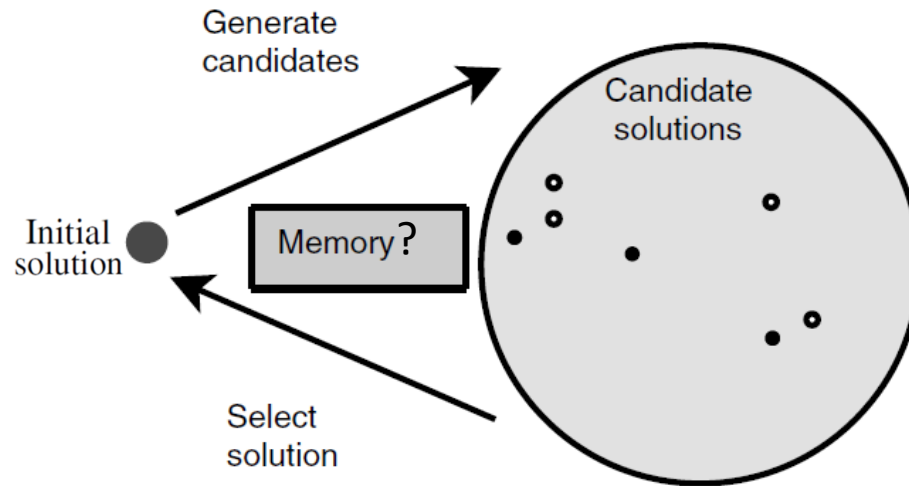# 2. Single solution based metaheuristics (S-metaheuristics)

S-metaheuristics

- # Properties
  - ## Single solution improvement
  - ## Walking through neighborhood
  - ## Iterative process
  - ## Search trajectory in the search space

S-metaheuristics

• Design

High-level template of S-metaheuristics.

Input: Initial solution s_0.

$t = 0$;

Repeat

/* Generate candidate solutions (partial or complete neighborhood) from s_t */
Generate($C(s_t)$) ;

/* Select a solution from $C(s)$ to replace the current solution s_t */
$s_{t+1} = \text{Select}(C(s_t))$;

$t = t + 1$;

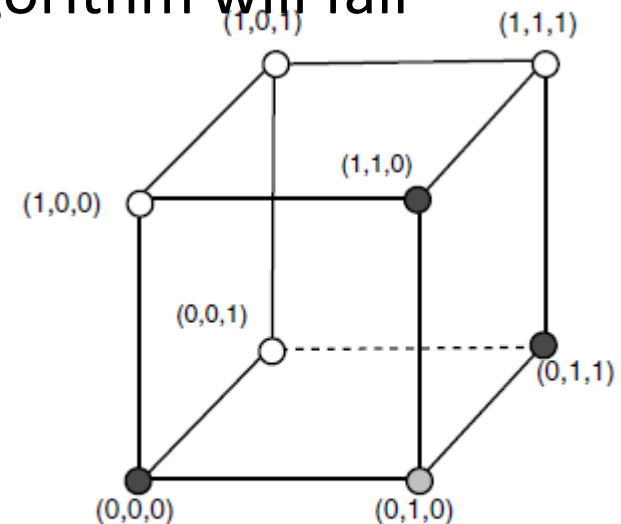**Until** Stopping criteria satisfied

Output: Best solution found.

S-metaheuristics

- # Neighborhood
  - ## Depends on the representation (encoding)
  - ## Straightforward impact on the performance
  - ## If not adequate to the problem, algorithm will fail

S-metaheuristics

- # Neighborhood
  - ## Depends on the representation (encoding)
  - ## Straightforward impact on the performance
  - ## If not adequate to the problem, algorithm will fail

- # Example of Hamming based neighborhood for binary representation
  - ## Neighborhood size is 3

- Nodes of the hypercube represent
  solutions of the problem.
- The neighbors of a solution (e.g., (0,1,0))
  are the adjacent nodes in the graph.

