Artificial Bee Colony (ABC) Optimization Algorithm

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- Bees in Nature
- Motivation to Optimization Algorithm
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Intelligent Behaviors of Natural Bees

1. The Power of Bee Democracy

https://www.youtube.com/watch?v=NDnQ4pAjBUg

Short Description: Bee in Nature, Bee and Neuron Relation and ABC

2. Facts About Bees 🐝 - Secret Nature | Bee Documentary | Natural History Channel

https://www.youtube.com/watch?v=mZTLatV1YIQ

N.B.: Information regarding ABC after 35 Mins

3. How Do Honeybees Get Their Jobs? | National Geographic

https://www.youtube.com/watch?v=9ePic3dtykk

Motivation to ABC

- There was a great interest between researchers to generate search algorithms that find near-optimal solutions in reasonable running time
- The Swarm Intelligence (SI)-based Algorithm is a search algorithm capable of locating good solutions efficiently
- The algorithm could be considered as belonging to the category of “Intelligent Optimisation Tools”
- **SIAs** mince nature’s methods to derive a search towards the optimal solution
- The key difference between **SIAs** and **direct search** algorithms such as **Hill Climbing** is that SIAs use a population of solutions for every iteration instead of a single solution
- As a population of solutions is processed in an iteration, the outcome of each iteration is also a population of solutions

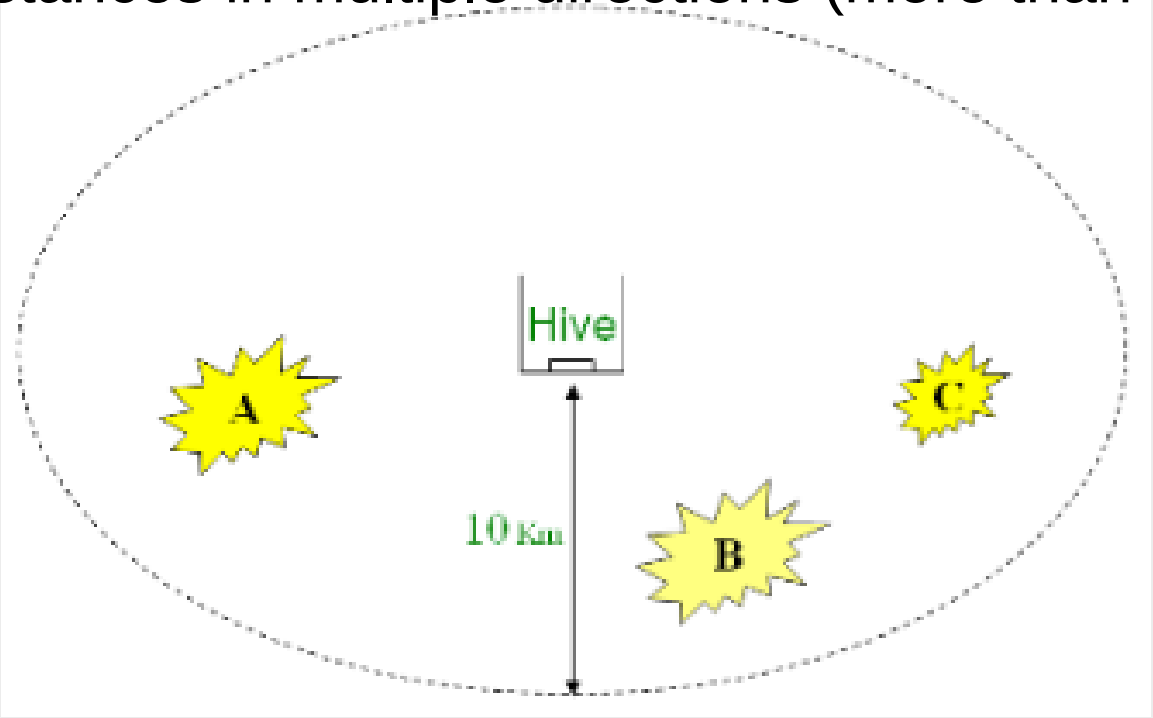
Motivation to ABC

- **SIAs** include:
  - *The **Ant Colony Optimisation** (ACO) algorithm*
  - *The **Genetic Algorithm** (GA)*
  - *The **Particle Swarm Optimisation** (PSO) algorithm*
  - *Others……(**Bee Algorithm**)*

Artificial Bee Colony (ABC) Algorithm is main concern of this Lecture

Points from Bees in Nature

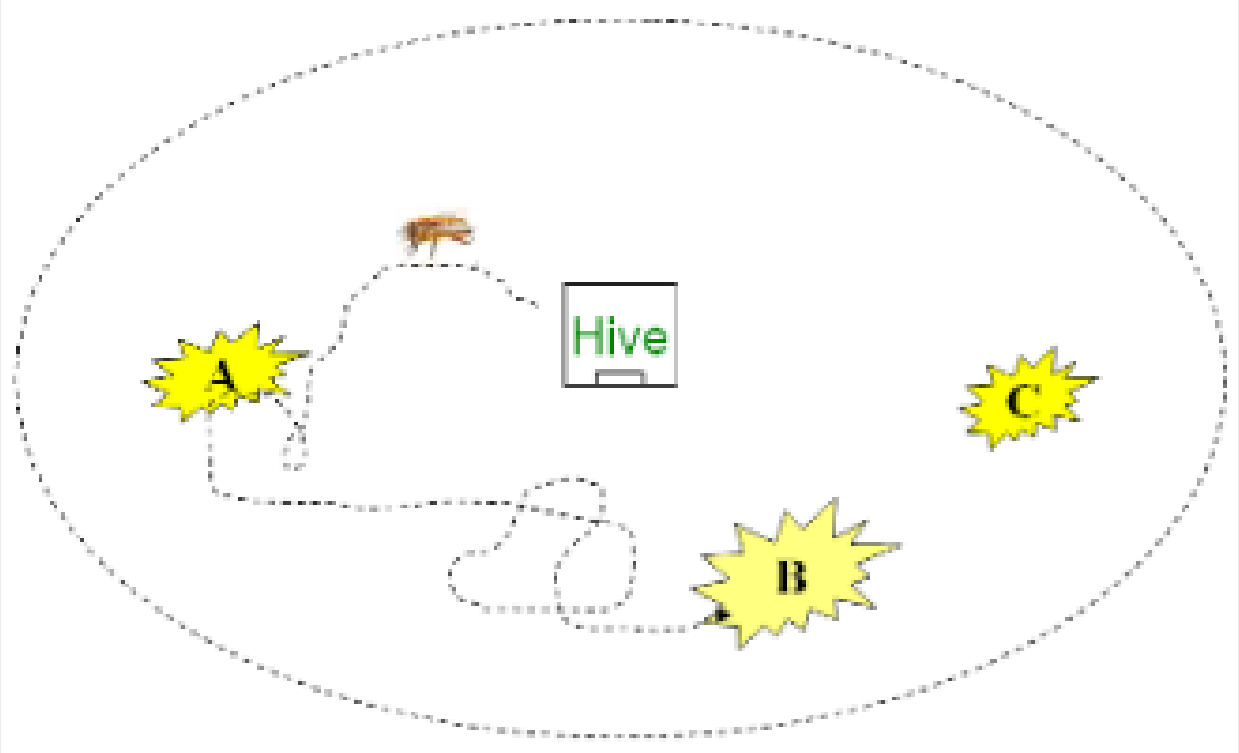
1- **A colony of honey bees** can extend itself over long distances in multiple directions (more than 10 km)



