CHAP. III

BEE COLONY OPTIMIZATION (BCO)

PLAN

1. INTRODUCTION

In nature, several species are characterized by their social behavior :

- Schools of fish,
- the flocks of birds,
- herds of land animals,
- ....

This is the result of the biological need that pushes them to live in groups .

1. INTRODUCTION

- One of these swarms, the most organized and rigorous in their life, are those of bees.
- Bees have a very great ability to communicate. And thanks to their intelligence, a method called the bee method has been developed.

Bee Colony Optimization (OCA)

Bees Colony Optimization (BCO)

- In this method, artificial bees represent agents that collaborate with each other to solve complex combinatorial optimization problems.

2. HISTORY

- The HONEY -BEE algorithm was first realized around 2004 by CRAIG A.TOVEY at GEORGIA TECH in collaboration with SUNIL NAKRANI .
- In early 2005 , XIN-SHE YANG at the University of CAMBRIDGE developed the VIRTUAL BEE ALGORITHM (VBA) to solve numerical optimization problems,
- A little later in 2005, HADDAD, AFSHAR and their colleagues presented an algorithm called HONEY -BEE MATING OPTIMIZATION (HBMO) which was then applied to reservoir modeling and clustering .
- In 2006, B.BASTURK and D.JARABOGO in Turkey, developed an algorithm called ARTIFICIAL BEE COLONY (ABC) for the optimization of numerical functions.

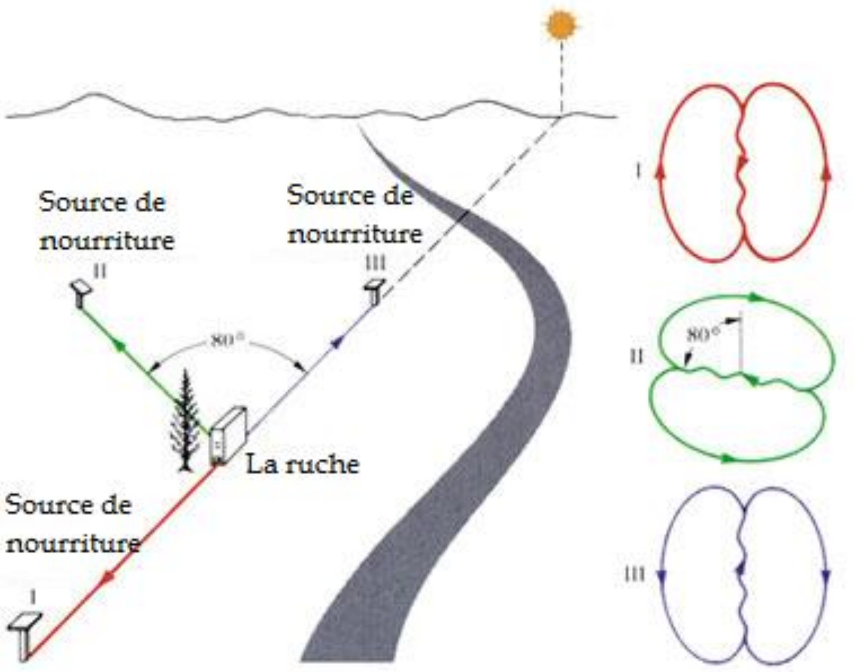
3. Bees in nature

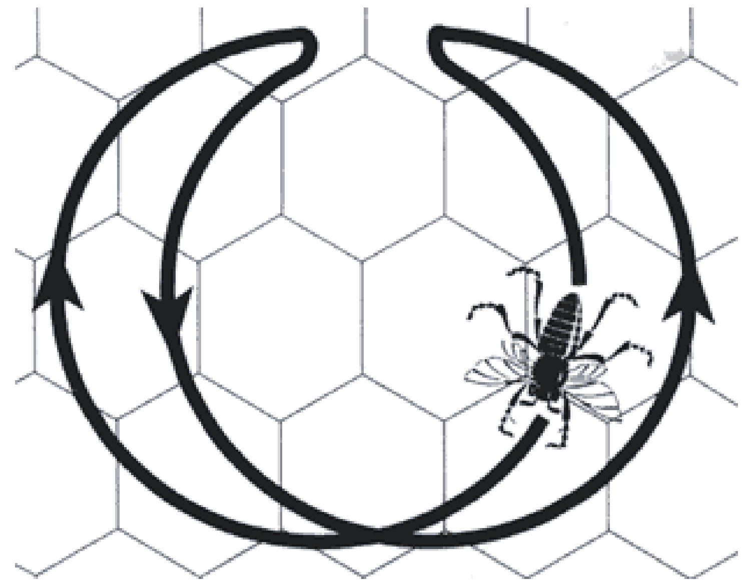
- Like ants, bees are social insects. They are forced to live in a highly organized colony, made up of workers, drones and a single queen.
- Bees feed mainly on pollen and honey. They will visit flowers to collect nectar.
- During her short life (about 45 days), the worker performs several jobs: she cleans the cells, feeds the larvae, she stores the pollen and nectar in the cells, she ventilates the hive by rapidly waving her wings, she builds the combs with the wax she produces, she guards the flight hole to chase away intruders, she becomes a forager, a water carrier and collects pollen and nectar until the end of her life.

3. Bees in nature

- The bee is able, by dancing or by producing " pheromones ", to communicate to other bees the place where it has discovered food.
- She **dances in a circle** when it finds pollen at a short distance (less than 25 meters).
- She uses a very complicated dance called the **wiggle dance** or figure eight dance, if food is within 10 kilometers.
- The direction of food is expressed relative to the position of the sun.
- The distance and quality of food are expressed by the number and speed of turns made by the bee on itself.
- In order to survive the winter, bees must collect and store about 15 to 50 kg of nectar .

