Université Badji Mokhtar – Annaba
Faculté de Technologie
Department: Computer Science
Specialization: Complex Software Engineering

Bee-inspired Algorithms

The Bees Algorithm

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Outline

1 - Biological Inspiration

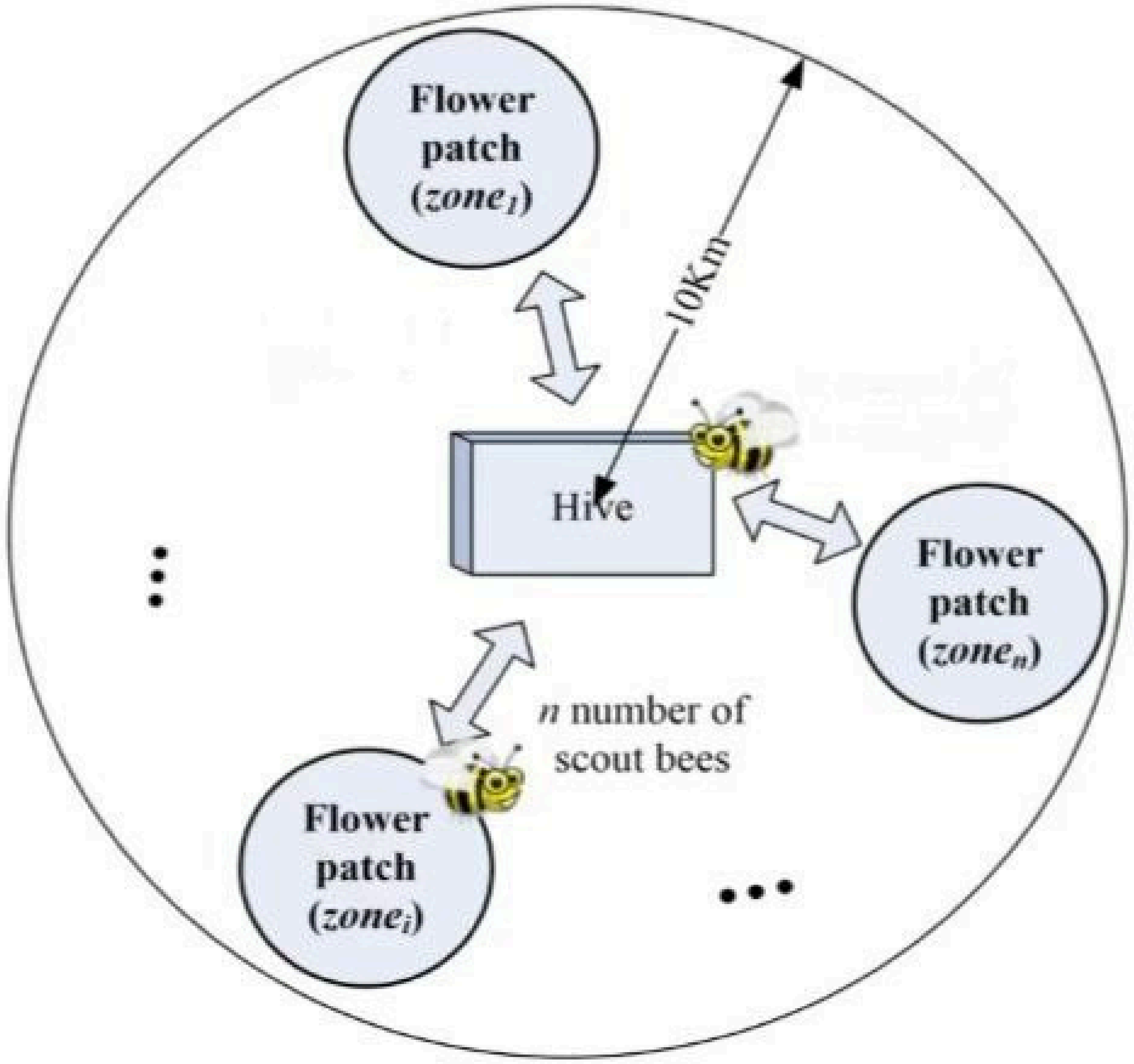
In nature, honey bees have several complicated behaviors such as mating, breeding and foraging These behaviors have been mimicked for several honey bee based optimization algorithms.

Feature	FORAGING Algorithms	BREEDING Algorithms
1. Algorithm Example(s)	• **Bee Algorithm (BA)** • **Artificial Bee Colony (ABC)**	• **Honey Bee Mating Optimization (HBMO)**
2. Core Metaphor	**Searching & Exploiting:** A swarm of agents explores a landscape to find the single best "food source" (solution).	**Reproduction & Inheritance:** "Parents" (good solutions) are combined to create "offspring" (new solutions) that inherit their traits.
3. Algorithm Family	**Swarm Intelligence** (Based on the collective behavior of a group)	**Evolutionary Algorithms** (Based on the concepts of natural selection and genetics)

1 - Biological Inspiration

The Foraging Behavior of Honey Bees

A colony of honey bees can exploit a large number of food sources in big fields and they can fly up to 10 km to exploit food sources. The colony employs about one-quarter of its members as forager bees. The foraging process begins with searching out promising flower patches by scout bees.



1 - Biological Inspiration

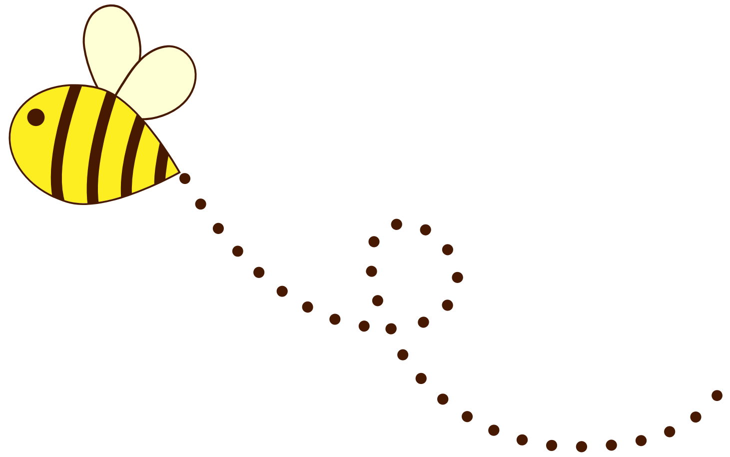
Maximize Profit

The swarm's goal is to find the **richest** food sources (highest nectar/pollen) to ensure the colony's survival and growth.