Flower patches with plentiful amounts of nectar or pollen that can be collected with less effort should be visited by more bees, whereas patches with less nectar or pollen should receive fewer bees

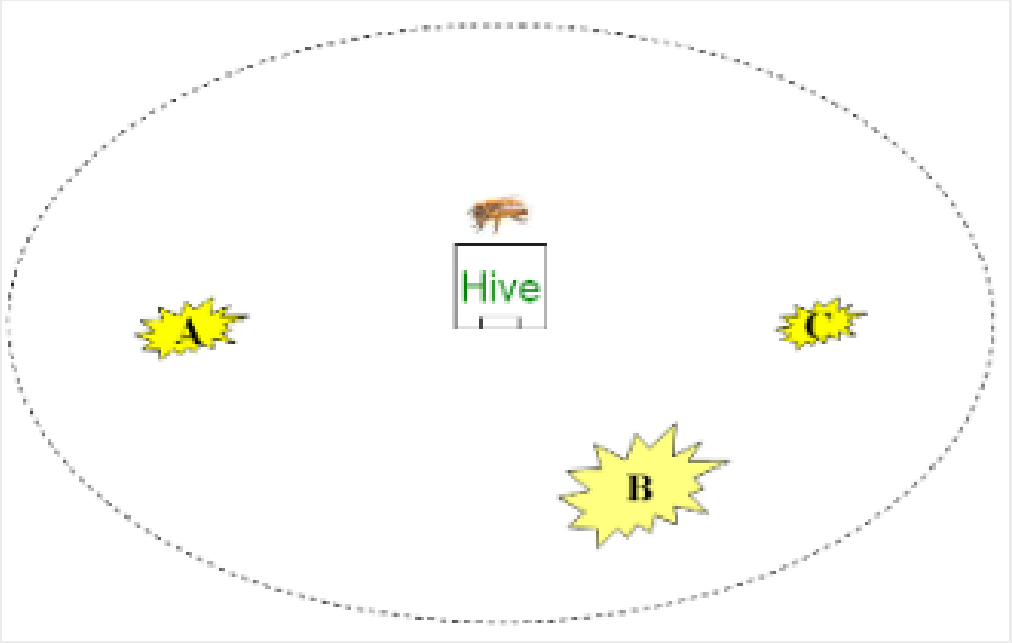
Points from Bees in Nature

2- **Scout bees** search randomly from one patch to another



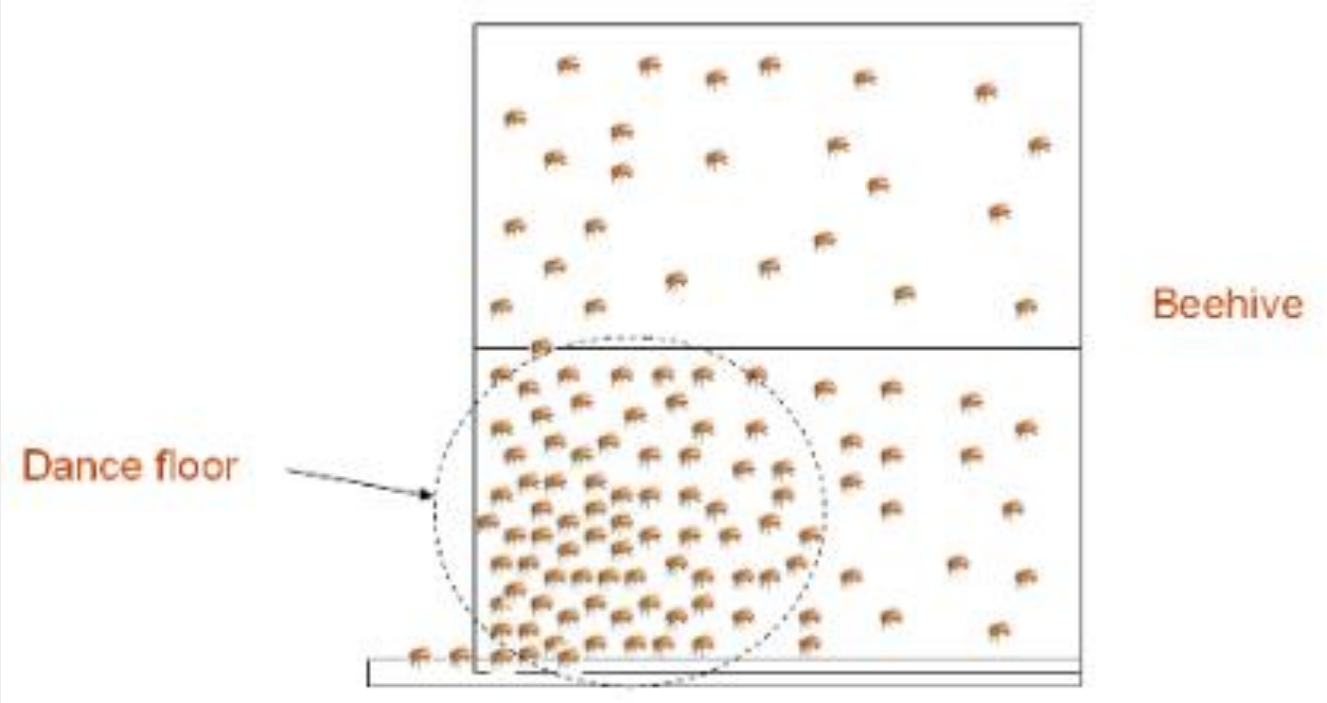
Points from Bees in Nature

3- The bees who return to the hive, **evaluate** the different patches depending on certain quality threshold (measured as a combination of some elements, such as sugar content)



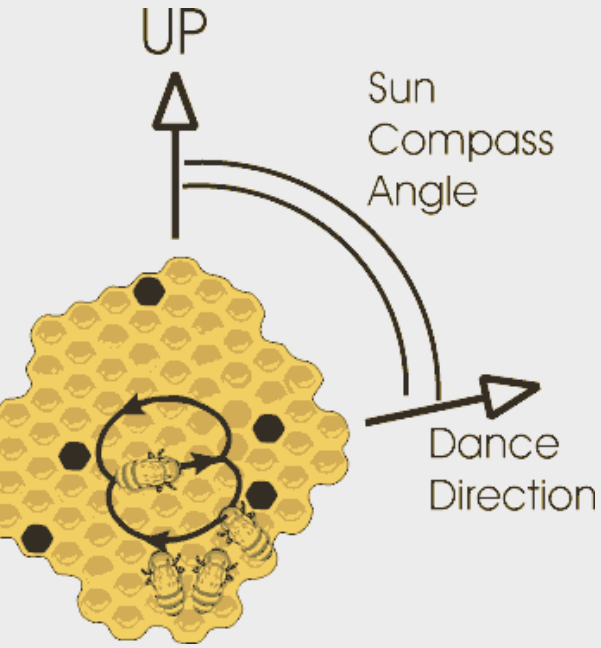
Points from Bees in Nature

4- They deposit their nectar or pollen go to the "**dance floor**" to perform a "waggle dance"