S-metaheuristics

- ## Neighborhood
  - Depends on the representation (encoding)
  - Straightforward impact on the performance
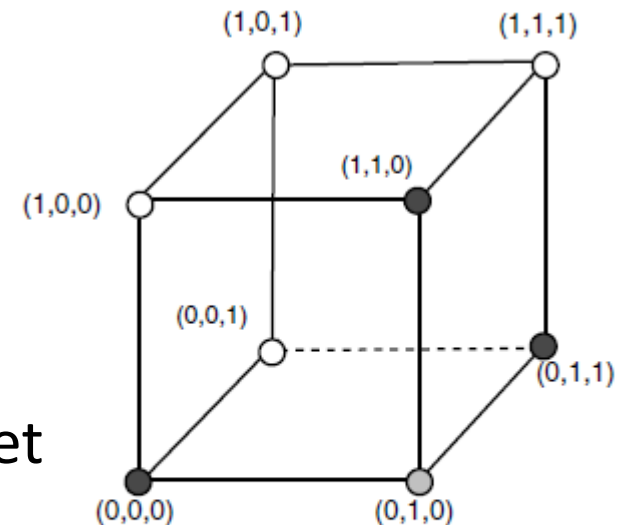 - If not adequate to the problem, algorithm will fail

- ## Example of Hamming based neighborhood for binary representation
  - Neighborhood size is 3

- ## What is the maximum size of solution set and size of neighborhood for a binary vector of length **n** using Hamming method?
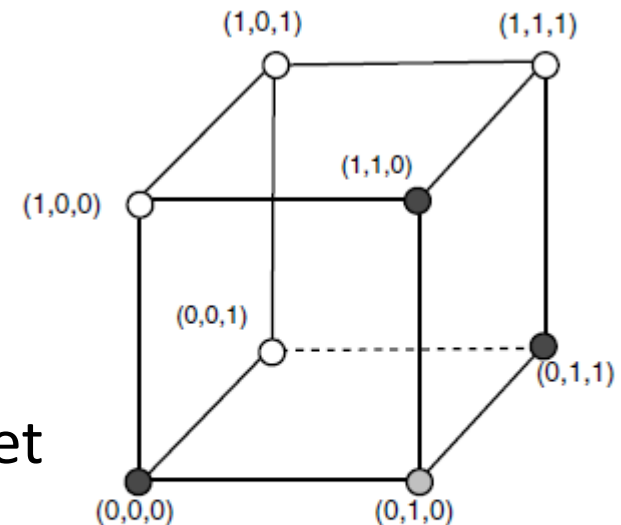

- Nodes of the hypercube represent solutions of the problem.
- The neighbors of a solution (e.g., (0,1,0)) are the adjacent nodes in the graph.

S-metaheuristics

- Neighborhood
  - Depends on the representation (encoding)
  - Straightforward impact on the performance
  - If not adequate to the problem, algorithm will fail

- Example of Hamming based neighborhood for binary representation
  - Neighborhood size is 3

- What is the maximum size of solution set and size of neighborhood for a binary vector of length **n** using Hamming method? 2^n and n
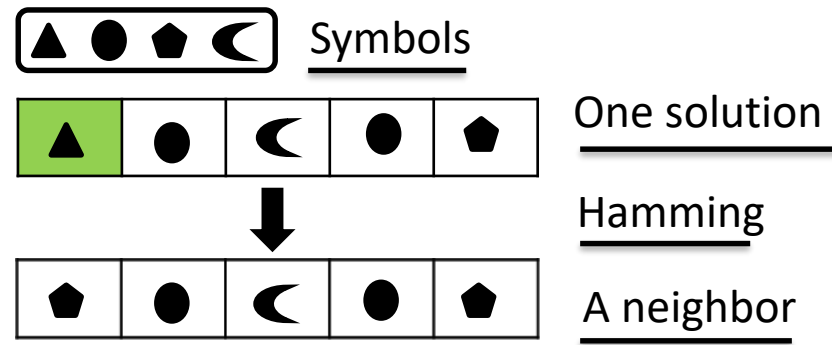

- Nodes of the hypercube represent solutions of the problem.
- The neighbors of a solution (e.g., (0,1,0)) are the adjacent nodes in the graph.

S-metaheuristics - Neighborhood

- Hamming neighborhood can be generalized for discrete representation with k symbols (integer values).

- How?
  Similar as for binary.
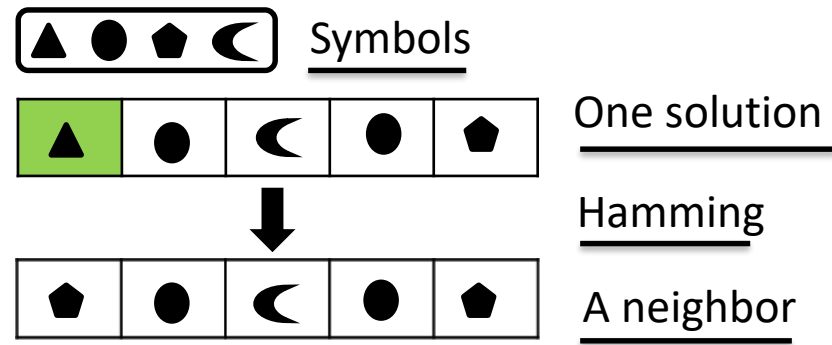

- What is the size of solution set and neighborhood for a discrete vector of size n and k symbols using Hamming method?