Minimize Cost

This must be balanced with efficiency. Bees naturally favor closer, high-quality sources to use the least amount of **energy** (flight time).

1 - Biological Inspiration



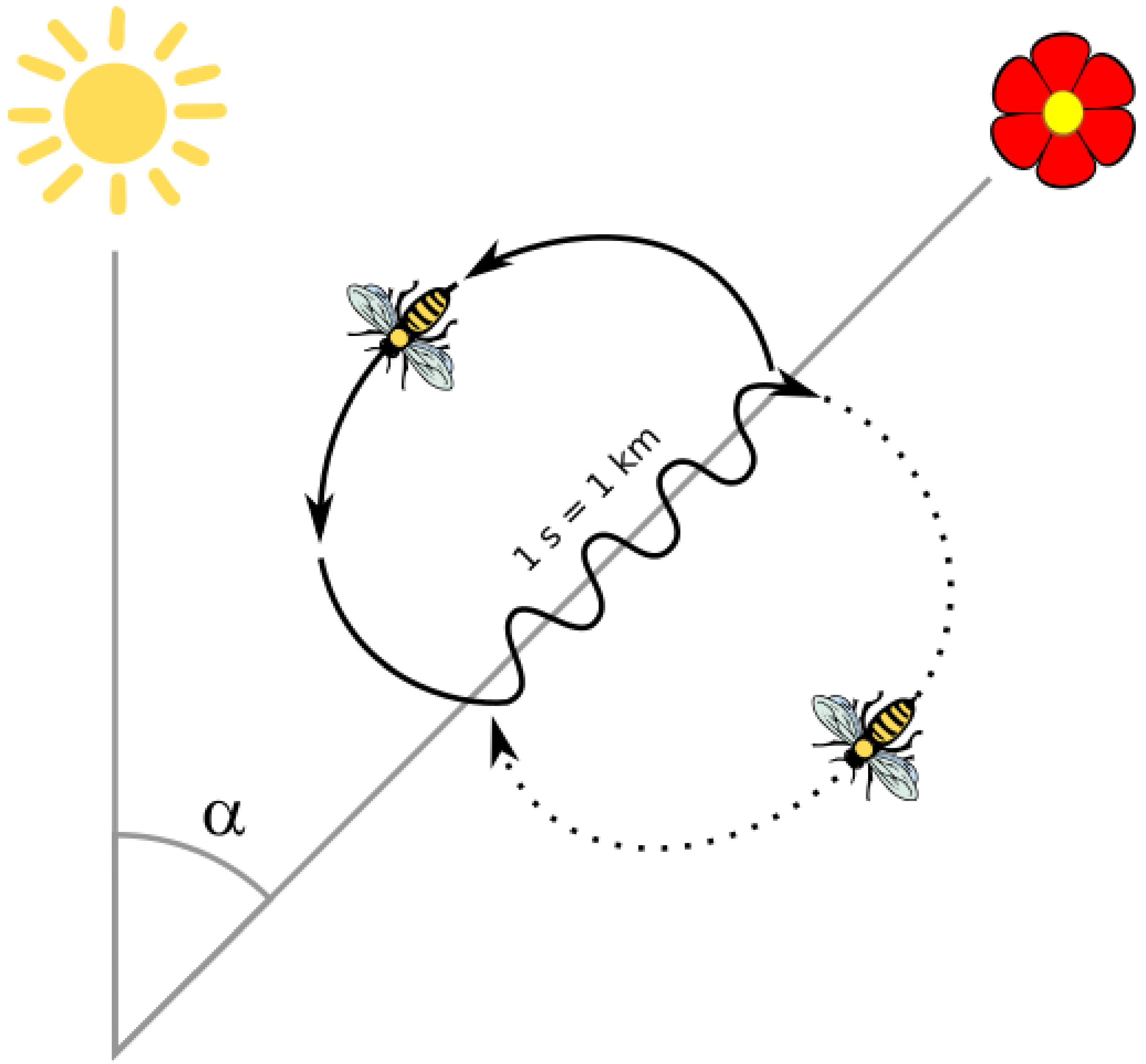
Scout Bees

The explorers. They fly out randomly to find new potential food sources.

Recruited Foragers

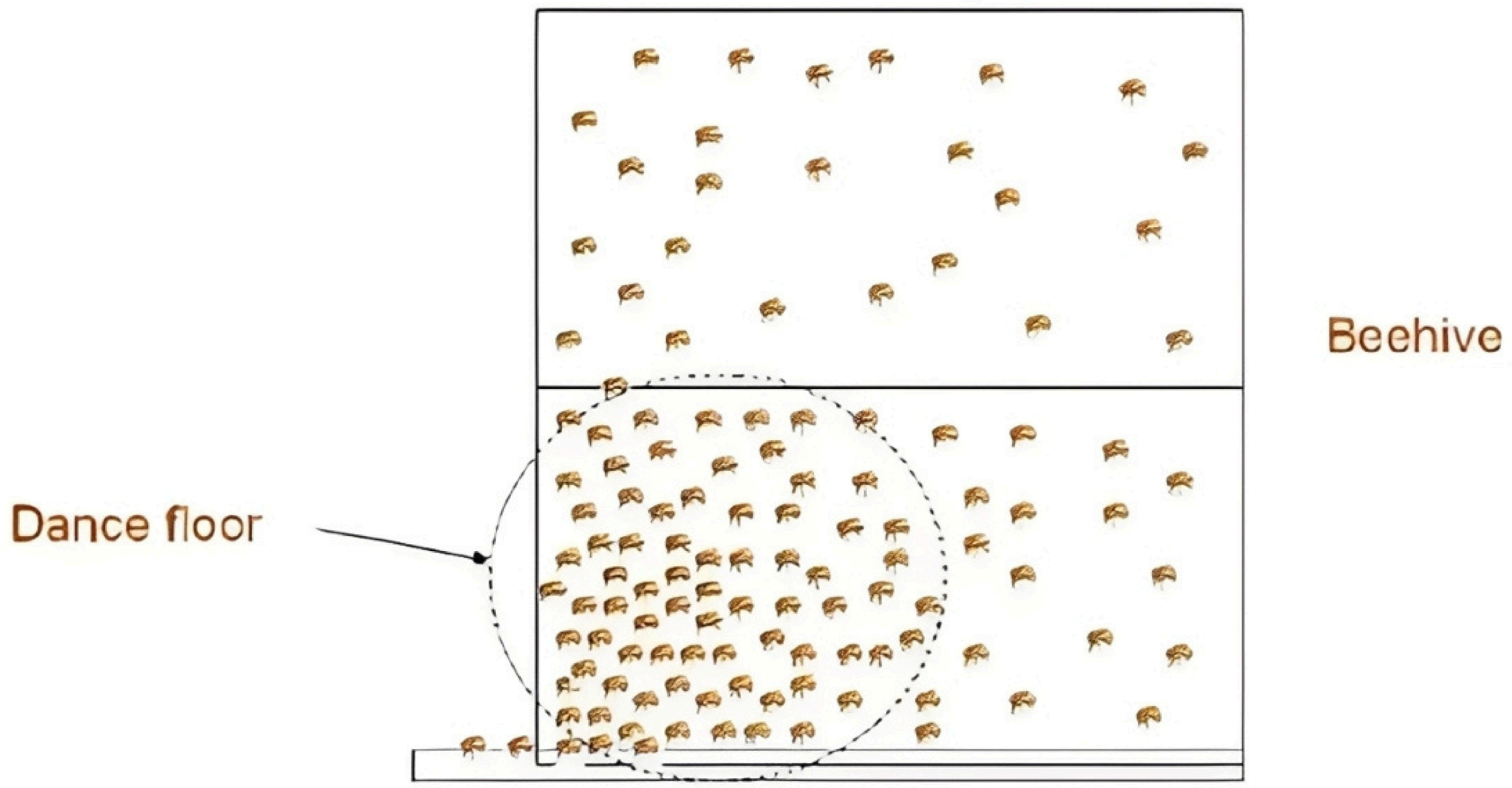
The workforce. These bees are assigned to exploit known, good sources.

