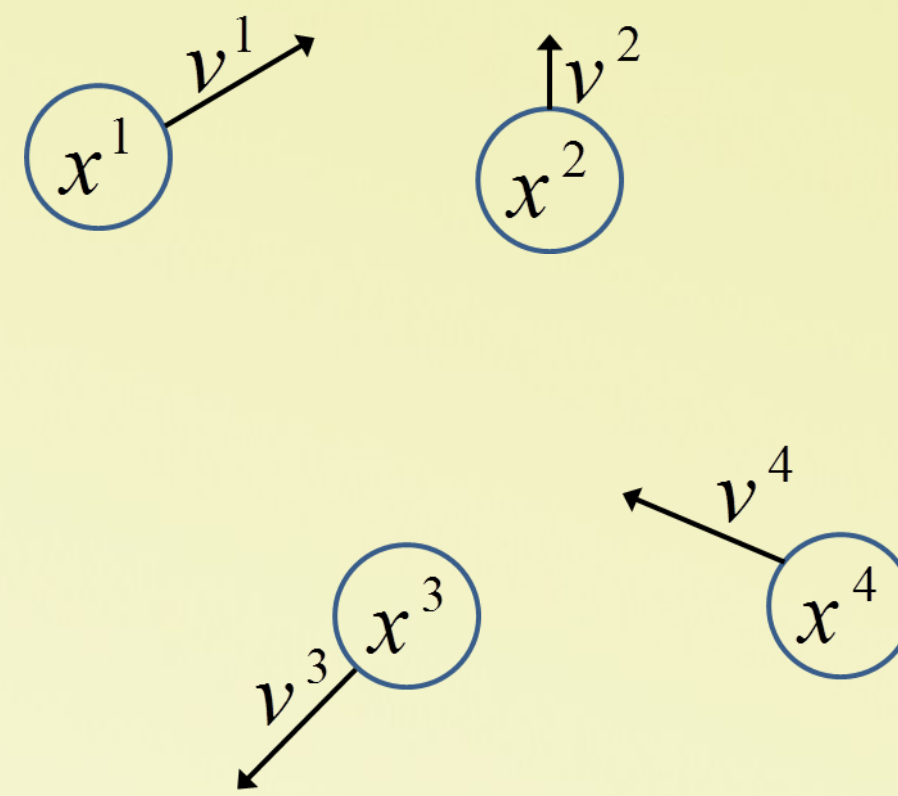
$$x_i^{k+1} = x_i^k + \chi v_i^{k+1}$$

The **inertia term** controls how quickly a particle will change direction.

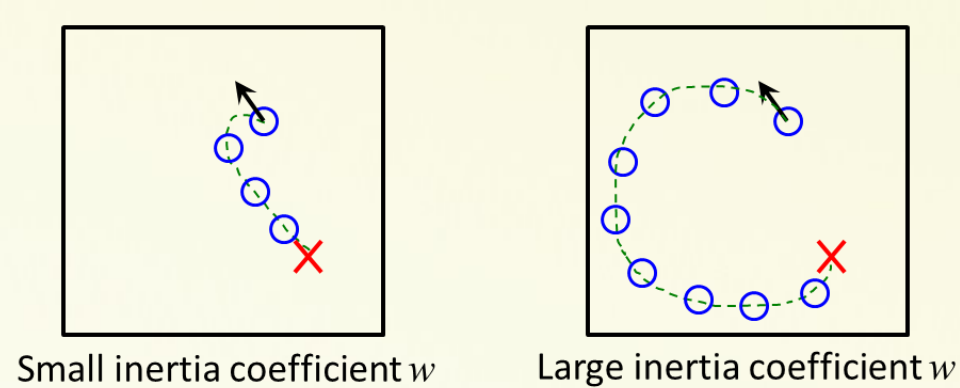
The **cognitive term** controls the tendency of a particle to move toward the best solution observed by that particle.

The **social term** controls the tendency of a particle to move toward the best solution observed by any of the particles.

