Bee Algorithm Fundamentals: Step-by-Step Explanation

Yasin Mohammadi

March 17, 2025

Introduction to the Bee Algorithm

- The **Bee Algorithm** is a nature-inspired optimization algorithm.
- Mimics the food foraging behavior of honeybees.
- Used for:
  - Function maximization
  - Shortest pathfinding
  - Resource allocation

How Do Real Bees Forage?

- Bees balance **exploration** (new flowers) and **exploitation** (known flowers).
- Key steps:
  1. **Scout Bees**: Randomly explore for flowers.
  2. **Worker Bees**: Exploit known flower patches.
  3. **Recruitment**: Best patches attract more bees.
  4. **Waggle Dance**: Communicate nectar source quality.
  5. **Iteration**: Repeat until optimal sources are found.
- **Key Idea**: Efficiently find the best flowers.

Bee Algorithm for Optimization

1. **Initialization**: Start with random solutions.
2. **Evaluation**: Measure solution quality (nectar).
3. **Selection**: Keep best solutions, discard weak ones.
4. **Local Search (Exploitation)**: Refine best solutions.
5. **Global Search (Exploration)**: Explore new solutions.
6. **Repeat**: Iterate until the optimal solution is found.

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Goal: Balance exploitation and exploration.

Problem: Maximizing a Function

- Function: $f(x) = -(x-3)^2 + 9$
- A parabola with a peak at $x = 3$.
- **Goal**: Find x that maximizes $f(x)$.

Step-by-Step Process

1. **Initialize**: Random positions: $x = \{1, 2, 3, 4, 5\}$
2. **Evaluate**:
   - $f(1) = 5$, $f(2) = 8$, $f(3) = 9$, $f(4) = 8$, $f(5) = 5$
3. **Select**: Best at $x = 3$, $x = 2$, $x = 4$.
4. **Local Search**: Check $x = 2.9$ (8.99), $x = 3.1$ (8.99).
5. **Global Search**: Try $x = 0$ (0), $x = 6$ (0).
6. **Repeat**: Confirm $x = 3$ is optimal.

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Final Answer: Max value is 9 at $x = 3$.

Problem: Finding the Shortest Route

- Visit 4 flower patches: A, B, C, D.
- Distances:

From	To	Distance
A	B	2
A	C	5
A	D	7
B	C	3
B	D	6
C	D	4

- **Goal**: Find the shortest path.

Step-by-Step Process

1. **Initialize**: Random routes:
   - $A \to B \to C \to D$: $2 + 3 + 4 = 9$
   - $A \to C \to B \to D$: $5 + 3 + 6 = 14$
   - $A \to D \to B \to C$: $7 + 6 + 3 = 16$
2. **Select**: Best is $A \to B \to C \to D$ (9).
3. **Local Search**: Modify route, but no improvement.
4. **Global Search**: New routes are worse.
5. **Repeat**: Confirm $A \to B \to C \to D$.

Step-by-Step Process

1. **Initialize**: Random routes:
   - $A \to B \to C \to D$: $2 + 3 + 4 = 9$
   - $A \to C \to B \to D$: $5 + 3 + 6 = 14$
   - $A \to D \to B \to C$: $7 + 6 + 3 = 16$
2. **Select**: Best is $A \to B \to C \to D$ (9).
3. **Local Search**: Modify route, but no improvement.
4. **Global Search**: New routes are worse.
5. **Repeat**: Confirm $A \to B \to C \to D$.

Final Answer: Shortest path is $A \to B \to C \to D$ (distance 9).

Summary of the Bee Algorithm

- Mimics bees searching for food.
- Balances **exploration** and **exploitation**.
- Solves:
  - Function optimization
  - Shortest path problems
  - Resource allocation
- Next Session: Python implementation Both Example