1 - Biological Inspiration



The frequency of the waggles in the dance and buzzing convey the quality of the source. This information will influence the number of follower bees.

1 - Biological Inspiration



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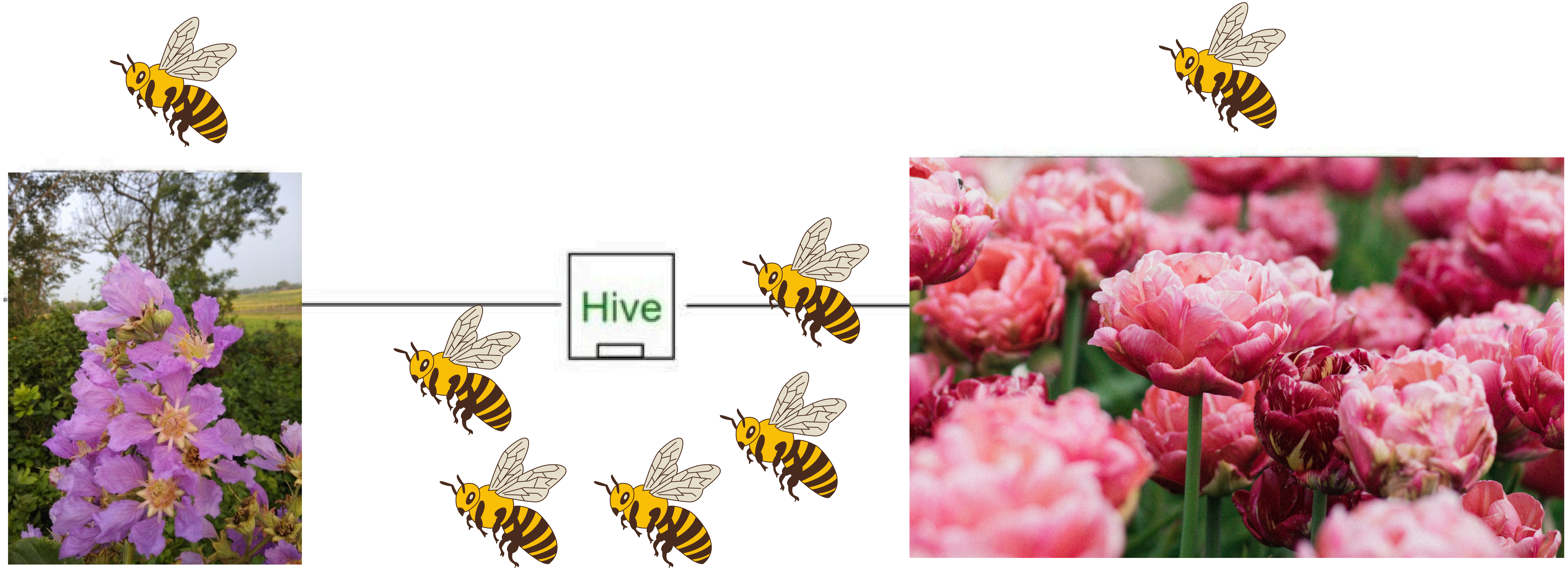


2 - Biological to Artificial Metaphor

The Bees Algorithm

proposed by Duc Truong Pham
(2005)

has a deterministic
approach during the neighborhood stage

Artificial Bee Colony optimization (ABC)

proposed by Dervis Karaboga
(2005)

has a probabilistic
approach during the neighborhood stage

2 - Biological to Artificial Metaphor

Biological Concept	Algorithmic Metaphor
Food Source (a patch of flowers)	A **potential solution** to the optimization problem.
Nectar Amount (quality of the source)	The **"fitness"** or **"quality"** of the solution.
Scout Bees	**Global Search agents.** They fly out randomly to find new food sources (new random solutions).
Forager Bees	**Local Search agents.** They are "recruited" and *sent* to search the neighborhood of the *best* sites found by the scouts.
Waggle Dance	A **ranking and assignment** mechanism. The algorithm ranks all found solutions and *assigns* more foragers to the top-ranked ones.
"Elite Sites"	A small number of the **absolute best** solutions found so far. These get the *most* forager bees.
"Best Sites"	A larger group of **good solutions** (but not elite). These get a *smaller* number of forager bees.

3 - Use Cases & Applications

1. Manufacturing and Industrial Engineering

- Job-Shop Scheduling: Finding the fastest order to run 100 jobs on 5 different machines.