Points from Bees in Nature

5- Bees communicate through the waggle dance which contains the following information:



1. The **direction** of flower patches (angle between the sun and the patch)
2. The **distance** from the hive (duration of the dance)
3. The **quality** rating (fitness) (frequency of the dance)

These information helps the colony to send its bees precisely

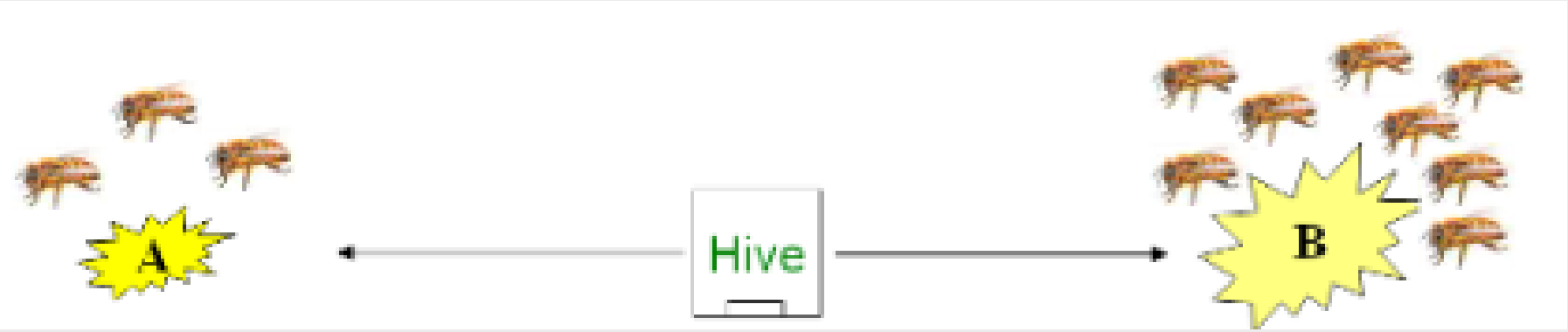
6- **Follower bees** go after the dancer bee to the patch to gather food efficiently and quickly

Points from Bees in Nature

7- The same patch will be **advertised** in the waggle dance again when returning to the hive is it still good enough as a food source (**depending on the food level**) and more bees will be recruited to that source

8- More bees visit flower patches with plentiful amounts of nectar or pollen

Thus, according to the fitness, patches can be visited by more bees or may be abandoned



Artificial Bee Colony (ABC) Algorithm

- ABC Algorithm is a population-based search algorithm inspired by the natural foraging behaviour of honey bees to find the optimal solution.
- The algorithm performs a kind of neighbourhood search combined with random search.

ABC Algorithm (Cont.)

Three type of Bees in ABC:

1) Employed bees

2) Onlooker bees, and

3) Scouts.

Employed and onlooker bees perform the exploitation search.

Scouts carry out the exploration search.

ABC Algorithm (Cont.)

ABC employs four different selection processes:

1) a global selection process used by onlookers,

2) a local selection process carried out in a region by employed and onlooker bees,

3) a greedy selection process used by all bees, and

4) a random selection process used by scouts.

ABC Algorithm (Cont.)

The ABC algorithm Steps:

Step 1: Initialize by picking *k* random **Employed** bees from data.

Step 2: Send **Scout** bees and test against Employed bees

(replace if better than Employed is found).

Step 3: Send Onlooker bees to Employed.

Step 4: Test Onlooker bees against Employed

(replace if better than Employed is found).

Step 5: Reduce the radius of Onlooker bees.

Step 6: Repeat steps 2 to 5 for a given number of iterations.

ABC Algorithm (Cont.): Pseudo Code

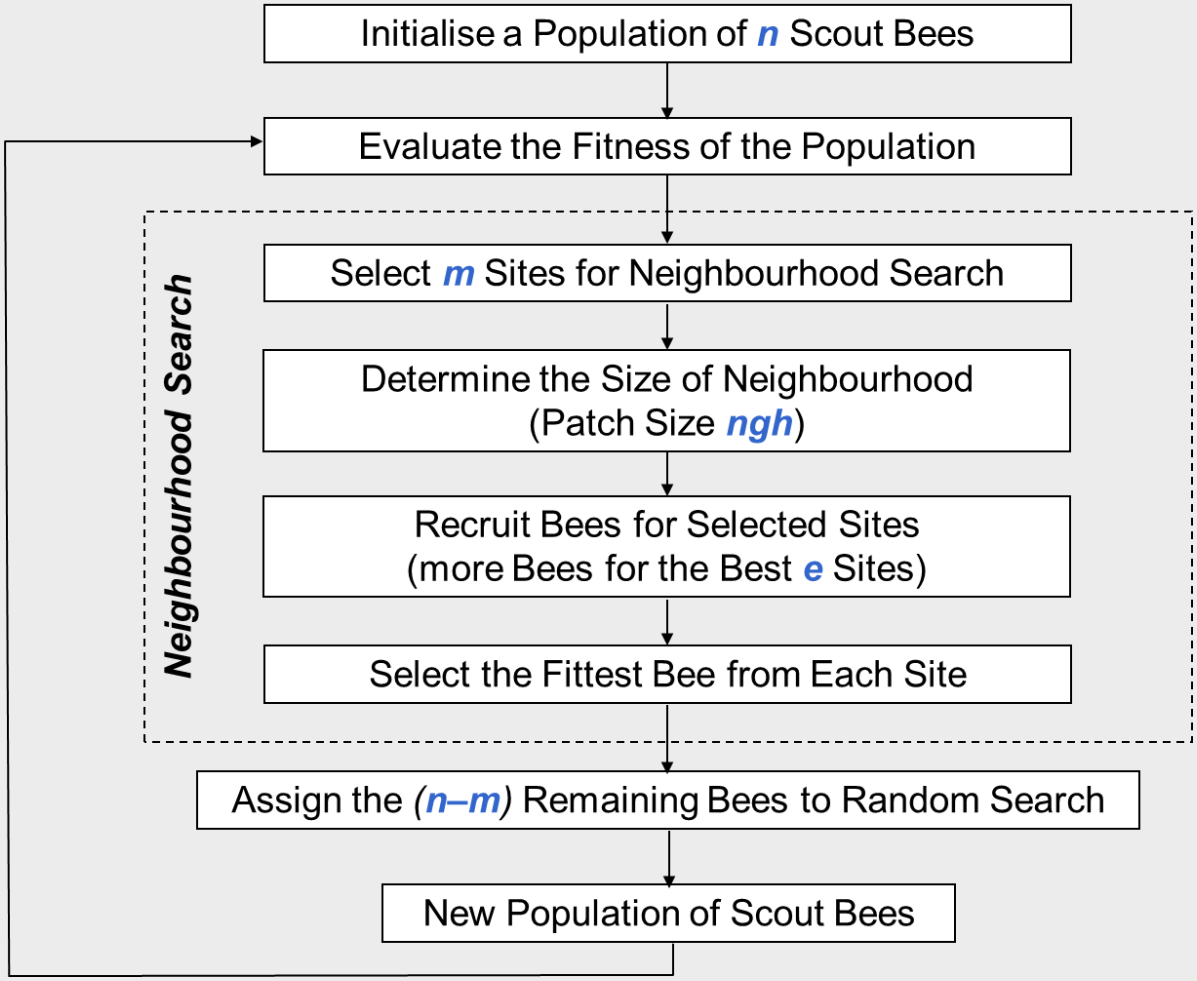
1. Initialise population with random solutions.
2. Evaluate fitness of the population.
3. While (stopping criterion not met)
    //Forming new population.
    4. Select sites for neighbourhood search.
    5. Recruit bees for selected sites (more bees for best **e** sites) and evaluate fitnesses.
    6. Select the fittest bee from each patch.
    7. Assign remaining bees to search randomly and evaluate their fitnesses.
8. End While.