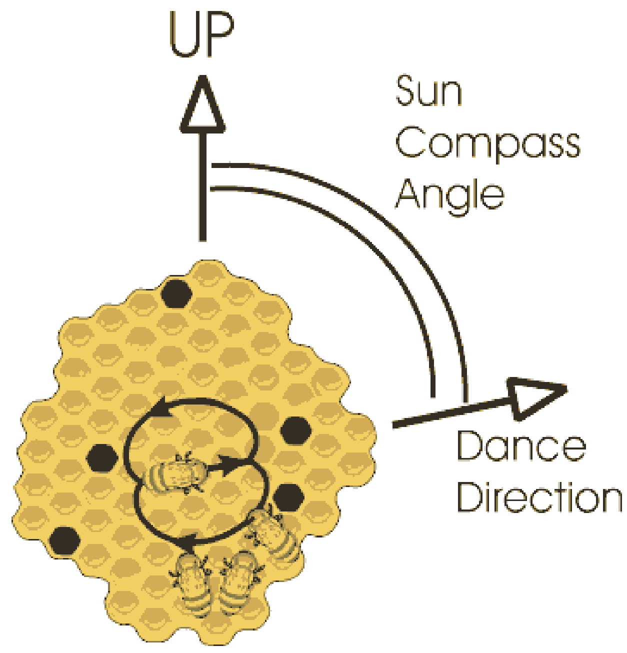
3. Bees in nature

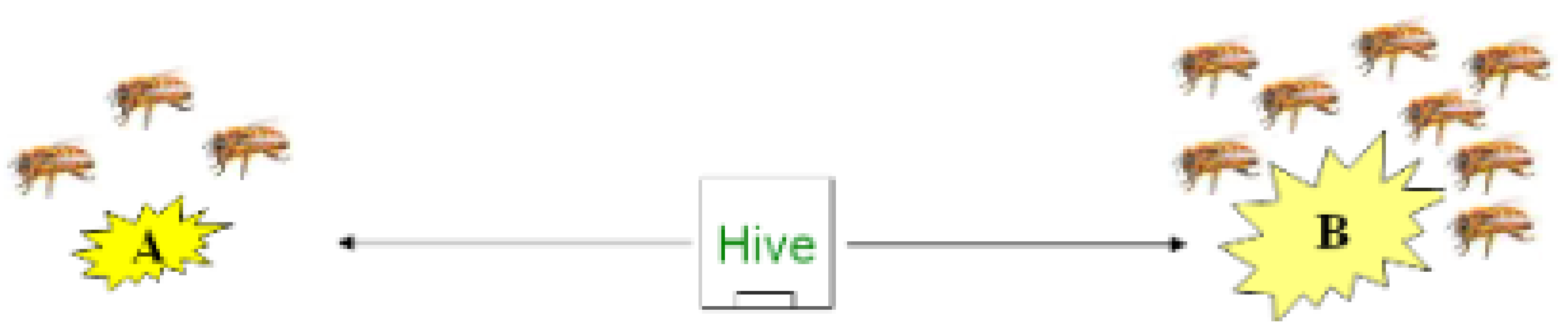




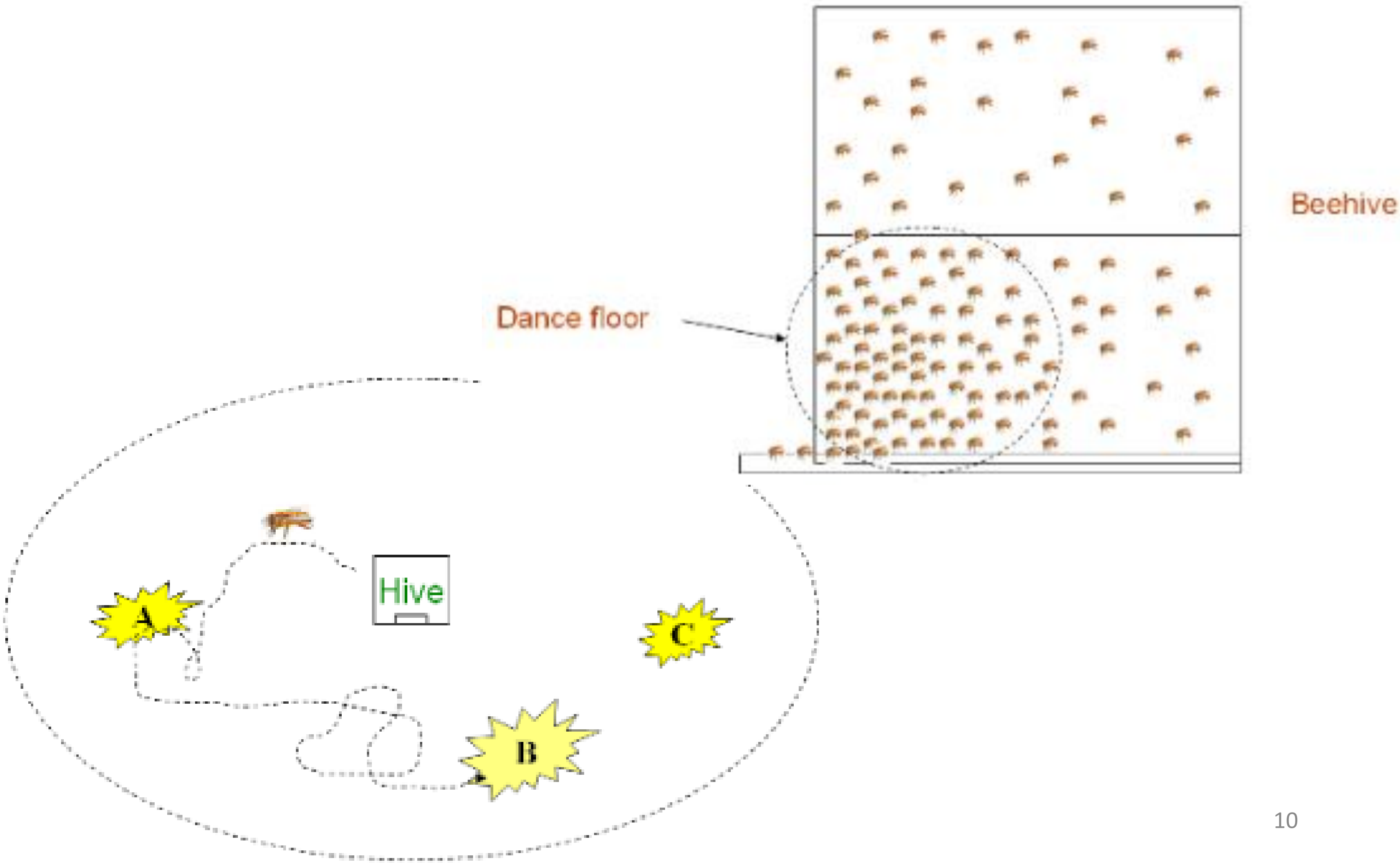
The round dance The wiggle dance

3. Bees in nature





3. Bees in nature



3. Bees in nature

- Drones are only used for reproduction. They are unable to feed themselves (the workers feed them) and they do not have a stinger to protect the hive.
- There is only one queen in the colony. A few days after her birth, she flies away for the only time in her life to be fertilized by a few drones. She will spend the rest of her days (4 to 5 years) laying up to 2000 eggs per day.
- Adult bees (20 to 40 days old) usually become foragers. Forager bees generally play one of three roles:
    - foragers ,
    - scout foragers
    - inactive foragers .