2. Computer Science and Networking

- The Traveling Salesman Problem (TSP) & Vehicle Routing (VRP) : Finding the shortest path for a delivery truck to visit 50 cities and return home.
- Load Balancing : Deciding how to assign website traffic to 10 different servers so no single server gets overloaded

3. Data Science & Machine Learning

- Training Neural Networks : Finding the best "settings" (weights) for an AI to make it smarter and more accurate.
- Feature Selection : Finding the most useful columns of data (e.g., the 20 best out of 500) to make a better prediction.

4 - Algorithm Variants

1. eBA (Enhanced Bee Algorithm)

- To make the local search (exploitation) more precise and to help the algorithm escape traps, adds two new mechanisms **Neighborhood Shrinking** , **Site Abandonment**

2. GBA (Grouped Bee Algorithm)

- It splits the swarm into several "groups." Each group of bees works independently (like its own mini-BA) to find the best solution in its part of the search space.

3. BA2 (The Two-Parameter Bee Algorithm)

- It is a complete redesign of the internal logic to boil the entire algorithm down to just two "master" parameters that the user sets.

4. Hybrid BA (e.g., BA-PSO or BA-GA)

5 - Core Algorithm Details

Generate the initial population size as *n*, set the best patch size as *m*, set the elite patch size as *e*, set the number of forager bees recruited to the of elite sites as *nep*, set the number of forager bees around the non-elite best patches as *nsp*, set the neighborhood size as *ngh*, set the maximum iteration number as *MaxIter*, and set the error limit as *Error*.

$i = 0$

Generate initial population.

Evaluate Fitness Value of initial population.

Sort the initial population based on the fitness result.

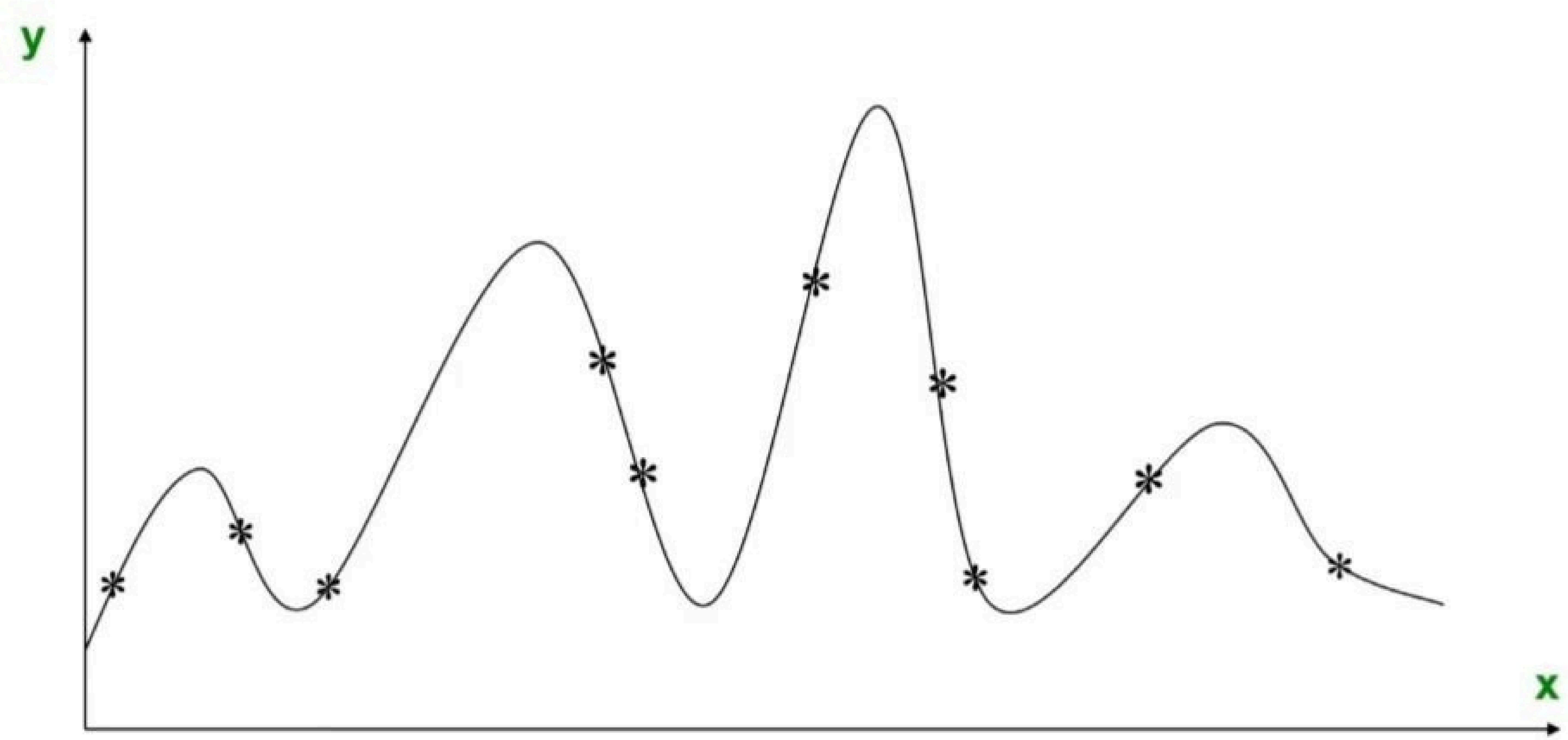
While $i \leq MaxIter$ or $FitnessValue_i - FitnessValue_{i-1} \leq Error$

1. $i = i + 1$;
2. Select the elite patches and non-elite best patches for neighborhood search.
3. Recruit the forager bees to the elite patches and non-elite best patches.
4. Evaluate the fitness value of each patch.
5. Sort the results based on their fitness.
6. Allocate the rest of the bees for global search to the non-best locations.
7. Evaluate the fitness value of non-best patches.
8. Sort the overall results based on their fitness.
9. Run the algorithm until termination criteria met.