ABC Algorithm (Cont.)

The algorithm requires a number of parameters to be set:

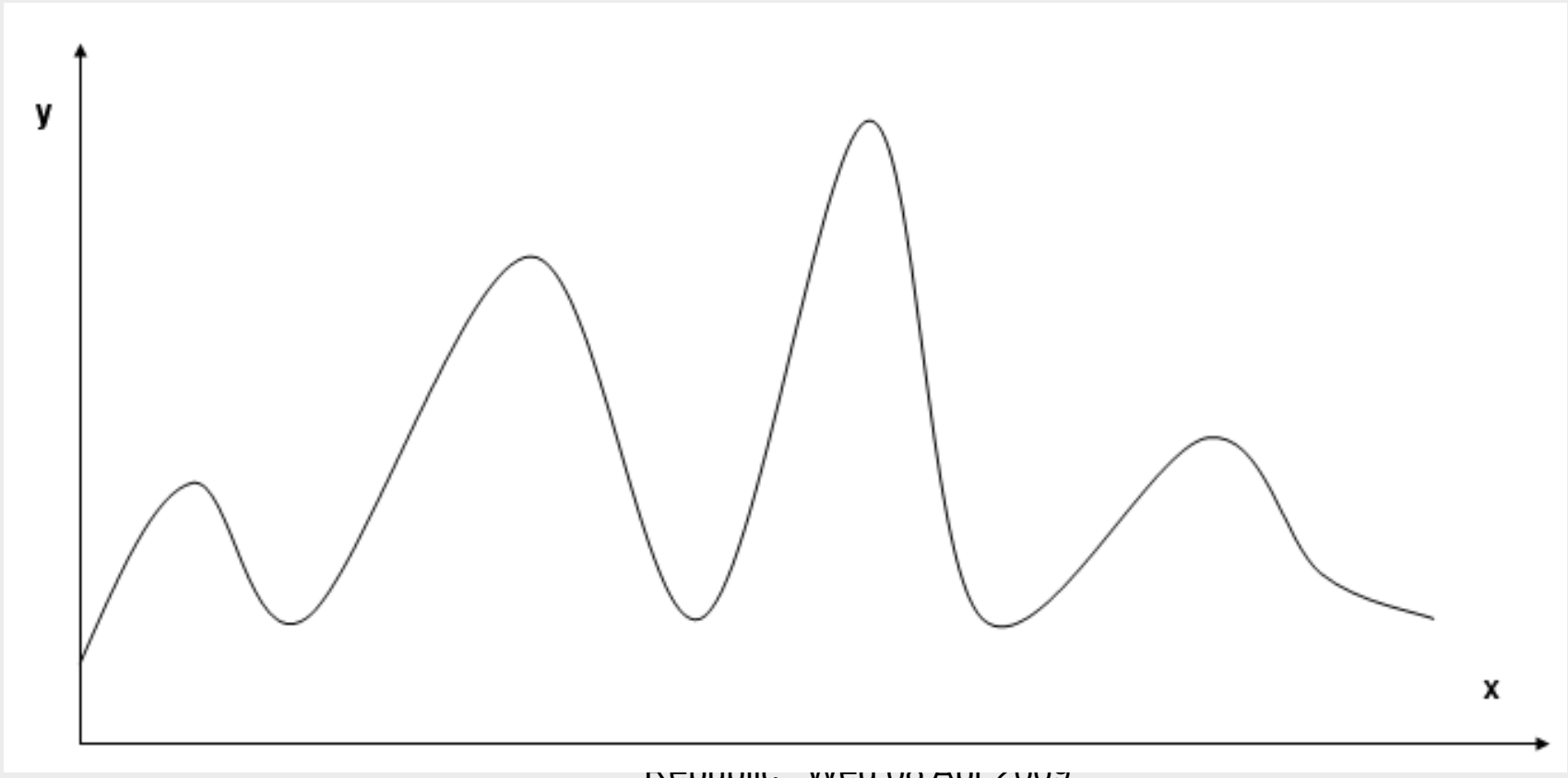
- *Number of scout bees **n*** → 100
- *Number of sites selected **m** out of **n** visited sites* → 10
- *Number of best sites **e** out of **m** selected sites* → 3
- *Number of bees recruited for best **e** sites **nep** or (**n2**)* Rich → 40 in neighborhood area
- *Number of bees recruited for the other (**m-e**) selected sites which is **nsp** or (**n1**)* Poor → 20
- *Initial size of patches **ngh** which includes site and its neighbourhood and stopping criterion* → 0-1 (0.2)
- *Number of algorithm steps repetitions **imax*** 10,300,1000