3. Bees in nature

4. ALGORITHM

- In this algorithm, the location of the food source represents the possible solution **to** the problem, and the amount of nectar from that source corresponds to a fitness value .
- Foragers are assigned to different food sources in order to maximize total nectar intake. The colony must **optimize** overall collection efficiency.
- The distribution of bees therefore depends on many factors such as the quantity of nectar and the distance between the food source and the hive.
- The number of active or inactive foragers represents the number of solutions in that population.
- In the first step, the algorithm generates an initial population of n randomly distributed solutions.
- Each solution x_i $(i = 1, 2, \dots, n)$ is initialized by the scouts, and represents a vector.

- After initialization, the population of solutions is subjected to repeated cycles $C = 1, 2, \ldots, C_{max}$, these cycles representing search processes made by active, inactive and scout foragers.
- Active foragers search the vicinity of the previous source x_i for new sources v_i with more nectar, then calculate their fitness.
- After the discovery of each new food source, a greedy selection mechanism is adopted, that is, this source is evaluated by the artificial bees, its performance is compared to that of $l'ancienne$. if the nectar of this source is equal to or better than that of the previous source, it is replaced by the new one. Otherwise, the old one is kept.

- At this stage, inactive foragers and scouts are waiting inside the hive. At the end of the search process, active foragers share information about the nectar of food sources and their locations with other bees via the waggle dance. The latter evaluate this information from all active foragers, and choose food sources according to the probability value $P_i$associated with this source, and calculated by the following formula:

$$P_i = \frac{fit_i}{\sum_{n=1}^{SN} fit_n}$$

Where $fit_i$is the fitness of the solution i, which is proportional to the amount of nectar from the food source of position i.

- The food source whose nectar is abandoned by the bees, the scouts replace it with a new source. If during a predetermined number of cycles " limit" a position cannot be improved, then this food source is assumed to be abandoned.

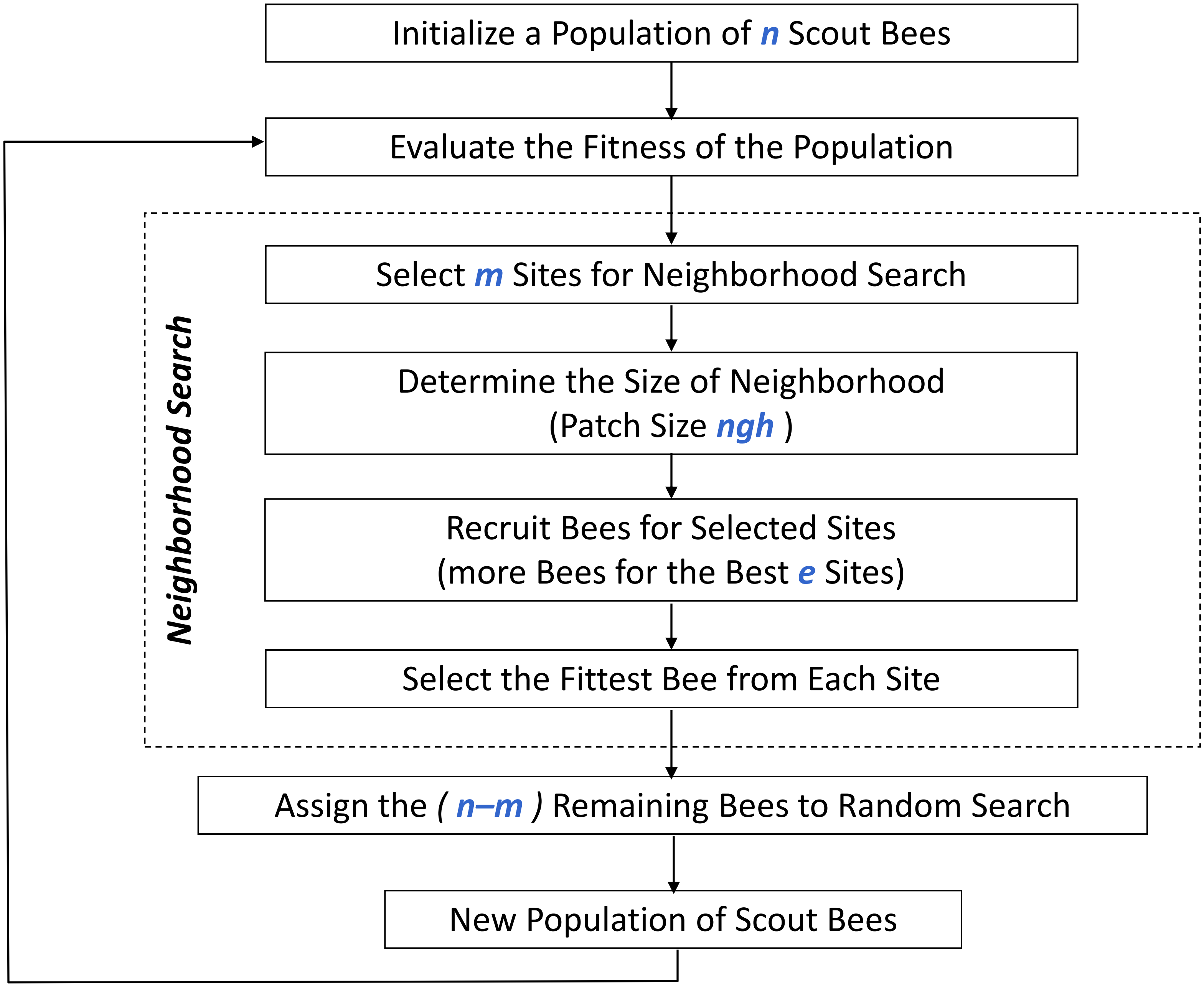
1. Initialize population with random solutions.
2. Evaluate fitness of the population.
3. While (stopping criterion not met)
//Forming new population.
4. Select sites for neighborhood search.
5. Recruit bees for selected sites (more bees for best **sites**) and evaluate fitnesses .
6. Select the fittest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

Pseudo code of the basic bees algorithm

- 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) → 40 in neighborhood area
  - Number of bees recruited for the other (me) selected sites which is nsp or (n1) → 20

    Rich

    Poor
  - Initial size of patches ngh which includes site and its neighborhood and stopping criterion → 0-1 (0.2)
  - Number of algorithm steps repetitions imax 10,300,1000