End

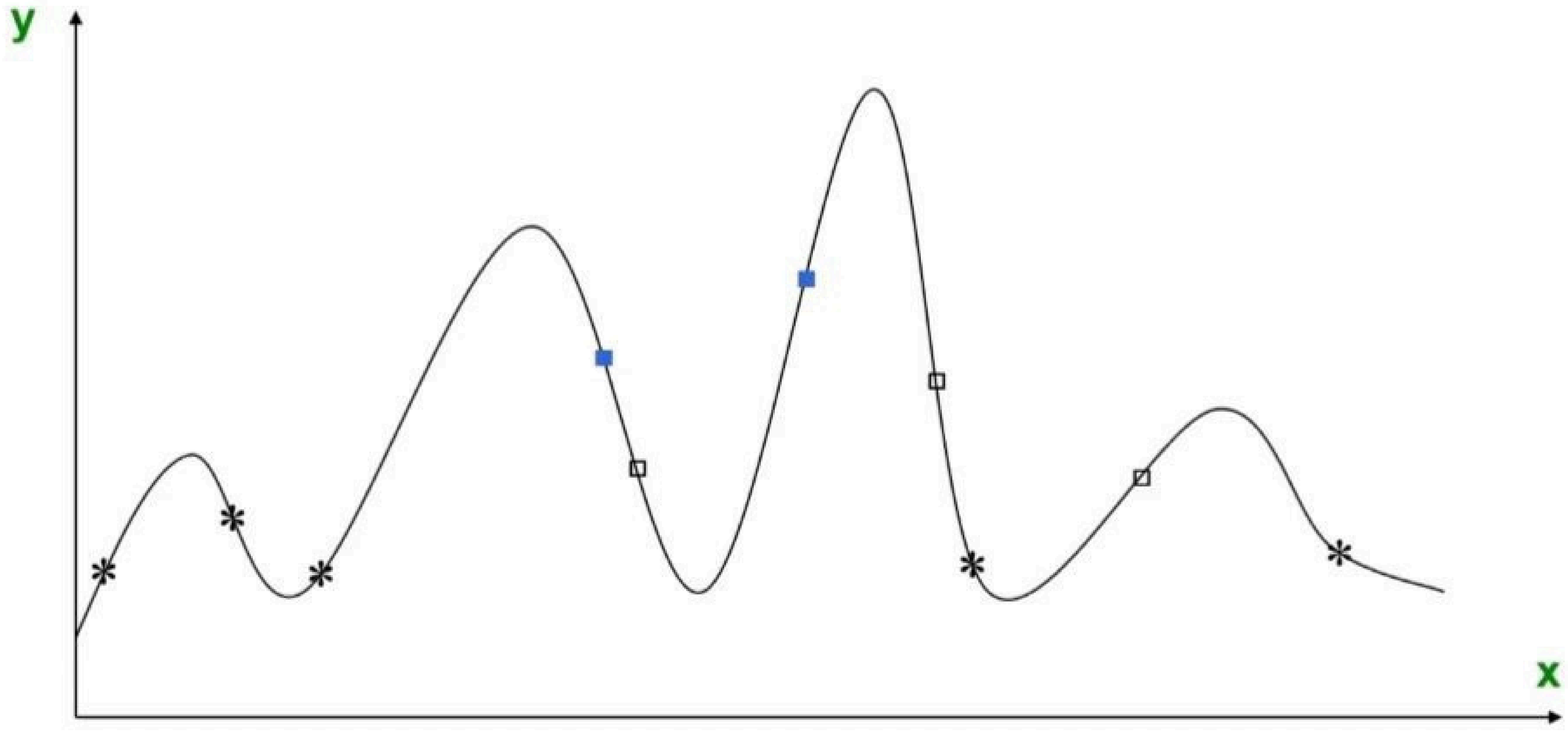
5 - Core Algorithm Details

- Generate initial population.
- Evaluate Fitness Value of initial population.
- Sort the initial population based on the fitness result