ABC Algorithm: Flowchart

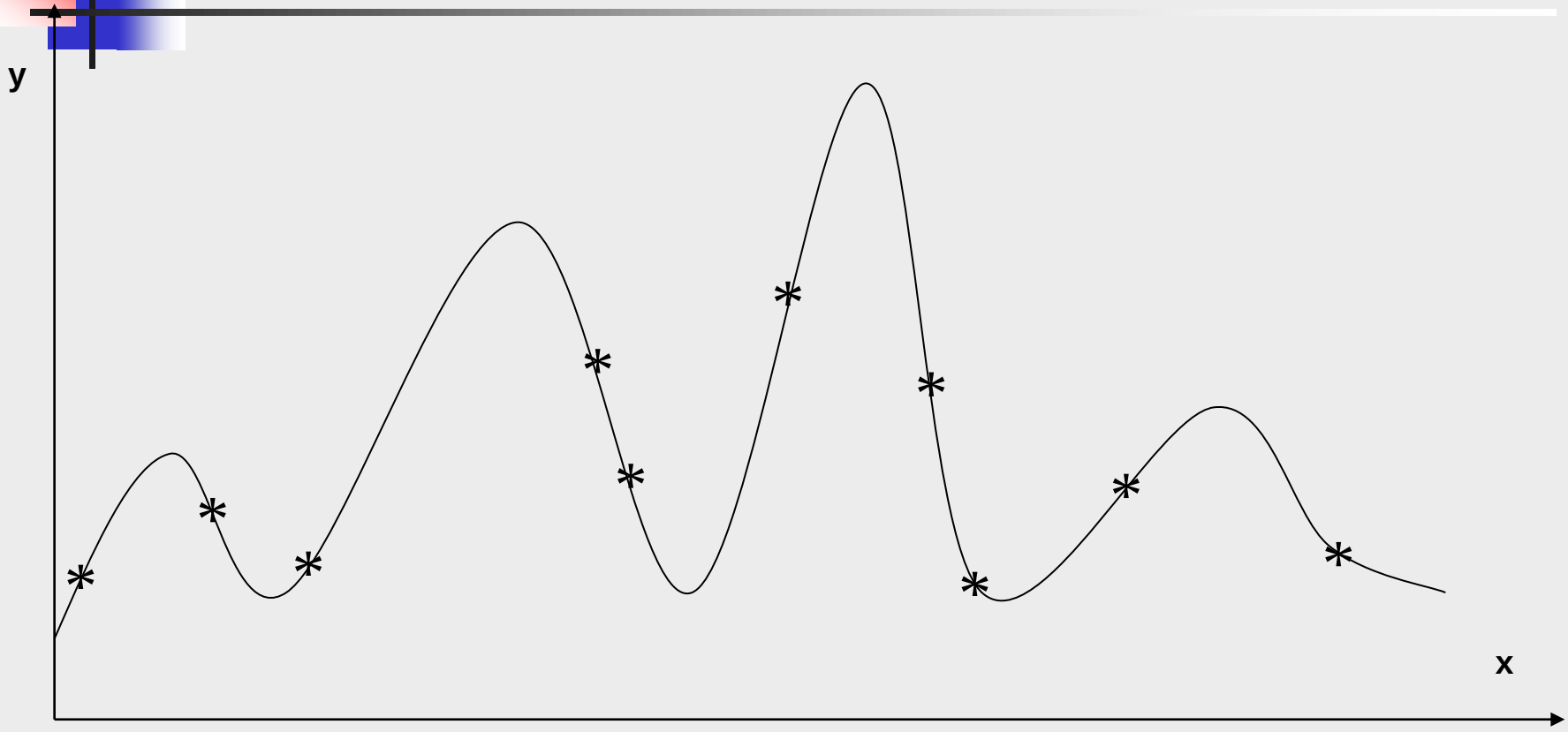


Simple Example

- The following figure shows the mathematical function



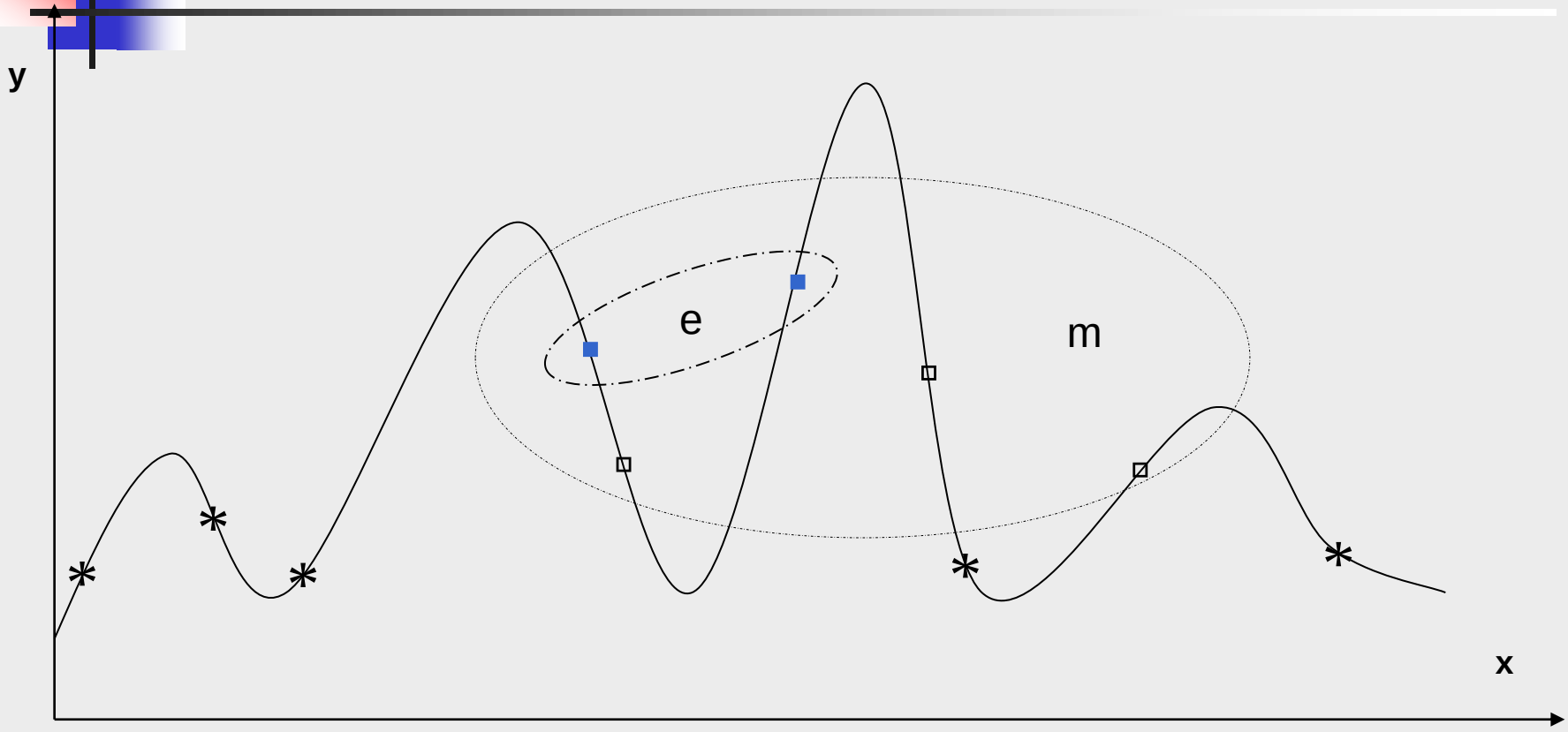
Simple Example



Graph 1. Initialise a Population of (**n=10**) Scout Bees with random Search and evaluate the fitness.