S-metaheuristics - Neighborhood

- Hamming neighborhood can be generalized for discrete representation with k symbols (integer values).

- Explain how?
  Similar as for binary.

- What is the size of solution set and neighborhood for a discrete vector of size n and k symbols using Hamming method?

  k^n and $(k-1)n$

S-metaheuristics - Neighborhood

- # Neighborhood generation method

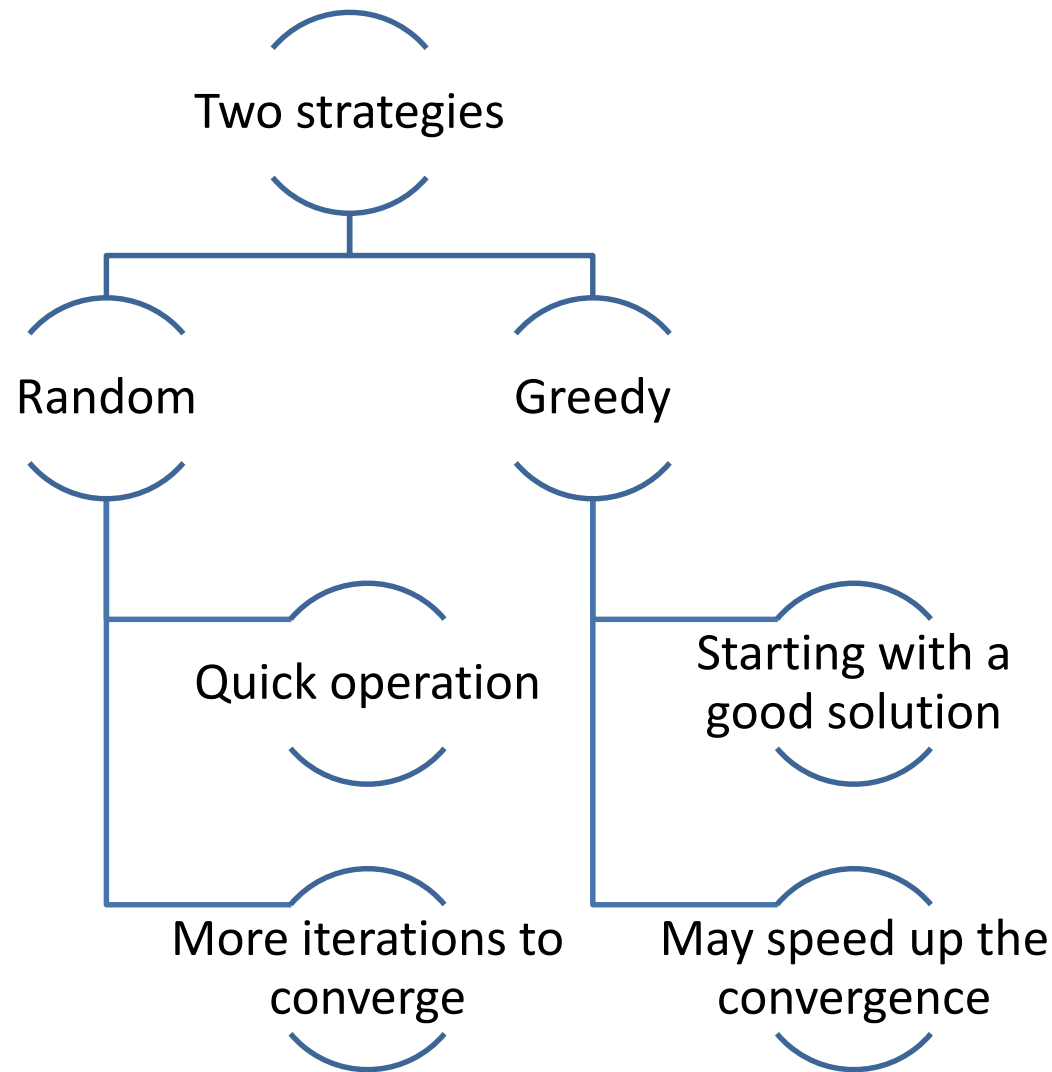| 1 0 0 0 1 1 0 1 1 1 0 1		5 7 6 6 4 3 8 4 2		1 4 8 9 3 6 5 2 7
Binary encoding		**Vector of discrete values**		**Permutation**
Hamming distance		**Hamming distance**		**Swap operator**
Flip one bit		Flip one box to a value of the k-1 symbols		Exchange values of two boxes