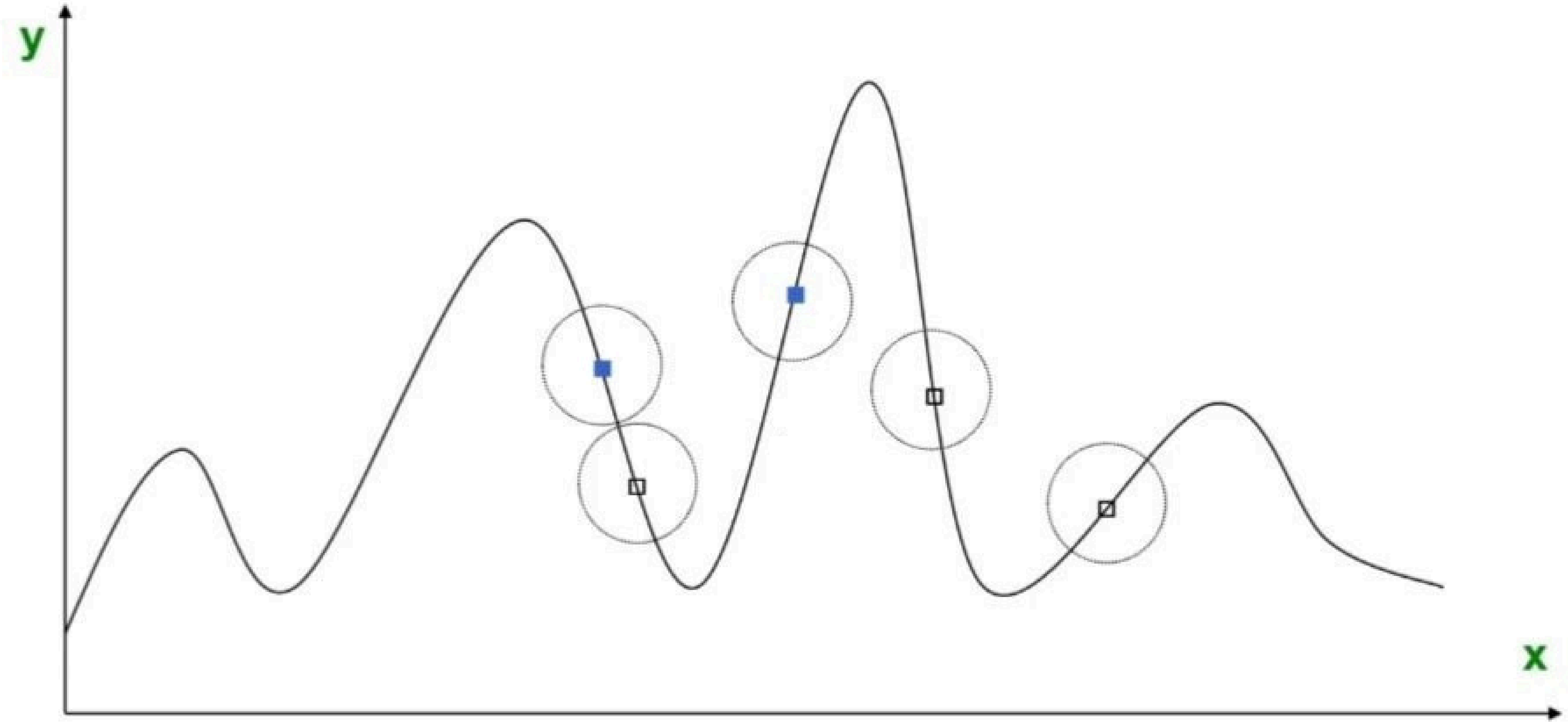
5 - Core Algorithm Details

- Select the elite patches and non-elite best patches for neighborhood search



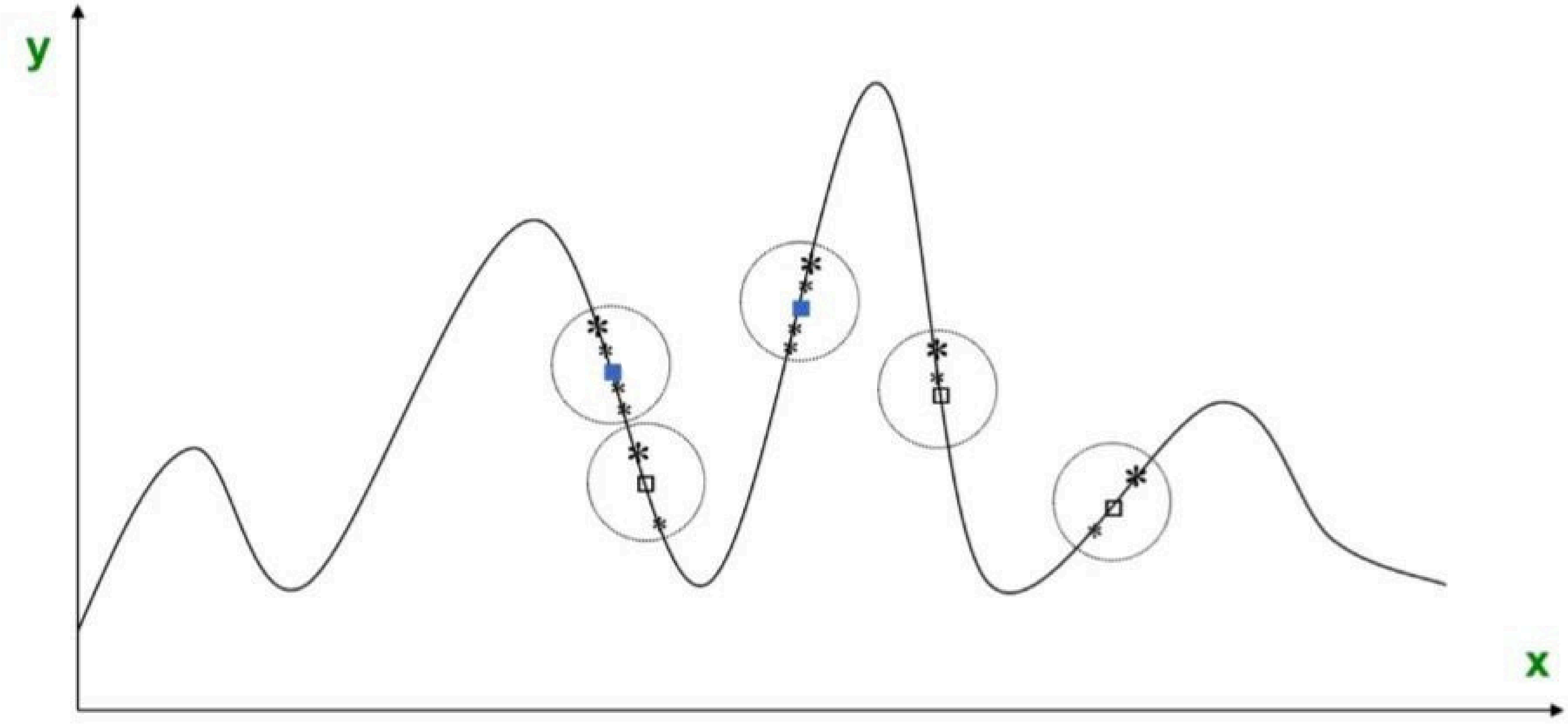
5 - Core Algorithm Details

- Recruit the forager bees to the elite patches and non-elite best patches.



5 - Core Algorithm Details

- Evaluate the fitness value of each patch.
- Sort the results based on their fitness.