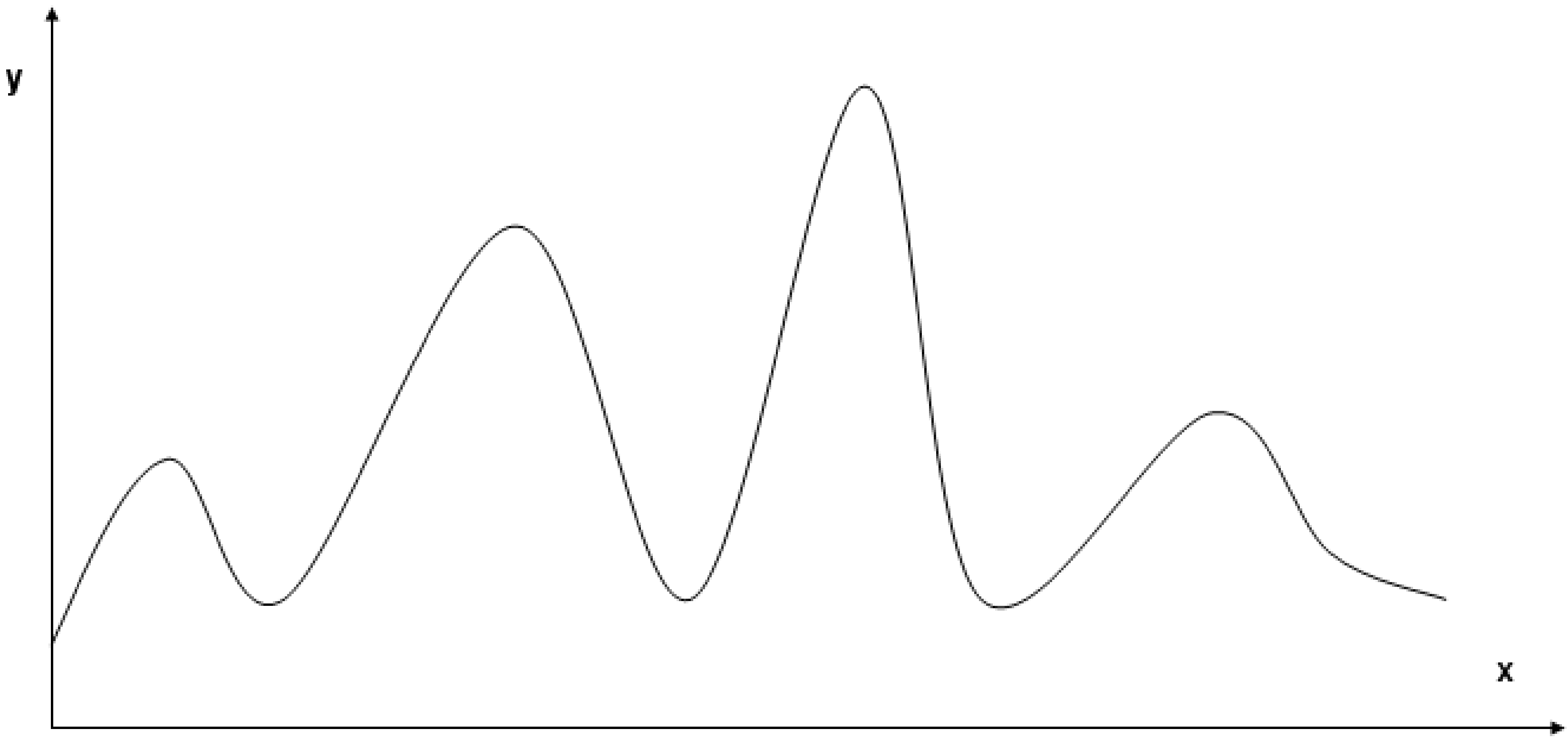
Flowchart of the Basic BA

Simple Example: Function Optimization

- Here are a simple example about how Bees algorithm works
- The example explains the use of bees algorithm to get the best value representing a mathematical function (functional optimal)

Simple Example

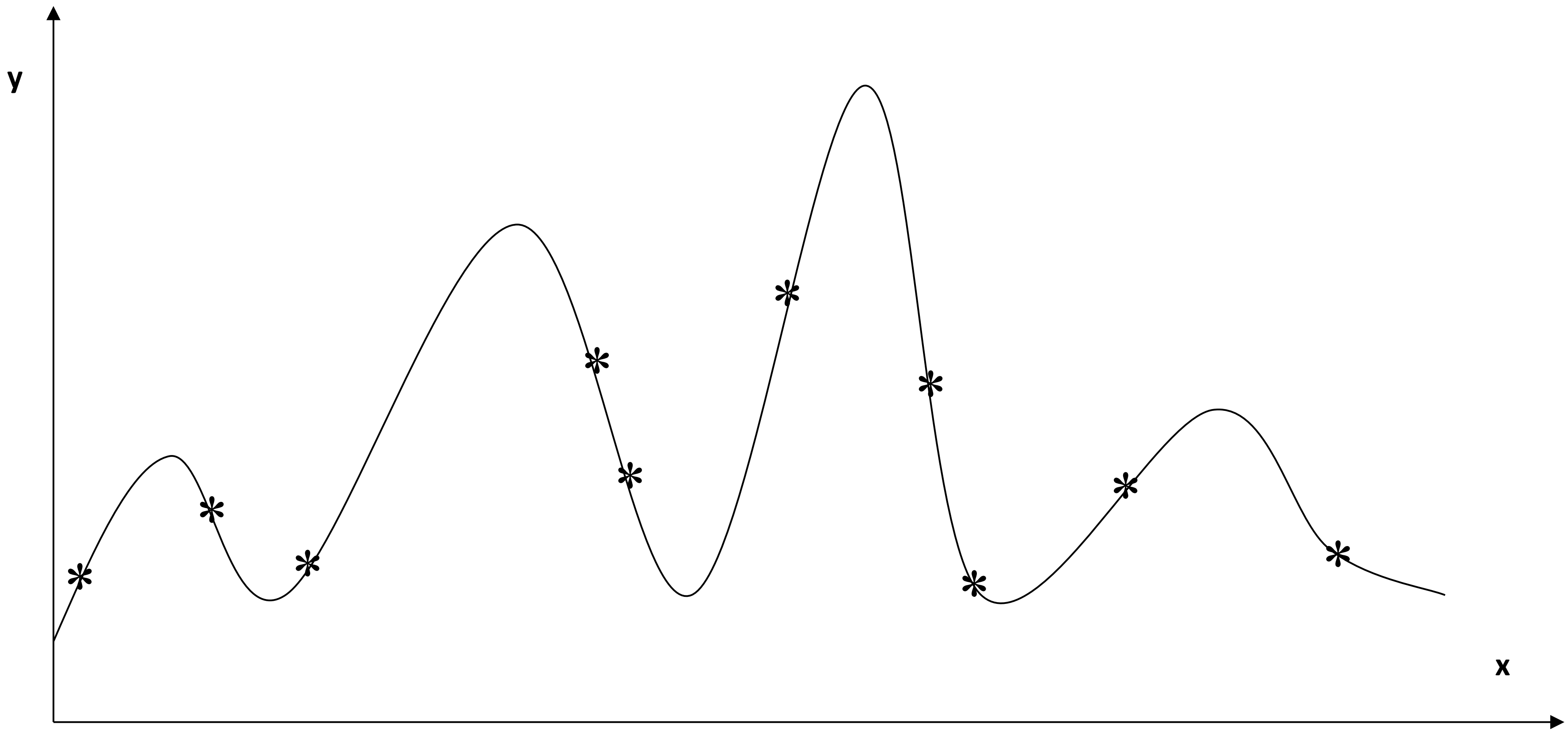
- The following figure shows the mathematical function