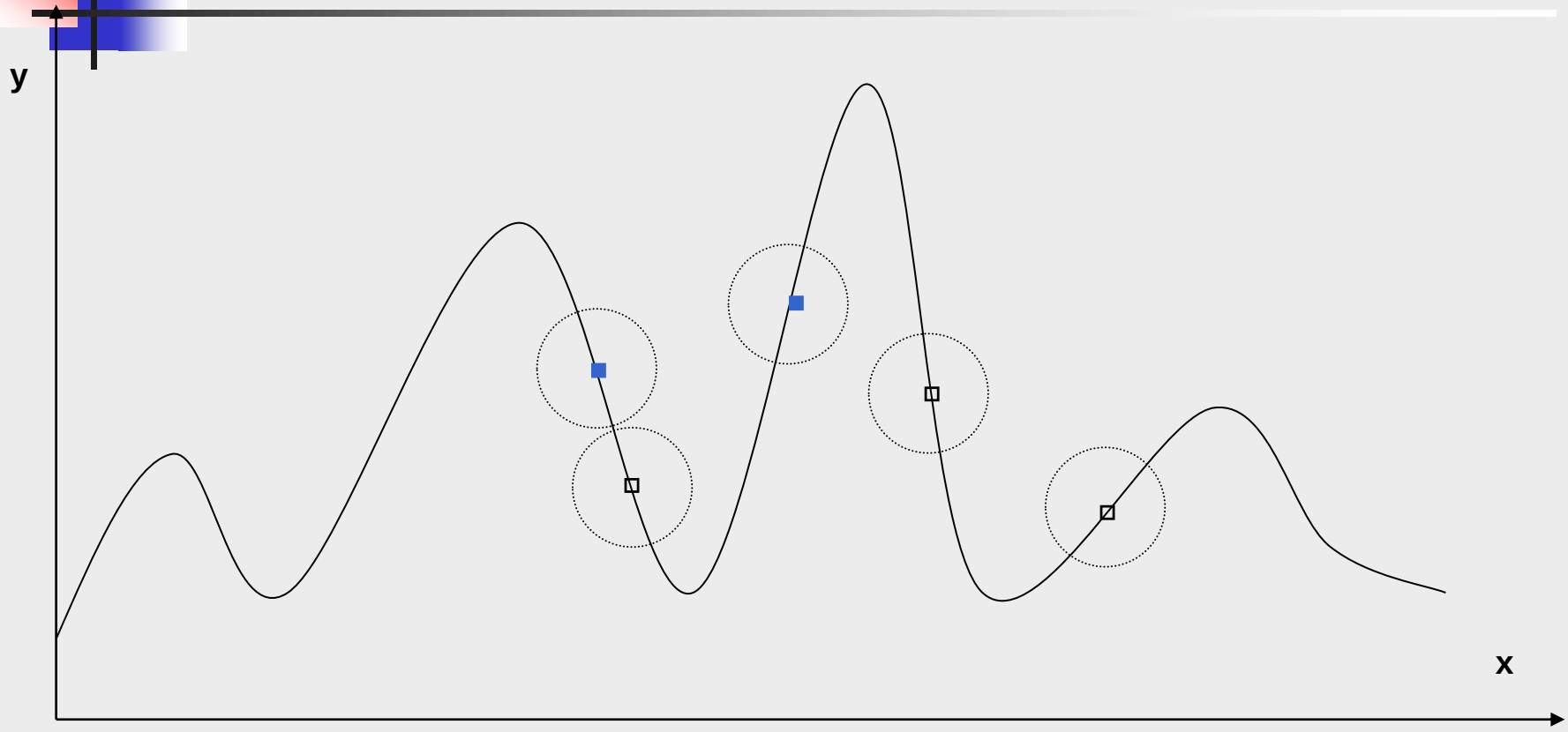
Masaryk University, Brno, Czech Republic , Wed 08 Apr 2009

Simple Example



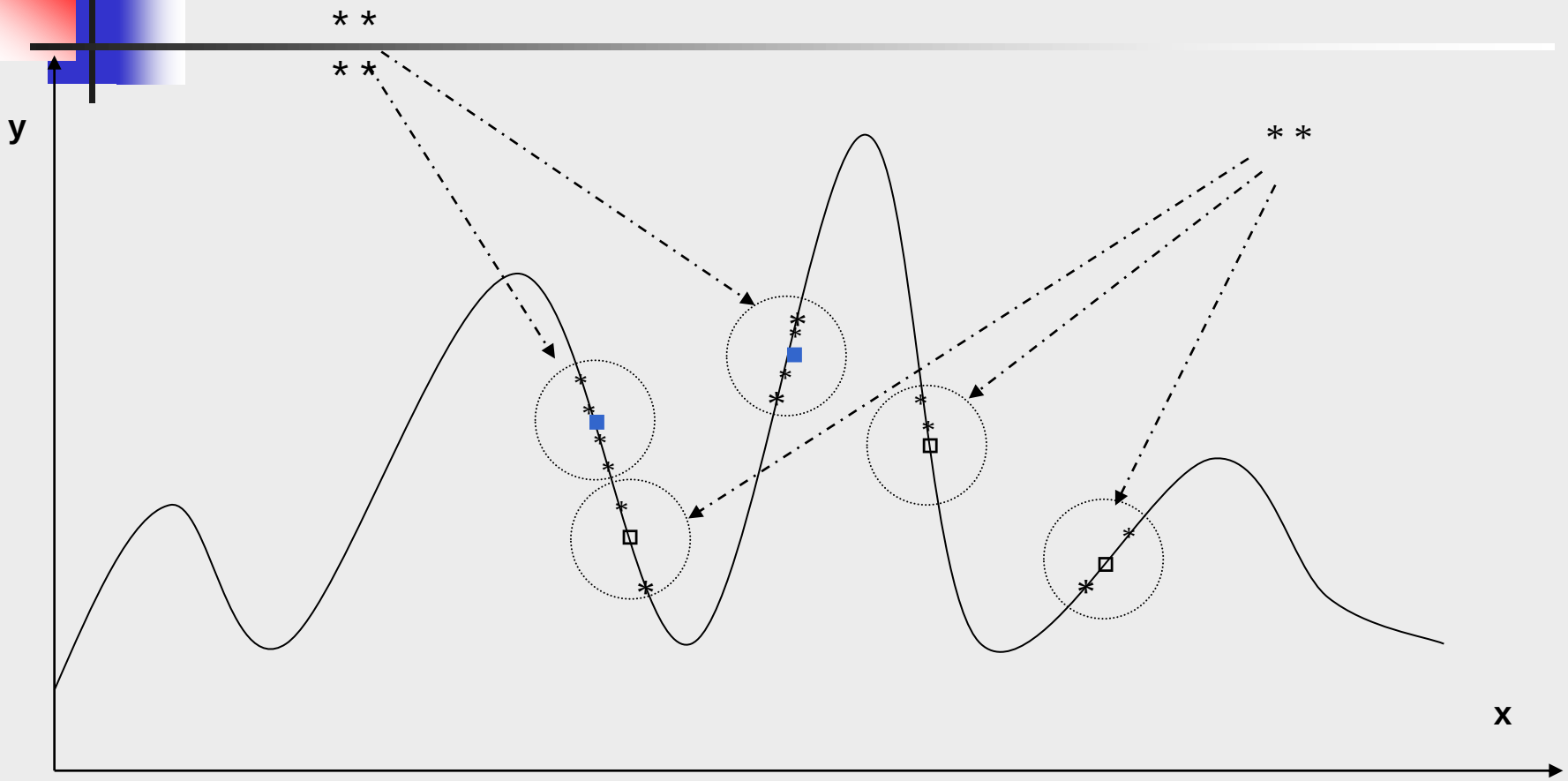
Graph 2. Select best (**m=5**) Sites for Neighbourhood Search:
(**e=2**) elite bees "▪" and (**m-e=3**) other selected bees"▫"