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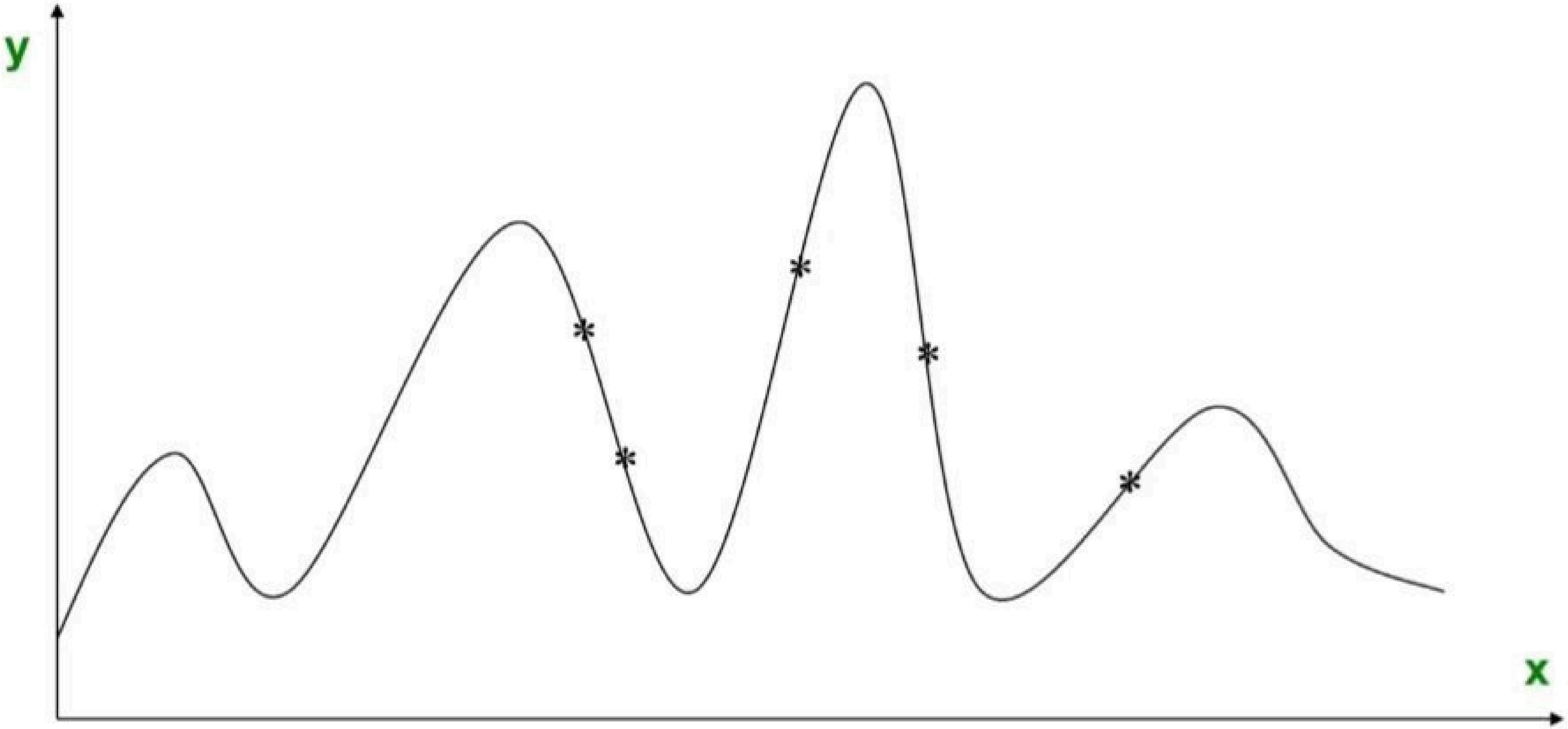
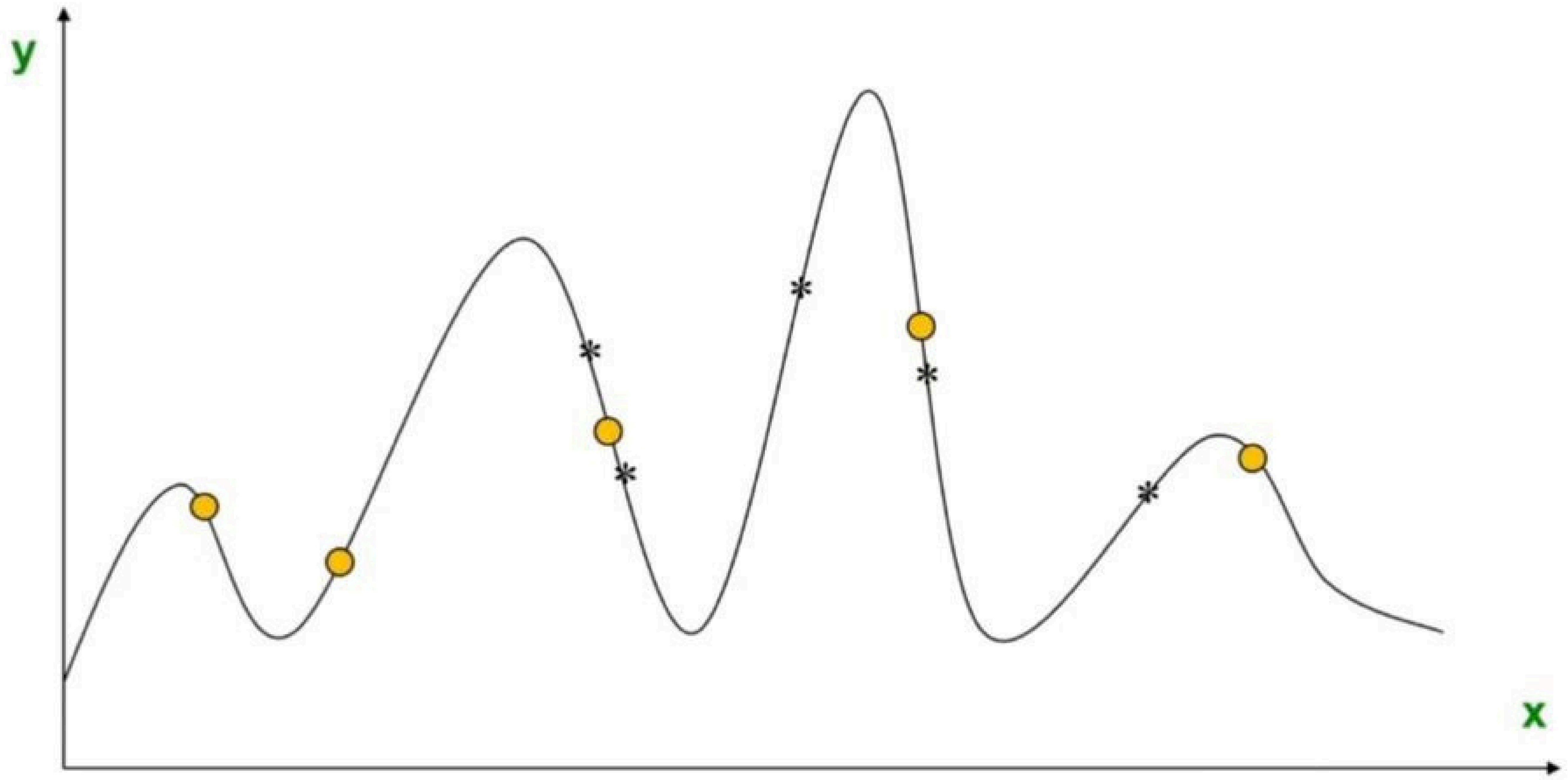