Simple Example

- 1- The first step is to initiate the population with any **10** scout bees with random search and evaluate the fitness. (**n=10**)

Simple Example



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

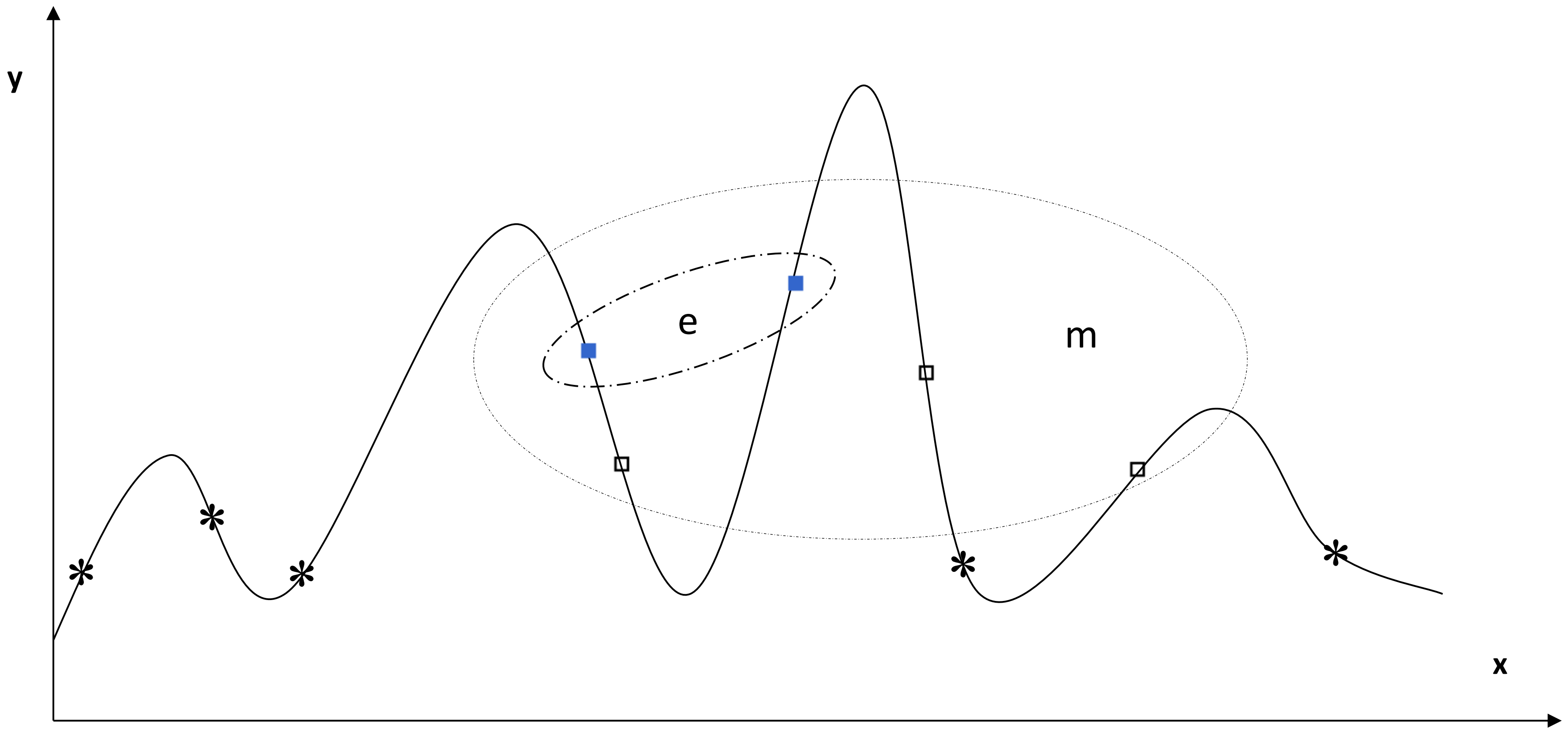
Simple Example

- **2- Population fitness assessment** :
- an array of **10** values in constructed and ordered in ascending way from the highest value of **y** to the lowest value of **y** depending on the previous mathematical function

Simple Example

- 3- The best **m** site is chosen randomly (the best evaluation to m scout bee) from **n**
  - **m=5, e=2, me=3**