Simple Example



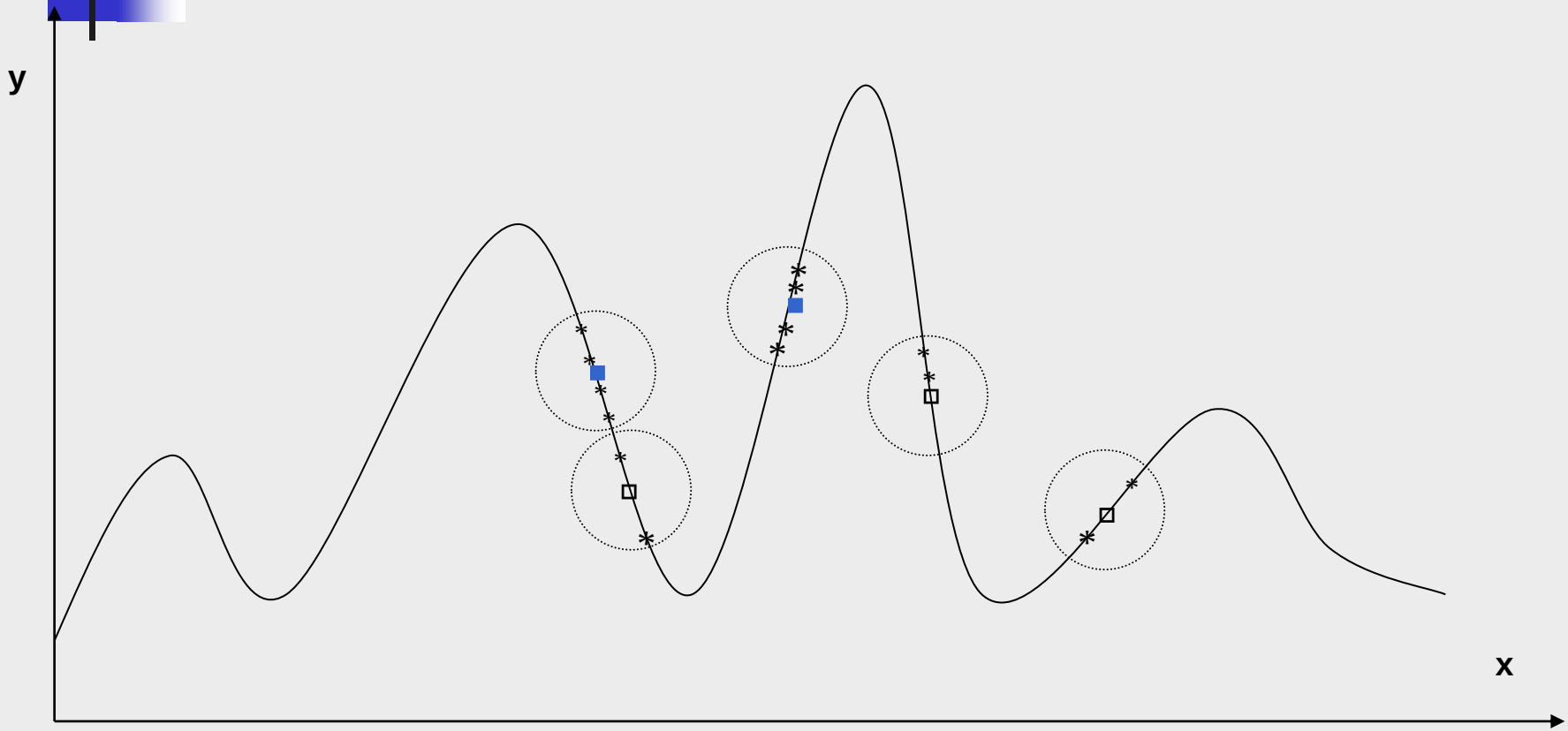
Graph 3. Determine the Size of Neighbourhood (Patch Size **ngh**)

Simple Example



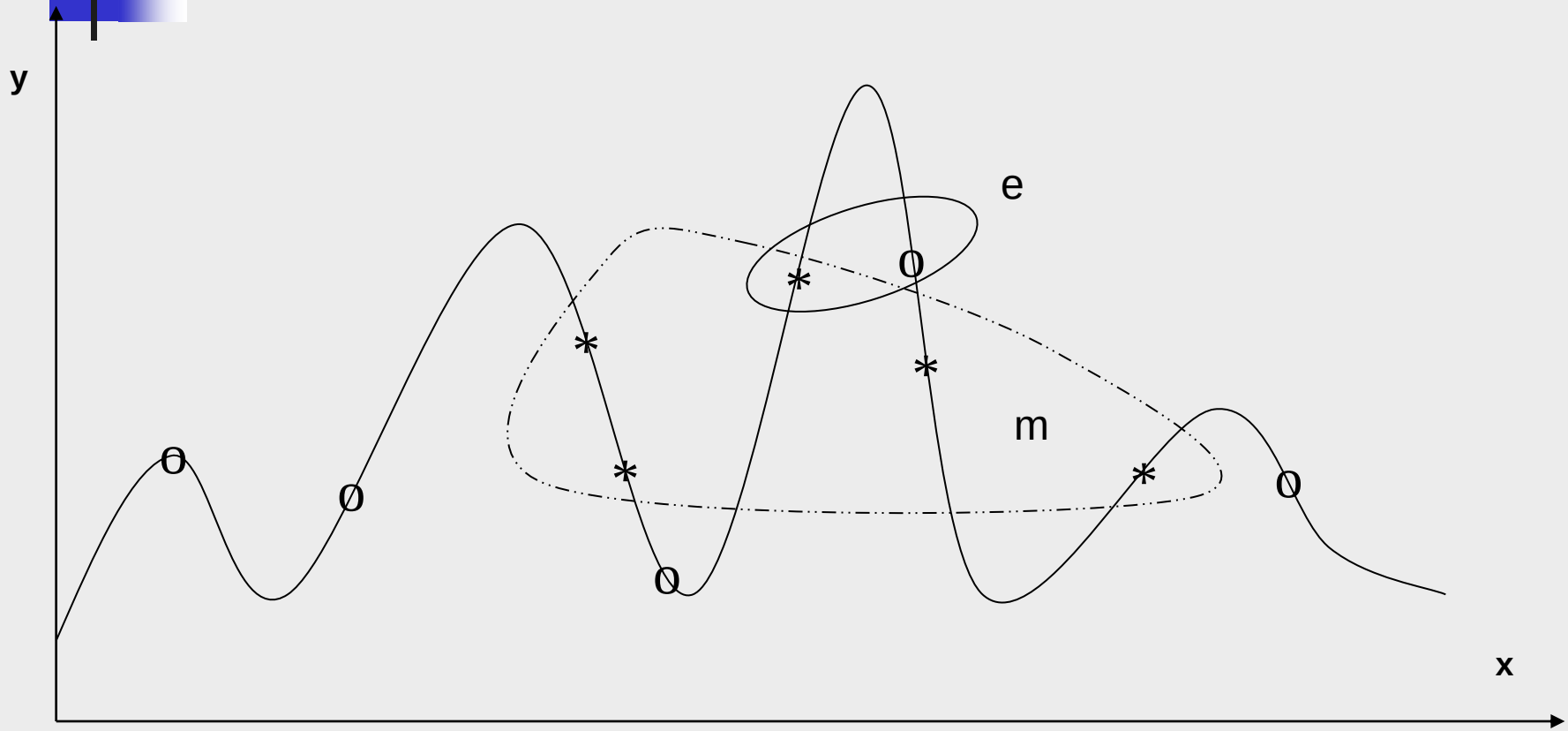
Graph 4. Recruit Bees for Selected Sites
(more Bees for the e=2 Elite Sites)