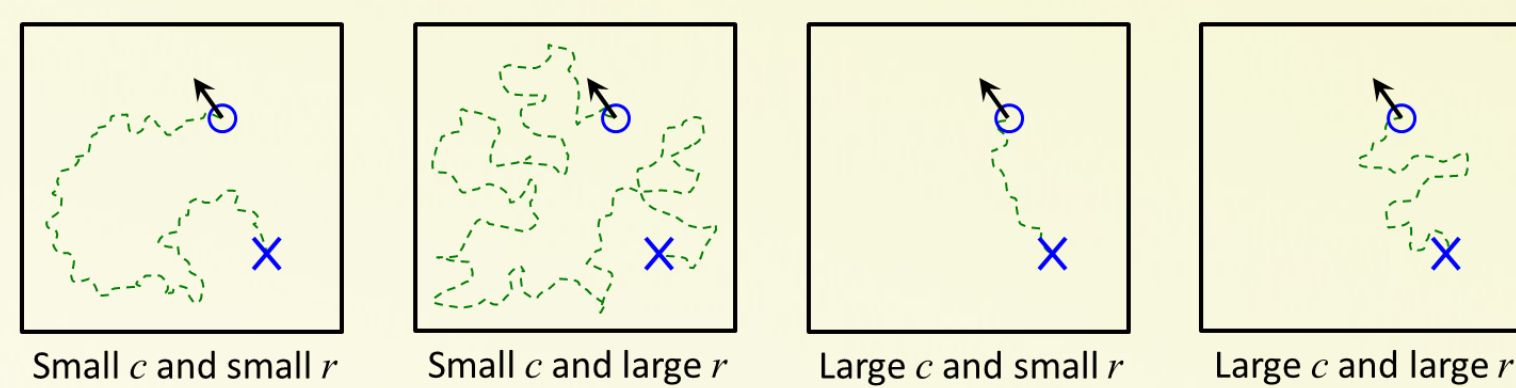
- x_i^k \equiv position of i^{th} particle at k^{th} iteration
- v_i^k \equiv velocity of i^{th} particle at k^{th} iteration
- p_i^k \equiv best solution observed by i^{th} particle
- p_g^k \equiv best solution observed by any particle
- w \equiv inertia coefficient
- c \equiv cognitive coefficient
- s \equiv social coefficient
- r \equiv randomness factor



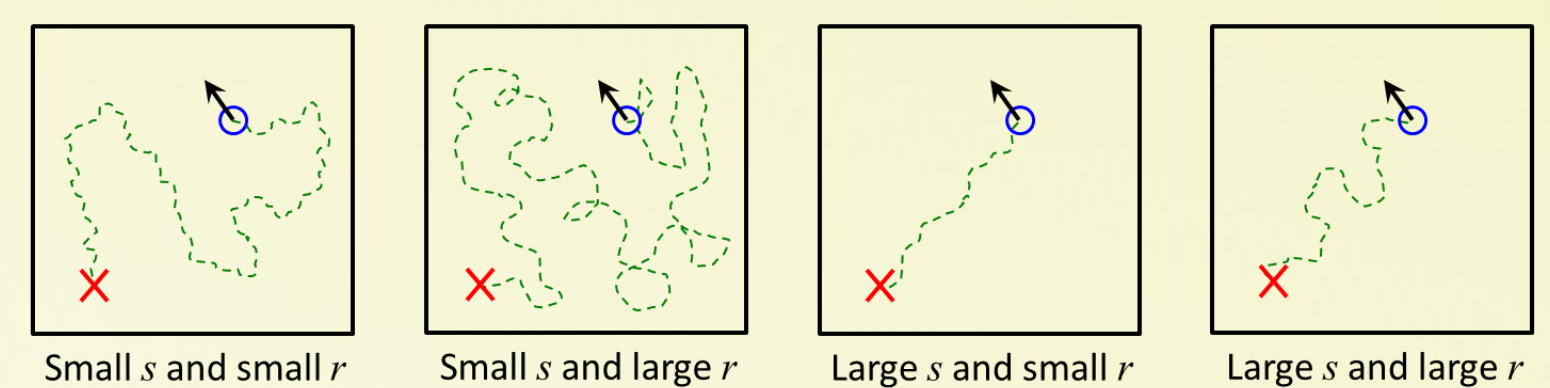
wv_i^k \equiv inertia term



$cr_1^k(p_i^k - x_i^k)$ \equiv cognitive term



$sr_2^k(p_g^k - x_i^k)$ \equiv social term



THE MERIT FUNCTION

It is necessary to quantify how “good” a solution is with a single number. This is perhaps the most critical aspect of any optimization.

When multiple factors must be considered, the merit function is typically the product of merit functions for each consideration. For example, a filter may be optimized for bandwidth BW and suppression S.

$$M = BW \cdot S$$

Sometimes these are not equally important and the terms can be “suppressed” or “enhanced” to convey this.

$$M = BW^\alpha \cdot S^\beta \quad M = \log(1+BW) \cdot S$$

Often, our merit functions involve finding the biggest rectangle to fit under a curve. The width of the rectangle determines bandwidth and its height quantifies performance.

$$MF = (\text{Bandwidth}) \times (\text{Performance})$$