Simple Example

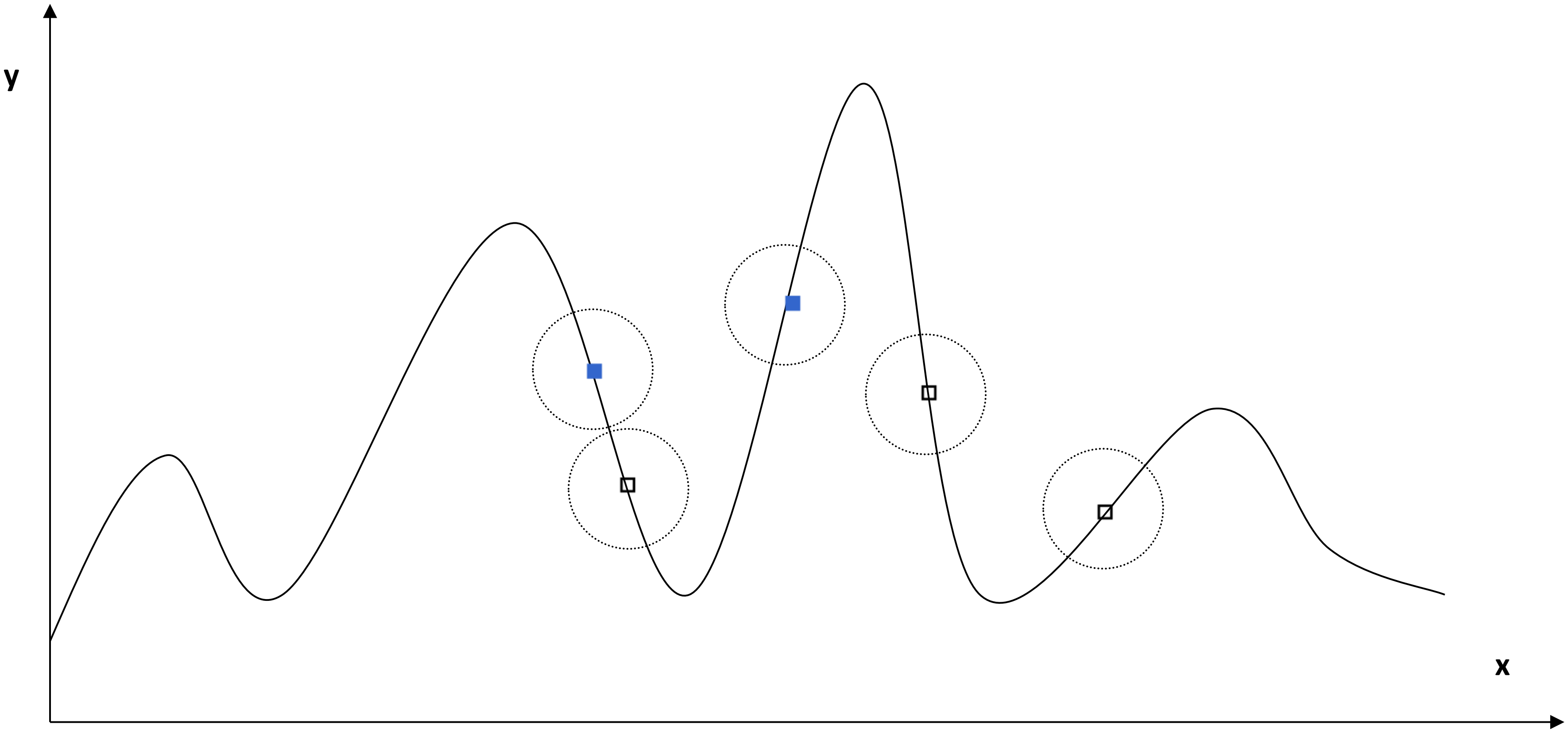


Graph 2. Select best (**m=5**) Sites for Neighborhood Search:
(**e=2**) elite bees “ ▪ ” and (**me=3**) other selected bees “▫”

Simple Example

- 4- Select a neighborhood search site upon **ngh** size:
  - **Assign random** neighborhood **ngh** as follow

Simple Example

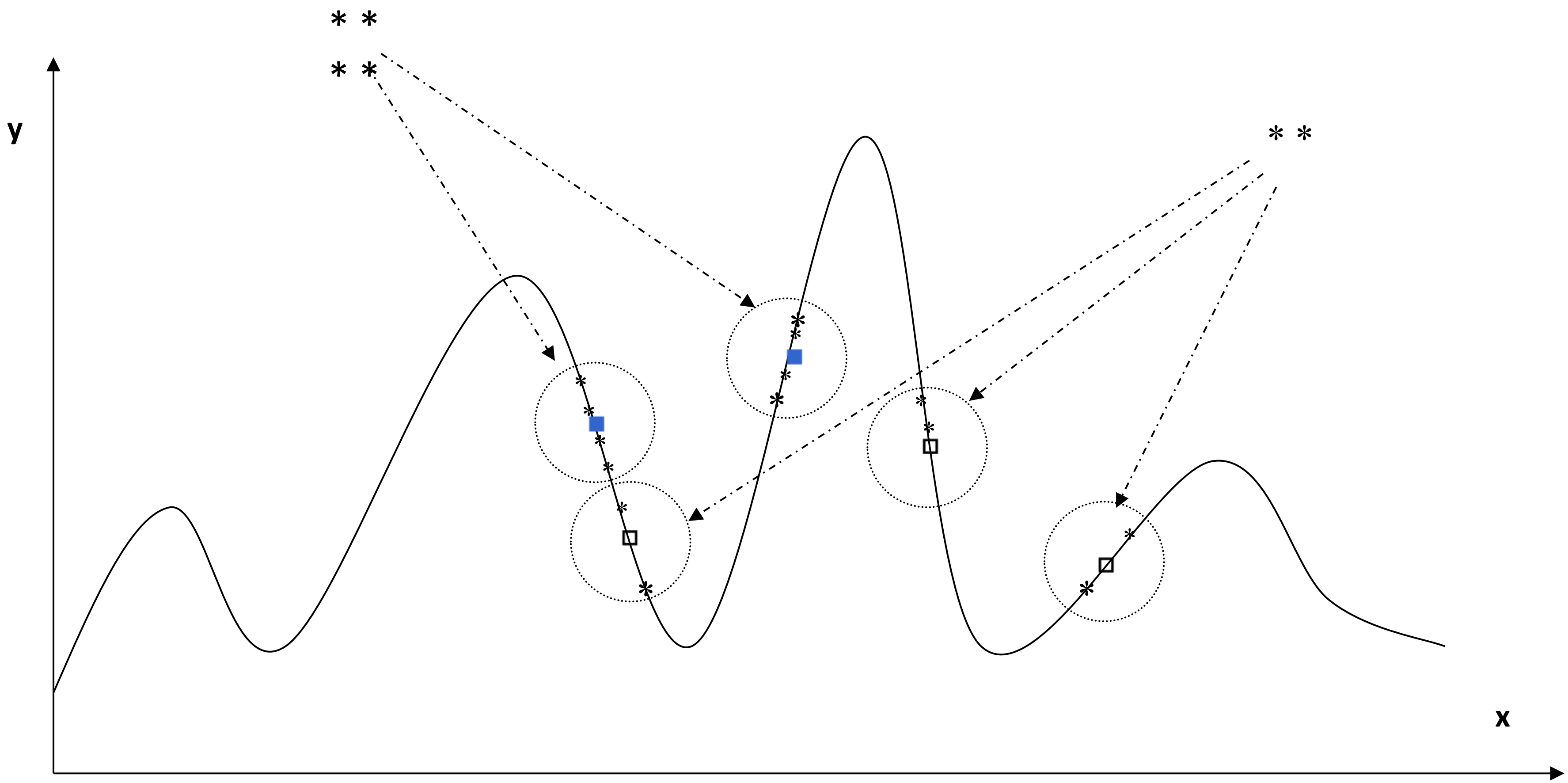


Graph 3. Determine the Size of Neighborhood (Patch Size **ngh**)