Simple Example



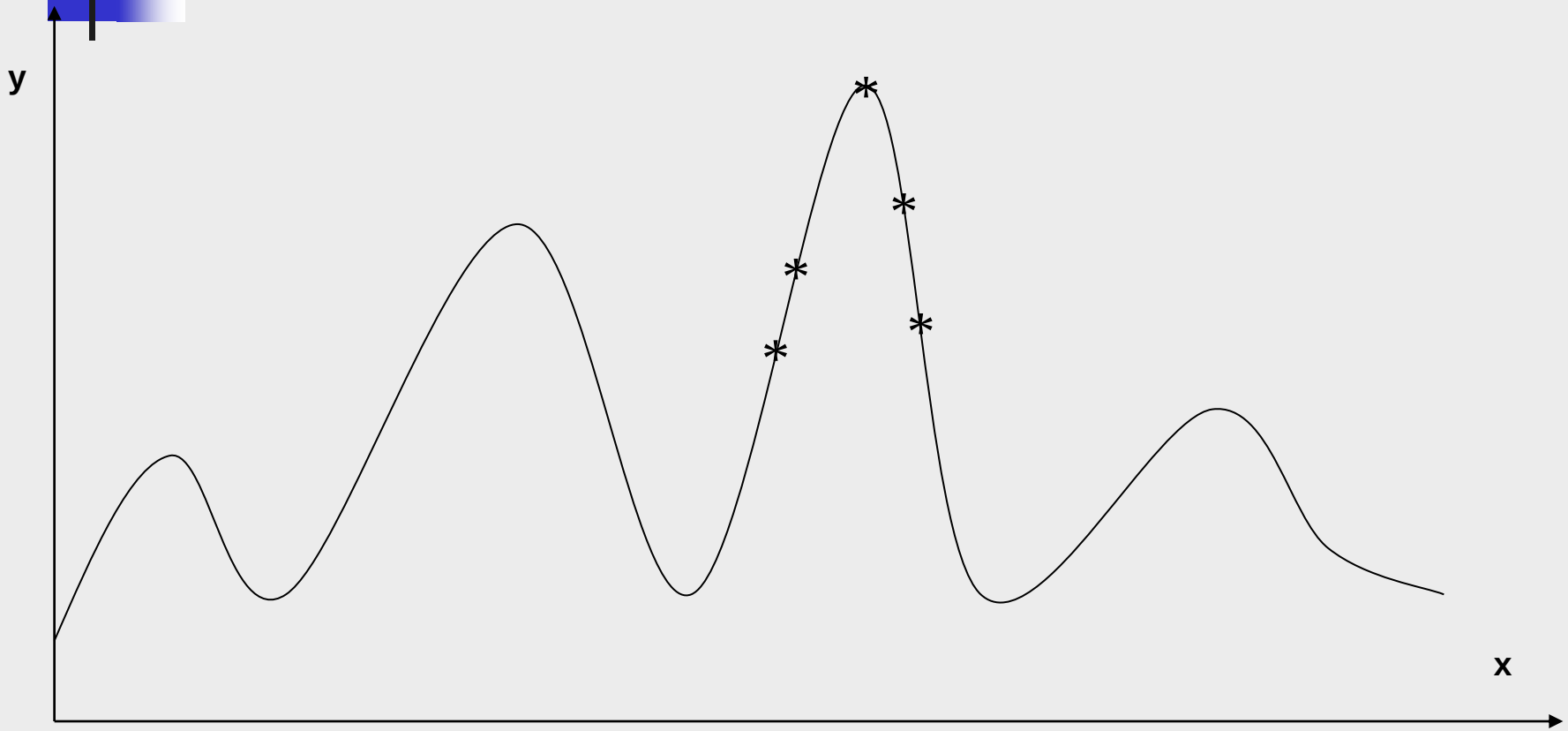
Graph 5. Select the Fittest Bee * from Each Site

Simple Example



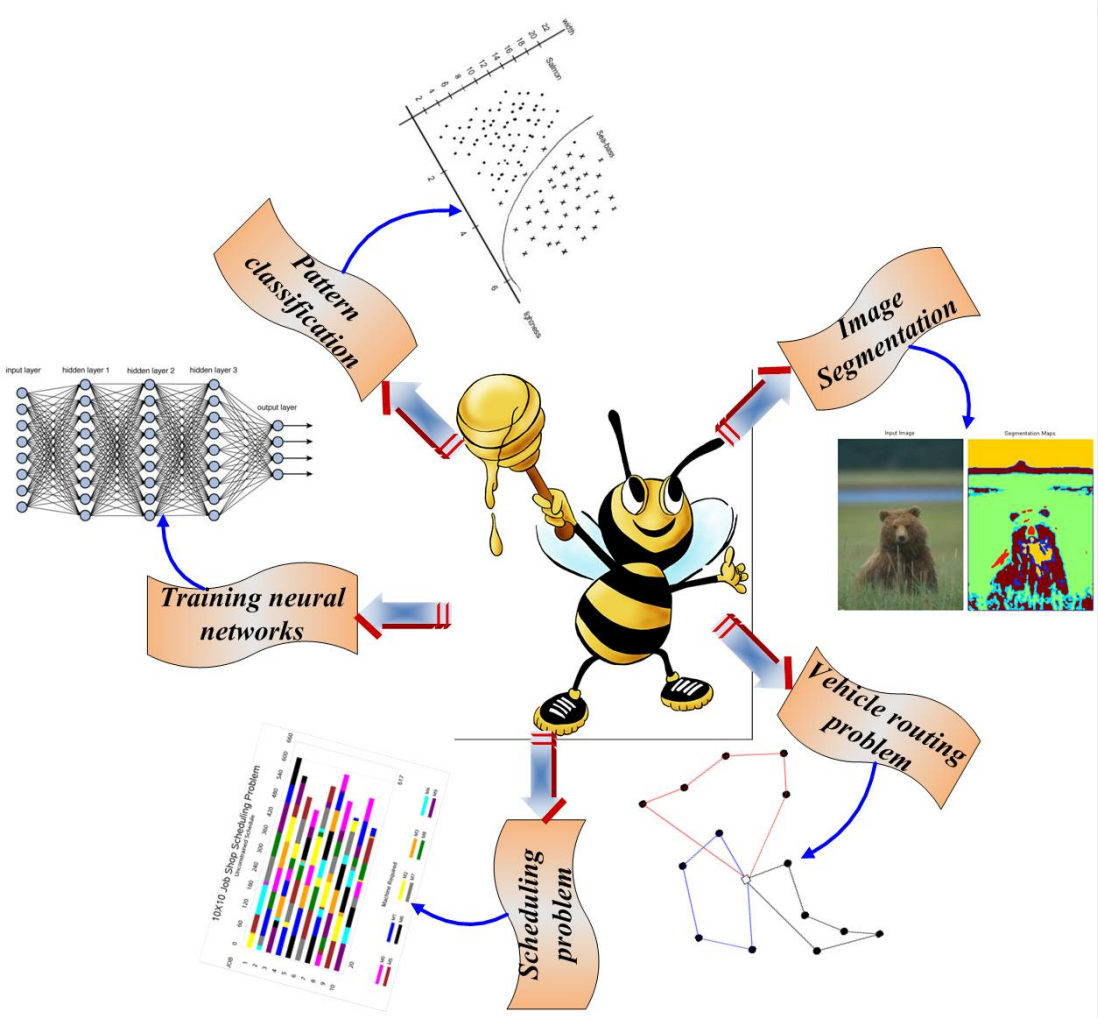
Graph 6. Assign the (**n–m**) Remaining Bees to Random Search

Simple Example



Graph 7. Find The Global Best point

Applications of ABC Algorithm



Many More Applications

https://transpireonline.blog/2019/08/02/artificial-bee-colony-abc-algorithm-a-novel-method-motivated-from-the-behavior-of-bees-for-optimal-solution/

Open Discussion