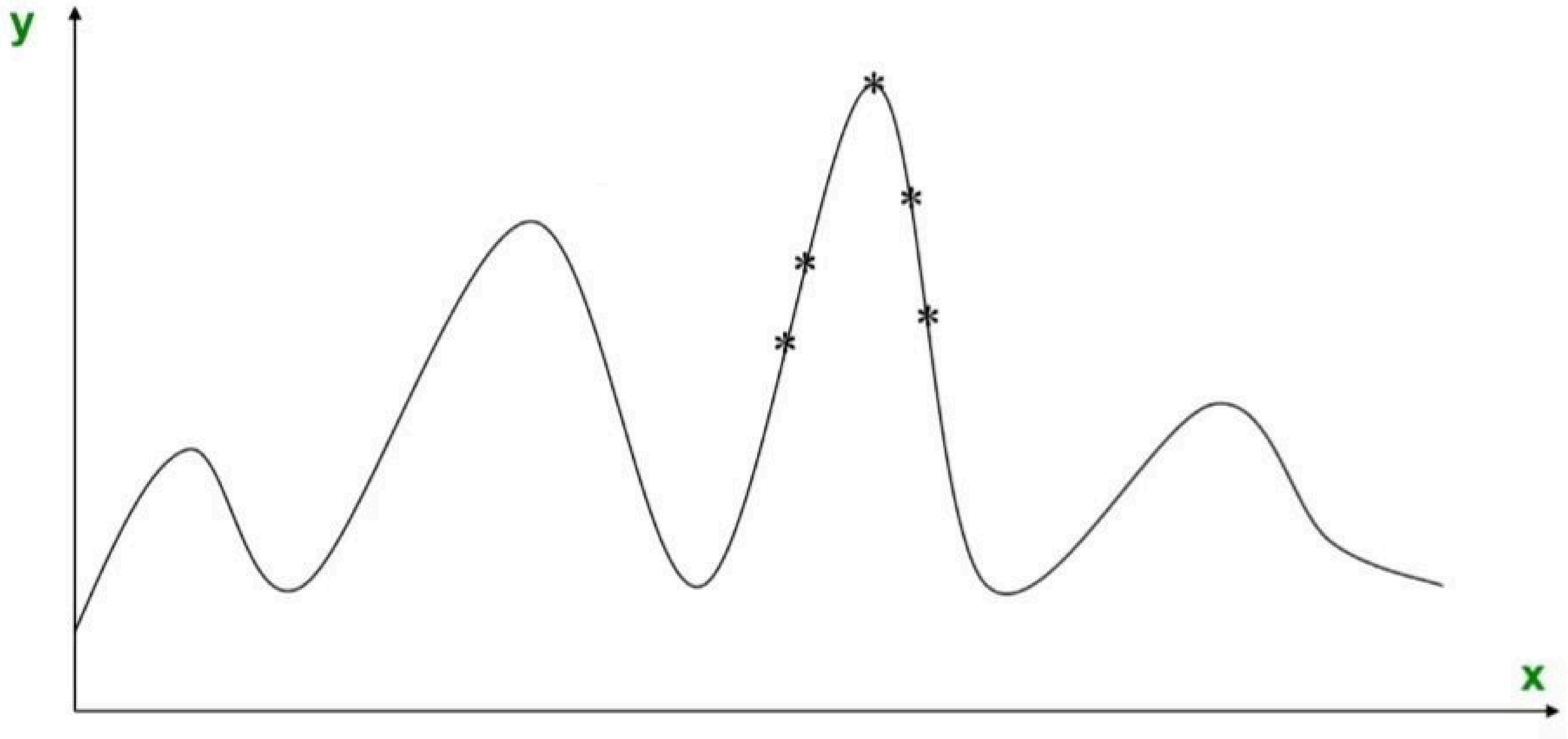
5 - Core Algorithm Details

- Allocate the rest of the bees for global search to the non-best locations.
- Evaluate the fitness value of non-best patches.
- Sort the overall results based on their fitness.



5 - Core Algorithm Details

- Run the algorithm until termination criteria met



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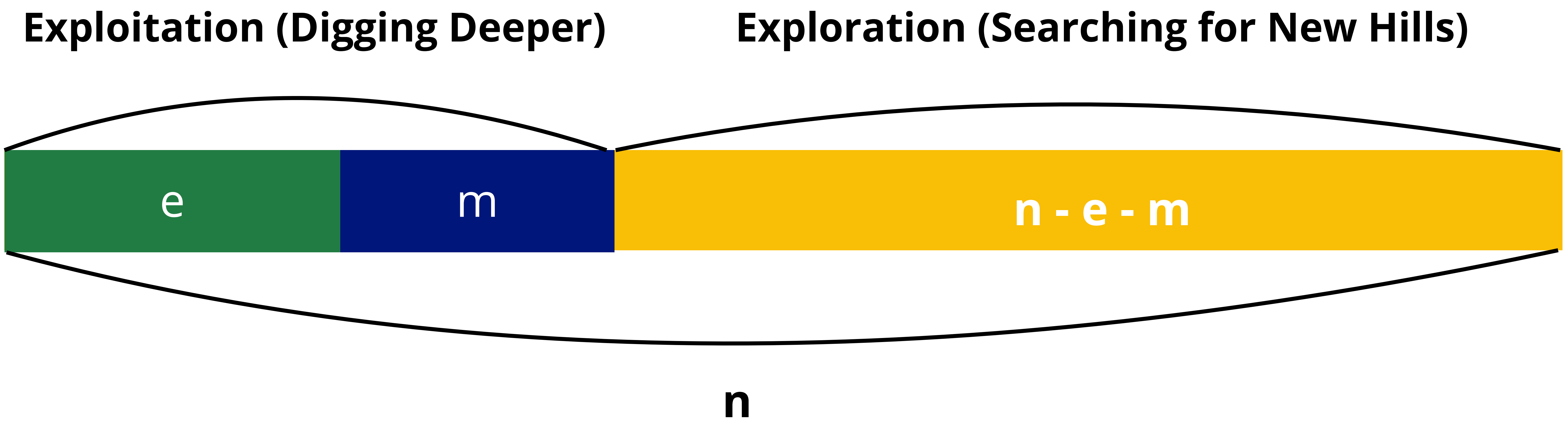

- n : number of the population
- e : number of the elite sites
- m : number of the best sites

5 - Core Algorithm Details

Parameter	Symbols
Number of scout bees in the selected patches	n
Number of best patches in the selected patches	m
Number of elite patches in the selected best patches	e
Number of recruited bees in the elite patches	nep
Number of recruited bees in the non-elite best patches	nsp
The size of neighborhood for each patch	ngh
Number of iterations	$Maxiter$
Difference between value of the first and last iterations	$diff$

5 - Core Algorithm Details

BA vs. PSO/ACO: Key Differences

- **No (complex)** interaction medium for the exchange of information
- Clear distinction between **exploratory** search (scout bees) and **exploitative** search (recruited foragers)
- In-built mechanisms to promote diversity and overcome **local optimum traps** (random scouting and site abandonment)

6 - Case Study

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7 - References

The Biological Inspiration

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The Bee Algorithm (Core Technical Paper)

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