- # Swap operator may be used for all linear representations
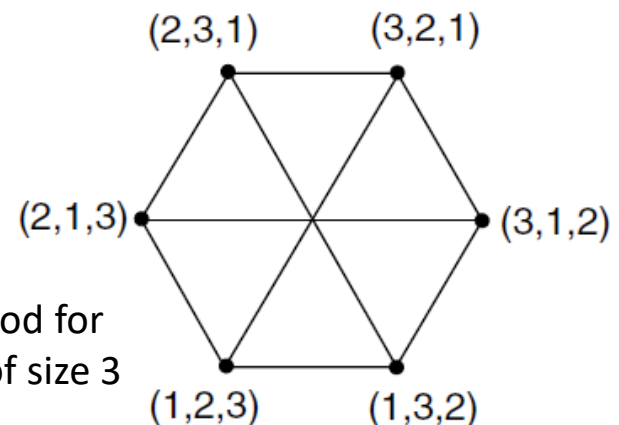
Example of neighborhood for permutation problem of size 3

S-metaheuristics – Initial solution

Two strategies

Random

Greedy

Quick operation

Starting with a good solution

More iterations to converge

May speed up the convergence

S-metaheuristics - Neighborhood

- ## Local optimality (minimization problem example)

Objective

Search space curve

Local optima

Local and global optima

Local optima
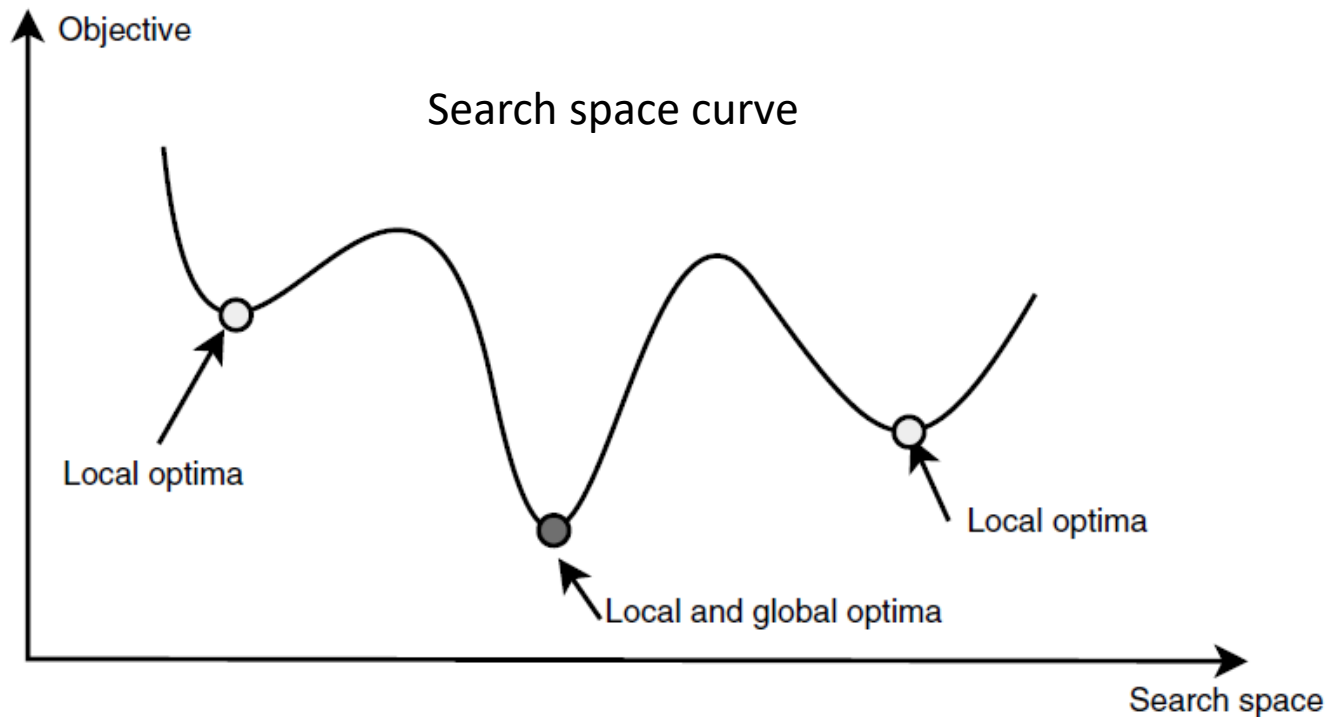
Search space

Local optimum and global optimum in a search space. A problem may have many local optimal solutions.