Simple Example

- 5- recruits more bees to the selected sites and evaluate the fitness to the sites:
  - Sending bees to **e** sites (rich sites) and **me** sites (poor sites).
  - More bees will be sent to the **e** site.
    - **n2 = 4 (rich)**
    - **n1 = 2 (poor)**

Simple Example

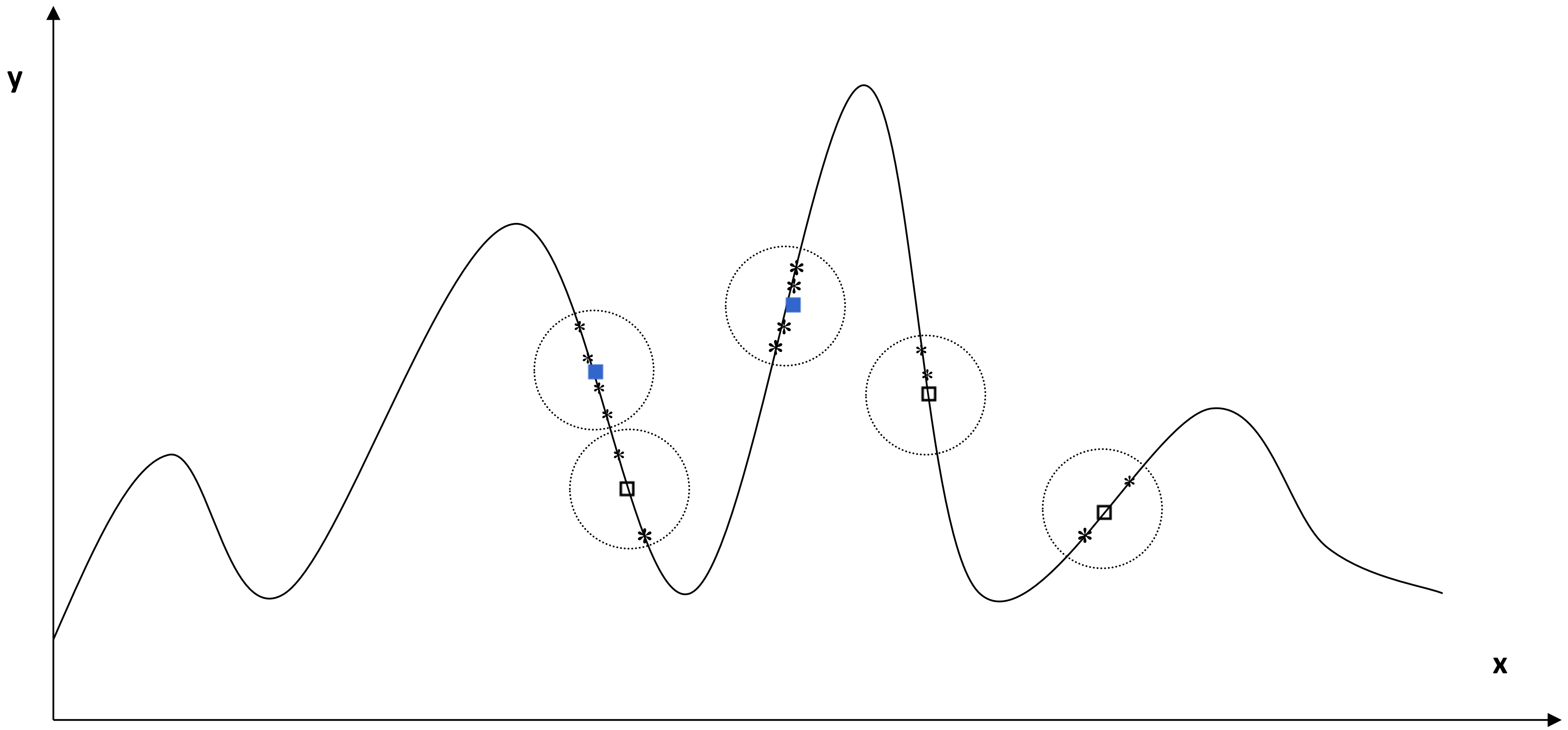


Graph 4. Recruit Bees for Selected Sites
(more Bees for the **e=2** Elite Sites)

Simple Example

- 6- Select the best bee from each location (higher fitness) to form the new bees population.
  - Choosing the best bee from every **m** site as follow:

Simple Example

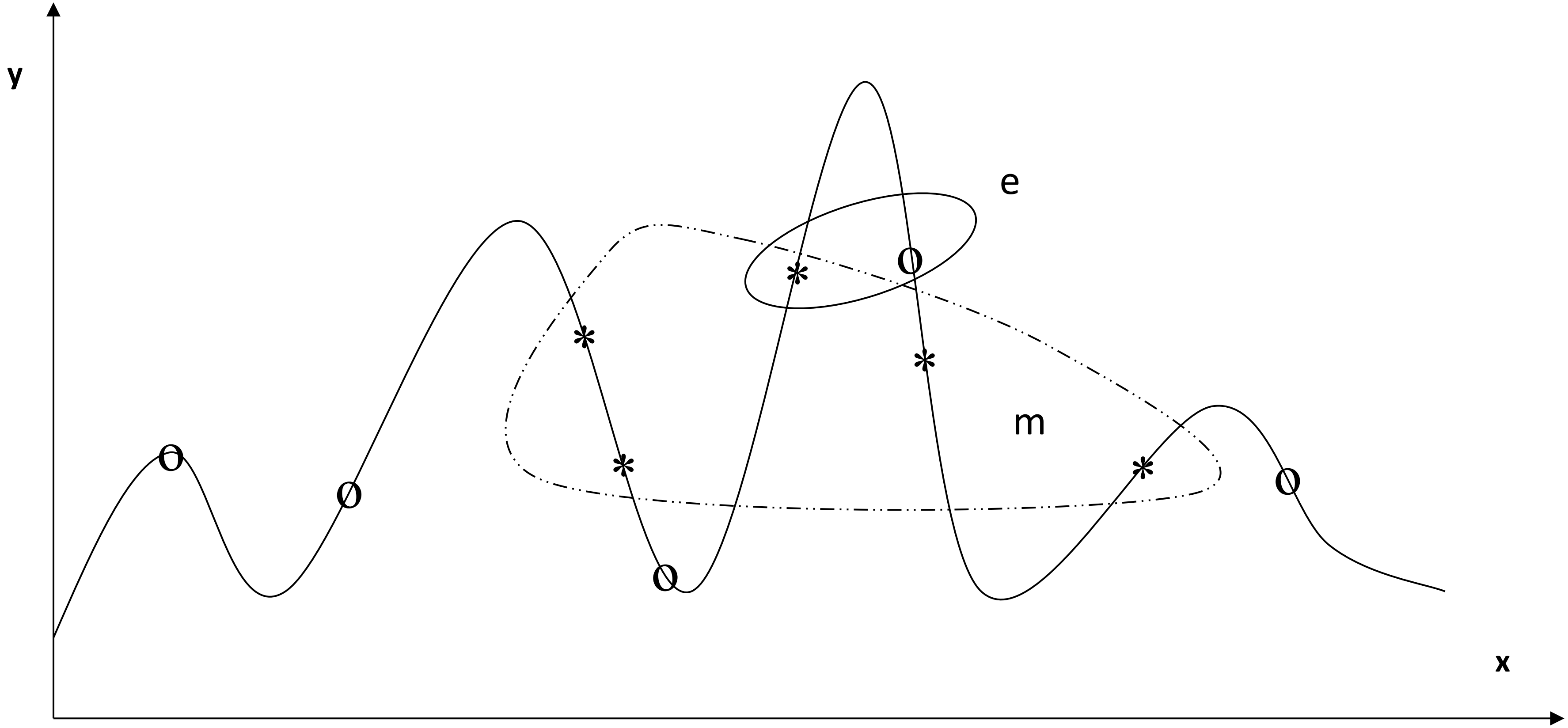


Graph 5. Select the Fittest Bee * from Each Site

Simple Example

- 7- initializes a new population:
  - Taking the old values (5) and assigning random values (5) to the remaining values **nm**

Simple Example

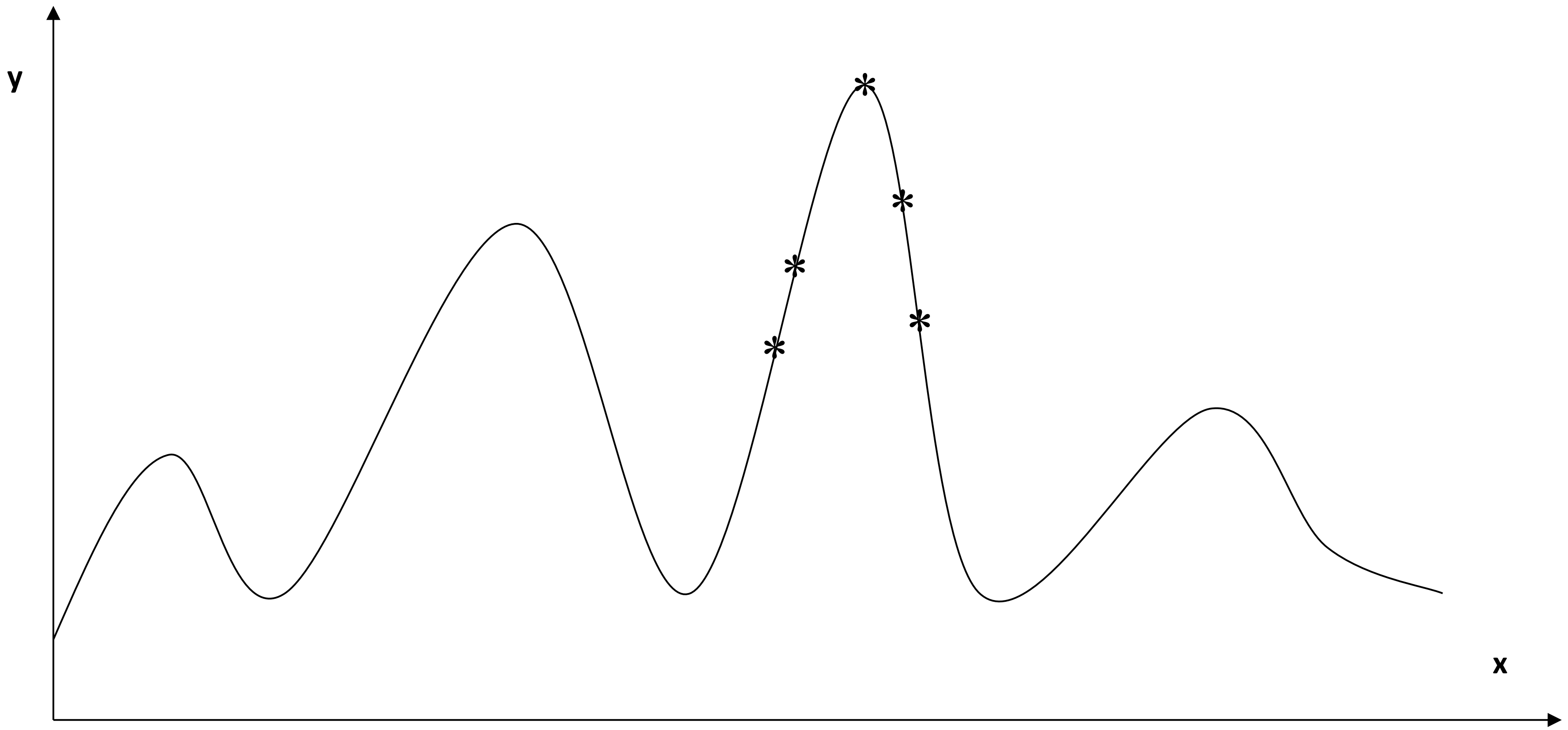


Graph 6. Assign the (**n–m**) Remaining Bees to Random Search

Simple Example

- 8- the loop counter will be reduced and the steps from two to seven will be repeated until reaching the stopping condition (ending the number of repetitions **imax**)
- At the end we reach the best solution as shown in the following figure
  - This best value (best bees from **m**) will represent the optimum answer to the mathematical function

Simple Example



Graph 7. Find The Global Best point

5. AREAS OF APPLICATION

There are many areas of application for bee algorithms, here are a few :

- Function optimization.
- The solution of the traveling salesman problem (TSP) which was done by Lucic and Teodorovic and which gave very good results.
- Learning neural networks such as MLP , RBF , SNN , LVQ .
- Electronic and mechanical design.
- Digital filter optimization.
- Data clustering .
- Robot control.
- Task scheduling.
- Protein structure prediction.

The majority of problems that were solved by this method gave very good results concerning the value of the objective function, and the execution time which was acceptable.

6. CONCLUSION

- The bee colony optimization method is one of the recent optimization methods. It is represented by an algorithm that can be applied to many optimization problems in management, engineering, and control.
- It is based on the concept of cooperation that makes bees more efficient and thus reach their goals quickly. This method has the ability, through the exchange of information and the recruitment process, to intensify the search in promising regions of the solution space.
- Preliminary results have shown that the development of new models based on bee principles must certainly contribute in quite complex problems.

7. REFERENCES

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